Future Options and Associated Costs for Management of Massachusetts Wastewater Sludge

PFAS and Residuals Technology and Management Study, Part 2

Prepared for
Massachusetts Department of Environmental Protection
September 2025

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Tighe&Bond Brown AND Caldwell

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Table of Contents

Table of Contents iv
List of Figures viii
List of Tables xii
List of Abbreviations xv
Executive Summary xvii
1. Introduction 1-1
1.1 Project Objectives 1-1
1.2 Background 1-2
1.3 Scope of Work 1-3
2. PFAS Impacts on Sludge Management Methods 2-1
2.1 Background 2-1
2.1.1 PFAS Background 2-1
2.1.2 Sludge Management in New England 2-4
2.2 Identification of PFAS-Related Sludge Management Issues 2-7
2.2.1 Landfilling 2-7
2.2.2 Land Application 2-8
2.2.3 Incineration 2-13
2.3 Wastewater Industry Representative Interviews 2-15
2.3.1 Limited Contracting Agreements and Flexibility 2-16
2.3.2 Lack of Commercially Available Technology 2-16
2.3.3 Lack of Public Support and Approval 2-17
2.3.4 Potential Impacts of Land Application Bans 2-17
2.3.5 Impacts to Current Capital Improvement Plans 2-18
2.3.6 Increased Operational Costs 2-18
2.3.7 Different Regulations Across States 2-19
2.3.8 Potential Opportunities 2-19
2.4 Literature Review of PFAS Impacts from Sludge Management 2-19
2.4.1 Incineration 2-20
2.4.2 Landfill Disposal 2-21
2.4.3 Land Application 2-22
2.4.4 Other Studies 2-23
2.5 Evaluation of PFAS-Related Limitations on the Management of Massachusetts Sludge 2-23
2.5.1 Sludge Regulations in New England States 2-24
2.5.2 Sludge PFAS Regulations Outside New England 2-26
2.5.3 Sludge PFAS Regulations in Canada 2-29

2.5.4 Federal Steps to Address PFAS 2-30
2.5.5 Proposed Massachusetts Legislation 2-32
2.6 Wastewater and Sludge PFAS Reduction Approaches in Other States 2-34
2.6.1 Michigan 2-37
2.6.2 Minnesota 2-37
2.6.3 New York 2-38
2.6.4 Wisconsin 2-38
2.6.5 Maine 2-39
2.6.6 Vermont 2-40
2.6.7 Maryland 2-40
2.7 Section Summary 2-41
3. Sludge Volume Reduction and PFAS Treatment Technologies for Wastewater and Sludge 3-1
3.1 PFAS Treatment Technologies Overview 3-2
3.1.1 Wastewater Liquid Fraction 3-2
3.1.2 Sludge – Emerging Technology 3-7
3.1.3 Sludge – Mature Technology 3-11
3.2 Sludge Volume Reduction Technologies Overview 3-14
3.2.1 Dewatering 3-16
3.2.2 Anaerobic Digestion 3-18
3.2.3 Thermal Drying 3-18
3.3 Leachate PFAS Treatment Technologies Overview 3-20
3.3.1 Leachate Collection in Massachusetts 3-20
3.3.2 Leachate - Selected Technologies for Further Analysis 3-20
3.4 Life Cycle Cost Evaluation of Representative Technologies 3-23
3.4.1 Facility Size Ranges 3-23
3.4.2 Net Present Cost Methodology 3-24
3.4.3 Wastewater Liquid Fraction PFAS Treatment Technologies 3-27
3.4.4 Sludge Volume Reduction and PFAS Treatment Technologies 3-35
3.4.5 Leachate PFAS Treatment Technologies 3-63
3.5 Sewer Rate Impact Estimates 3-70
3.5.1 Assumptions 3-70
3.5.2 Calculation Approach 3-70
3.5.3 Comparison to Select POTW Operating Budgets 3-71
3.5.4 Comparison to Median Income 3-73
3.5.5 Comparison to Existing Water and Sewer Bills 3-76
3.5.6 Sewer Rate Impact Estimate Summary 3-77
3.6 Non-Cost Criteria 3-77
3.6.1 Wastewater Liquid Fraction PFAS Treatment Technologies 3-77
3.6.2 Sludge Volume Reduction and PFAS Treatment Technologies 3-80
3.6.3 Anaerobic Digestion in Combination with PFAS Treatment Technologies 3-82

3.7 Considerations for Regional Sludge Facilities 3-82
3.7.1 Economics 3-83
3.7.2 Logistics 3-84
3.7.3 Permitting 3-84
3.7.4 Relationships 3-84
3.7.5 Case Studies 3-86
3.7.6 Future Considerations 3-88
3.8 Potential Funding Sources 3-88
3.8.1 Loan Programs 3-89
3.8.2 State and Federal Grant Funding for Anaerobic Digestion 3-90
3.8.3 Grants for Other Technologies 3-91
3.8.4 Other Incentives 3-92
3.8.5 Public-Private Partnerships 3-93
4. Contributions of PFAS Into POTWs 4-1
4.1 Introduction 4-1
4.1.1 Objectives & Scope of Work 4-1
4.1.2 Background 4-1
4.1.3 Review of Relevant Literature 4-2
4.2 Methods 4-13
4.2.1 Compilation of Existing Data 4-13
4.2.2 Data Processing 4-14
4.2.3 Data Analyses 4-17
4.2.4 Selection Criteria for POTW Case Studies 4-18
4.3 Massachusetts Wastewater PFAS 4-19
4.3.1 Overview of PFAS at POTWs 4-19
4.3.2 Analysis of PFAS Loadings from Specific Sources 4-35
4.3.3 POTW Case Studies 4-49
4.4 Potential Source Control Opportunities 4-88
4.4.1 Product Replacement 4-88
4.4.2 Contaminated Equipment Remediation or Replacement 4-89
4.4.3 Pretreatment Technology 4-90
4.4.4 Pretreatment of Hauled-in Wastes 4-91
5. Analysis of Potential Sludge Management Scenarios 5-1
5.1 Scenario Introduction 5-1
5.2 Scenario Overview and Assumptions 5-1
5.2.1 Scenario 1 – Land Application Restrictions in Massachusetts 5-6
5.2.2 Scenario 2 – Land Application Restrictions Regionally or Nationally 5-11
5.2.3 Scenario 3 – Landfill Restrictions in Massachusetts 5-15
5.2.4 Scenario 4 – Landfill Restrictions Regionally or Nationally 5-16
5.2.5 Scenario 5 – Incineration Capacity Reduction in Massachusetts 5-19

5.2.6 Scenario 6 – Incineration Capacity Reduction Regionally or Nationally 5-23
5.2.7 Scenario 7 – New Capacity Becomes Available 5-27
5.2.8 Scenario 8 – Additional Sludge Reduction Capacity Becomes Available 5-29
5.2.9 Scenario 9 – New PFAS Treatment Capacity Becomes Available 5-31
5.2.10 Scenario 10 – Source Reduction to Reduce PFAS at POTWs 5-32
5.3 Review of Scenarios 5-33
6. Conclusions and Options to Consider for Sludge Management 6-1
6.1 Introduction 6-1
6.2 Options to Consider for Massachusetts POTWs 6-6
6.2.1 Reduce Sludge Volume 6-6
6.2.2 Consider Commitments to Regional Facilities 6-7
6.2.3 Undertake Local PFAS Source Reduction 6-7
6.2.4 Consider Pilot Testing Promising PFAS Reduction Technologies 6-10
6.3 Regulatory and Legislative Options to Consider 6-10
6.3.1 Implement PFAS Source Control Measures 6-10
6.3.2 Limit Biosolids Land Application 6-13
6.3.3 Promote PFAS Treatment Technologies 6-13
6.3.4 Support Sludge Volume Reduction and PFAS Treatment Projects 6-16
6.3.5 Promote Regional Facilities 6-18
6.4 Conclusion 6-20
7. References 1
Appendix A: Sample Questions A-1
Appendix B: PFAS Mitigation Technologies – Wastewater Liquid Fraction B-1
Appendix C: PFAS Mitigation Technologies – Sludge C-1
Appendix D: Sludge Volume Reduction Technologies D-1
Appendix E: Statistical Methods E-1
Appendix F: Supplemental Figures & Tables F-1
Appendix G: Results of the Land Use and Environmental Justice Analyses G-1
Appendix H: Potential Sludge Management Scenario Calculations H-1
Appendix I: Capital Cost Calculations I-1
Appendix J: Recommendations for Future Scientific Research J-1

List of Figures

Figure ES-1. PFAS flows into and out of a POTW with control points (and report section numbers)....xix

Figure ES-2. Estimated Annual Costs Per Household in the Service Area of Technology Implementation as a Percent of Current Median Annual Household Water and Sewer Bills.....xx

Figure ES- 3. Options for POTWs, Legislators and Regulators to Improve Sludge Management xxiii

Figure 1-1. PFAS Flows into and out of A POTW With Control Points (And Report Section Numbers).1-4

Figure 2-1. PFAS Water Cycle (EGLE, 2020b) 2-3

Figure 2-2. Massachusetts sludge (dry U.S. tons) summarized by management method in 2023 from Part 1 Figure 3-12a (Tighe & Bond and Brown and Caldwell, 2024a) 2-5

Figure 2-3. National Biosolids Data Project Charts for Other New England States and New York, 2018 (Beecher et al., 2024).....2-6

Figure 2-4. Destinations for Wastewater Sludge Produced in Massachusetts..... 2-11

Figure 3-1. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of GAC 3-28

Figure 3-2. Annual Estimated O&M Cost Curve for GAC..... 3-29

Figure 3-3. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of IX .3-30

Figure 3-4. Annual Estimated O&M Cost Curve For IX..... 3-31

Figure 3-5. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of GAC+IX 3-32

Figure 3-6. Annual Estimated O&M Cost Curve of GAC+IX..... 3-34

Figure 3-7. A Summary of the 20-Year NPC for Liquid Fraction of Wastewater PFAS Mitigation Technologies..... 3-35

Figure 3-8. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of Screw Presses..... 3-36

Figure 3-9. Annual Estimated O&M Cost Curve of Screw Presses..... 3-38

Figure 3-10. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of Centrifuges..... 3-39

Figure 3-11. Annual Estimated O&M Cost Curve of Centrifuges 3-40

Figure 3-12. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of Mesophilic Anaerobic Digestion 3-42

Figure 3-13. Annual Estimated O&M Cost Curve of Mesophilic Anaerobic Digestion 3-44

Figure 3-14. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of Belt Dryers..... 3-45

Figure 3-15. Annual Estimated O&M Cost Curve of Belt Dryers 3-47

Figure 3-16. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of Rotary Drum Dryers 3-48

Figure 3-17. Annual Estimated O&M Cost Curve of Rotary Drum Dryers 3-50
Figure 3-18. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of Gasification Systems 3-51
Figure 3-19. Annual Estimated O&M Cost Curve of Gasification Systems 3-53
Figure 3-20. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of Pyrolysis Systems 3-54
Figure 3-21. Annual Estimated O&M Cost Curve of Pyrolysis Systems 3-56
Figure 3-22. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of SCWO Systems 3-57
Figure 3-23. Annual Estimated O&M Cost Curve of SCWO Systems 3-59
Figure 3-24. A Summary of the 20-Year NPC for Sludge Volume Reduction Technologies 3-61
Figure 3-25. A summary of the 20-year NPC for Biosolids PFAS Mitigation Technologies 3-62
Figure 3-26. A summary of the 20-year NPC for Retrofits at UBCW and LRWPF 3-63
Figure 3-27. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of Foam Fractionation 3-65
Figure 3-28. Project Capital Cost Curve for Installation of Foam Fractionation 3-66
Figure 3-29. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of Reverse Osmosis 3-67
Figure 3-30. Project Capital Cost Curve for Installation of Reverse Osmosis 3-69
Figure 3-31. A Summary of the 20-year NPC for Leachate PFAS Mitigation Technologies 3-69
Figure 3-32 Annualized Capital and O&M Cost of Implementing Technologies as a Percent of Reference POTW Current Annual Operating Budgets 3-73
Figure 3-33 Estimated Annual Costs of Technology Implementation Per Household in the Service Area as a Percent of Massachusetts Median Household Income by Modeled POTW Size 3-74
Figure 3-34 Estimated Annual Costs of Technology Implementation Per Household in the Service Area as Percent of Boston Area Median Household Income by Modeled POTW Size 3-75
Figure 3-35 Estimated Annual Costs of Technology Implementation Per Household in the Service Area as a Percent of Western Massachusetts Median Household Income by Modeled POTW Size 3-76
Figure 3-36. Estimated Annual Costs Per Household in the Service Area of Technology Implementation as a Percent of Current Median Annual Household Water and Sewer Bills by Modeled POTW Size 3-77
Figure 4-1. Essex Junction Wastewater Treatment Facility Standard Assay Summary 4-6
Figure 4-2. Essex Junction Wastewater Treatment Facility TOP Assay Summary 4-7
Figure 4-3. Middlebury Wastewater Treatment Facility Standard Assay Summary 4-7
Figure 4-4: Middlebury Wastewater Treatment Facility TOP Assay Summary 4-8
Figure 4-5. Summary of PFAS contributions to PFAS loading at two Vermont POTWs 4-9

Figure 4-6. Average PFAS Concentrations in Landfill Leachate from Four Vermont Landfills 4-10
Figure 4-7. Sum of POTWs' PFAS Concentrations for the Five Regulated PFAS in Vermont..... 4-11
Figure 4-8. Average PFAS Concentrations at the Newport Wastewater Treatment Facility 4-12
Figure 4-9. Average PFAS Concentrations at the St. Johnsbury Wastewater Treatment Facility..... 4-12
Figure 4-10. NMDS plot of POTW and industrial users' PFAS molar concentrations (µmol/g)..... 4-20
Figure 4-11. Most common PFAS species detected in MA POTW influent..... 4-23
Figure 4-12. Cumulative Average PFAS Mass Concentrations (ng/L) for the Eight PFAS Most Frequently Detected in Massachusetts POTW Influent..... 4-28
Figure 4-13. Cumulative Average PFAS Mass Concentrations (ng/L) for the Eighteen PFAS Least Frequently Detected in Massachusetts POTW Influent..... 4-29
Figure 4-14. Cumulative Average PFAS Mass Concentrations (ng/L) for the Eight PFAS Most Frequently Detected in Massachusetts POTW Effluent 4-31
Figure 4-15. Cumulative Average PFAS Mass Concentrations (ng/L) for the 18 PFAS Least Frequently Detected in Massachusetts POTW Effluent 4-32
Figure 4-16. Cumulative Average PFAS Mass Concentrations (ng/g, dry) for the Seven PFAS Most Frequently Detected in Massachusetts POTW Sludge 4-33
Figure 4-17. Cumulative Average PFAS Mass Concentrations (ng/g, dry) for the 28 PFAS Least Frequently Detected in Massachusetts POTW Sludge 4-34
Figure 4-18. NMDS Plot of POTW and Industrial Users' PFAS Molar Concentrations (µmol/g) by Industry Type..... 4-38
Figure 4-19. Average PFAS Concentrations for Centralized Waste Treaters 4-39
Figure 4-20. Average PFAS Concentrations for Ceramics and Plastics..... 4-39
Figure 4-21. Average PFAS Concentrations for Coloring Manufacturing..... 4-40
Figure 4-22. Average PFAS Concentrations for Commercial Car Washes..... 4-40
Figure 4-23. Average PFAS Concentrations for Drinking Water Treatment Residuals 4-41
Figure 4-24. Average PFAS Concentrations for Electronics 4-41
Figure 4-25. Average PFAS Concentrations for Food 4-42
Figure 4-26. Average PFAS Concentrations for Landfill Leachate 4-42
Figure 4-27. Average PFAS Concentrations for Laundering..... 4-43
Figure 4-28. Average PFAS Concentrations for Manufacturers of Parts with Polytetrafluoroethylene (PTFE) or Teflon-type coatings 4-43
Figure 4-29. Average PFAS Concentrations for Medical/Pharma..... 4-44
Figure 4-30. Average PFAS Concentrations for Paper 4-44
Figure 4-31. Average PFAS Concentrations for Platers/Metal Finishers 4-45
Figure 4-32. Average PFAS Concentrations for Power Plant..... 4-45
Figure 4-33. Average PFAS Concentrations for Tanneries and Leather/Fabric/Carpet Treaters..... 4-46

Figure 4-34. Average Influent Concentrations Separated by Influent Sources 4-48
Figure 4-35. Influent and Effluent PFAS Mass Loading for POTW A 4-54
Figure 4-36. Mass Loading of PFAS from Industrial Sources for POTW A's Sewershed 4-55
Figure 4-37. Identified Industrial and Influent Mass Loading to POTW A Presented with the Percent Contribution from Industrial Sources to the Facility Influent 4-56
Figure 4-38. Influent and Effluent PFAS Mass Loading for POTW B 4-58
Figure 4-39. Influent And Effluent PFAS Mass Loading for POTW C 4-60
Figure 4-40. Mass loading of PFAS from industrial sources for POTW C's sewershed 4-61
Figure 4-41. Industrial And Influent Mass Loading to POTW C Presented with the Percent Contribution from Industrial Sources to the Facility Influent 4-62
Figure 4-42. Influent and Effluent PFAS Mass Loading for POTW D 4-64
Figure 4-43. Influent and Effluent PFAS Mass Loading for POTW E 4-66
Figure 4-44. Influent and Effluent PFAS Mass Loading for POTW F 4-68
Figure 4-45. Influent, Effluent, and Industrial PFAS Concentrations for POTW F 4-69
Figure 4-46. Sludge PFAS Concentrations for POTW F 4-70
Figure 4-47. Influent and Effluent PFAS Mass Loading for POTW G 4-72
Figure 4-48. Influent PFAS Mass Loading for POTW H 4-74
Figure 4-49. Mass Loading of PFAS from Industrial Sources for POTW H's Sewershed 4-75
Figure 4-50. Industrial and Influent Mass Loading to POTW H Presented with the Percent Contribution from Industrial Sources to the Facility Influent 4-76
Figure 4-51. Influent and Effluent PFAS Mass Loading for POTW I 4-78
Figure 4-52. Influent and Effluent PFAS Mass Loading for POTW J 4-80
Figure 4-53. Influent and Effluent PFAS Mass Loading for POTW K 4-82
Figure 4-54. Influent and Effluent PFAS Mass Loading for POTW L 4-84
Figure 4-55. Influent and Effluent PFAS Mass Loading for POTW M 4-86
Figure 4-56. Influent, Effluent, and Industrial PFAS Concentrations for POTW M 4-87
Figure 5-1. Map of Massachusetts Department of Environmental Protection Regions 5-4
Figure 6-1.Options for POTWs, Legislators and Regulators to Improve Sludge Management 6-5

List of Tables

Table 2-1. Short- and Long-Chain PFCAs and PFSAs[1] 2-2
Table 2-2. Summary of Biosolids Information in New England 2-25
Table 2-3. Summary of Biosolids Information in Other States 2-27
Table 2-4. U.S. EPA National Primary Drinking Water Regulation (NPDWR) for PFAS 2-30
Table 2-5. Summary of Current Land Application PFAS Strategies in Other States Using a Tiered Approach 2-35
Table 2-6. Substantial PFOS Reduction with IPP at WWTP with Exceedances taken from Table 9 of EGLE April 2021 (AECOM, 2021) 2-37
Table 3-1. Pros and Cons of GAC for PFAS Treatment 3-3
Table 3-2. Pros and Cons of IX for PFAS Treatment 3-4
Table 3-3. Pros and Cons of NF and RO for PFAS Treatment 3-5
Table 3-4. Pros and Cons of Foam Fractionation for PFAS Treatment in Wastewater 3-6
Table 3-5. Wastewater Sludge Technology Comparison 3-9
Table 3-6. Full-Scale or Demonstration Scale Biosolids Pyrolysis and Gasification Facilities 3-10
Table 3-7. Dewatering Technology Comparison 3-17
Table 3-8. Leachate Management Approach for Massachusetts Respondents to Landfill Operator Survey 3-20
Table 3-9. Pros and Cos of Leachate Treatment Technologies by Location 3-23
Table 3-10. Representative Facility Flows Evaluated 3-24
Table 3-11. NPC Assumptions 3-24
Table 3-12. A Summary of Capital Costs Markups 3-25
Table 3-13. Assumptions for Operations and Maintenance Cost Analyses 3-26
Table 3-14. O&M Totals Per Component - GAC 3-29
Table 3-15. O&M Totals Per Component - IX 3-31
Table 3-16. O&M Totals Per Component – GAC with IX 3-33
Table 3-17. O&M Totals – Screw Press 3-37
Table 3-18. O&M Totals - Centrifuge 3-40
Table 3-19. O&M Totals - Mesophilic Anaerobic Digestion 3-43
Table 3-20. O&M Totals - Belt Dryer 3-46
Table 3-21. O&M Totals - Rotary Drum 3-49
Table 3-22. O&M Totals - Gasification 3-52
Table 3-23. O&M Totals - Pyrolysis 3-55
Table 3-24. O&M Totals - SCWO 3-58

Table 3-25. Project Capital Cost Estimates with Estimating Range (-50% to 100%) for Installation of Sludge Volume Reduction Technologies at Various POTW Sizes 3-60

Table 3-26. Project Capital Cost Estimates with Estimating Range (-50% to 100%) for Installation of Sludge PFAS Treatment Technologies at Various POTW Sizes 3-60

Table 3-27. Summary of Capital and O&M Costs for Incinerator Retrofits 3-62

Table 3-28. A Summary of Capital Costs Markups Purchased Equipment Delivered 3-63

Table 3-29. A Summary of Capital Costs Markups for Lump Sum Packages 3-64

Table 3-30. O&M Totals - Foam Fractionation 3-66

Table 3-31 O&M Totals - Reverse Osmosis 3-68

Table 3-32. Input Assumptions for Sewer Rate Impact Calculations 3-70

Table 3-33. Annual O&M Budgets for Various Wastewater Treatment Plants in Massachusetts 3-72

Table 3-34. Rating of PFAS Mitigation Technologies for Wastewater by Priority Criteria Identified by MassDEP 3-79

Table 3-35. Rating of Sludge Volume Reduction and PFAS Treatment Technologies by Priority Criteria Identified by MassDEP 3-81

Table 3-36. Governance Options Between Municipalities and with a Private Entity 3-86

Table 4-1. Sources of PFOS to WWTPs in Michigan[1] 4-4

Table 4-2. PFOS & PFOA Concentrations in Wastewater Sludge 4-5

Table 4-3. Brief Definitions of Property Use Classifications 4-16

Table 4-4. Definitions of Environmental Justice Criteria[1] 4-17

Table 4-5. Summary of Overall PFAS Detection 4-21

Table 4-6. Summary of Influent PFAS Data from Massachusetts POTWs 4-24

Table 4-7. Summary of Effluent PFAS Data from Massachusetts POTWs 4-25

Table 4-8. Summary of Sludge PFAS Data from Massachusetts POTWs 4-26

Table 4-9. Summary of PFAS Species Present in >50% of POTWs 4-27

Table 4-10. Summary of Industrial Sampling Data 4-36

Table 4-11. Comparison of Massachusetts and Maine Septage Concentrations 4-49

Table 4-12. Summary of Case Study POTW Characteristics 4-51

Table 4-13. Example Industrial Mass Loading Calculations 4-52

Table 4-14. Pipe Replacement Costs 4-90

Table 4-15. Pipe Rehabilitation Costs 4-90

Table 5-1. Schedule of Estimated Direct and Indirect Impacts to Sludge Management Costs 5-2

Table 5-2. Sludge Management Scenarios (through 2044 and beyond) 5-5

Table 5-3. Facilities Accepting Liquid Sludges from Massachusetts POTWs (2023) 5-6

Table 5-4. Land-Applied Solids sent to MA from MA Plants 5-7

Table 5-5. Scenario 1 Summary: Land Application Restrictions in Massachusetts 5-10

Table 5-6. Land-Applied Solids sent to CT, NH or VT from MA Plants..... 5-12

Table 5-7. Scenario 2 Summary: Regional/National Land Application Restrictions with Regional Impact on Massachusetts POTWs..... 5-14

Table 5-8. Scenario 3 Summary: Landfill Restrictions in Massachusetts..... 5-16

Table 5-9. Scenario 4 Summary: Regional/National Landfill Restrictions with Regional Impact on Massachusetts POTWs..... 5-18

Table 5-10. Scenario 5 Summary: Incineration Capacity Reduction in Massachusetts 5-22

Table 5-11. Scenario 6 Summary: Regional/National Incinerator Capacity Reductions with Regional Impact on Massachusetts POTWs..... 5-26

Table 5-12. Scenario 7 Summary: Innovation / New Capacity / Legislative & Funding Solutions affecting all Massachusetts POTWs..... 5-29

Table 5-13. Scenario 8 Summary: Additional Sludge Volume Reduction Capacity Benefitting all Massachusetts POTWs..... 5-30

Table 5-14. Scenario 9 Summary: New PFAS Treatment Capacity Benefitting all Massachusetts POTWs 5-32

Table 5-15. Scenario 10 Summary: PFAS Source Reduction Benefitting all Massachusetts POTWs... 5-33

Table 5-16. Scenarios 1-6 Summary - Analysis Overview 5-35

Table 5-17. Scenarios 7-10 Analysis Overview..... 5-36

Table 6-1. Scenarios 1-6 Analysis Overview..... 6-2

Table 6-2. Scenarios 7-10 Analysis Overview 6-3

Table 6-3. Project Capital Cost Estimates with Estimating Range (-50% to 100%) for Installation of Sludge Volume Reduction Technologies at Various POTW Sizes 6-16

Table 6-4. Project Capital Cost Estimates with Estimating Range (-50% to 100%) for Installation of Sludge PFAS Treatment Technologies at Various POTW Sizes..... 6-16

List of Abbreviations

ANR	Agency of Natural Resources
AOP	Advanced oxidation process
AOS	Approval of Suitability
APC	air pollution control
ARP	advanced reduction process
BFP	belt filter press
CASA	California Association of Sanitation Agencies
CERLA	Comprehensive Environmental Response, Compensation and Liability Act
CPS	Clean Peak Energy Portfolio Standard
CPEC	Clean Peak Energy Certificates
CTDEEP	Connecticut Department of Energy & Environmental Protection
DITP	Deer Island Treatment Plant
DOER	Department of Energy Resource
dtpd	dry U.S. tons per day
dtpy	dry ton per year
ECHO	Enforcement and Compliance History Online
ECOS	Environmental Council of States
EGLs	Effluent Limitations Guidelines
EIR	Environmental Impact Report
EJ	Environmental Justice
ENR	Environmental Notification Form
EO	electrochemical oxidation
EPA	Environmental Protection Agency
FCSWMD	Franklin County Solid Waste Management District
FF	Foam Fractionation
FOG	fats, oils and grease
GAC	granular activated carbon
GHG	greenhouse gas
GIS	geographic information system
GLSD	Greater Lawrence Sanitary District
GNHWPCA	Greater New Haven Water Pollution Control Authority
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation
HTC	Hydrothermal carbonization
HTL	Hydrothermal liquefaction
IPP	Industrial Pretreatment Programs
ITRC	Interstate Technology & Regulatory Council
IX	ion exchange resin
JRL	Juniper Ridge Landfill
MABA	Mid-Atlantic Biosolids Association
MAD	mesophilic anaerobic digestion
MassDEP	Massachusetts Department of Environmental Protection
MAWEA	Massachusetts Water Environment Association
MBR	Membrane Bioreactor
MCGL	maximum contaminant level goals
MDC	Metropolitan District (Hartford, CT)
MEPA	Massachusetts Environmental Policy Act
MFT	Manufactured topsoil
mgd	million gallons per day
MWRA	Massachusetts Water Resources Authority
NBDP	National Biosolids Data Project
NEBRA	North East Biosolids and Residuals Association
NEIWPCC	formerly known as the New England Interstate Water Pollution Control Commission
NF	nanofiltration
ng/L	nanograms per liter (approximately equivalent to parts per trillion in aqueous media)
NMDS	Non-metric multidimensional scaling
NPDES	National Pollutant Discharge Elimination System
NPDWR	National Primary Drinking Water Regulations
NWRA	National Waste & Recycling Association
NYSDEC	New York Department of Environmental Conservation
O&M	operations and maintenance
OMRC	Organic Material Recovery Center
OTM	other test method

PEER	Public Employees for Environmental Responsibility
PFAS	per- and polyfluoroalkyl substances
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonic acid
POTW	publicly owned treatment works
ppb	parts per billion
ppt	parts per trillion
PWS	public water systems
QA/QC	quality assurance / quality control
RBE	Renewable Biosolids Energy
RECS	Renewable Energy Certificates
RFS	Renewable Fuel Standard
RO	Reverse Osmosis
RPS	Renewable Energy Portfolio Standard
RTO	regenerative thermal oxidizer
SSI	sewage sludge incinerator
SWANA	Solid Waste Association of North America
SVCW	Silicon Valley Clean Water
TSCA	Toxic Substances Control Act
UBCW	Upper Blackstone Clean Water
UF	ultrafiltration
ug/kg	micrograms per kilogram (equivalent to parts per billion)
µm	micrometer or micron
VfM	Value of Money
VOCs	volatile organic compounds
VT DEC	Vermont Department of Conservation
WEF	Water Environment Federation
WESP	wet electrostatic precipitator
WisPAC	Wisconsin PFAS Action Council
WPCF	water pollution control facility
WPCP	water pollution control plant
WQD	water quality district
wt	wet ton
wtpd	wet ton per day
wtpy	wet ton per year
WWTF	wastewater treatment facility
WWTP	wastewater treatment plant

Executive Summary

Managing wastewater sludge from publicly owned treatment works (POTWs) has been increasingly challenging in Massachusetts, as health impacts associated with per- and polyfluoroalkyl substances (PFAS) and other contaminants have received increasing attention, and as available management options have declined, driving up costs of sludge management. To better understand the constraints and options for sludge management in Massachusetts, the Massachusetts Department of Environmental Protection (MassDEP) commissioned a two-part study to evaluate the current volumes of sludge generated at POTWs, where that sludge is managed or disposed and options for managing residuals in the future (this Part 2 report) (Tighe & Bond and Brown and Caldwell, 2024a). Health and environmental impacts associated with management or disposal of wastewater or sludge containing PFAS were not emphasized in these studies.

As shown in the Part 1 report of this study (Section 7.1), the existing capacity at outlets for sludge (e.g., compost and dryer facilities producing biosolids for land application, landfills and incinerators) is decreasing, with few if any projects in advanced development in the Commonwealth or surrounding region that will significantly reverse the trend. POTWs have seen sludge management account for an ever-increasing share of their overall budgets (increasing 35% between 2018 and 2023), challenging utility budgets (Tighe & Bond and Brown and Caldwell, 2024a Section 7.3).

The Part 1 report, entitled "Current and Near-Term Management of Massachusetts Wastewater Sludge," estimated that by 2028, due to anticipated facility closures and increased sludge production from population increases, at least 7% of the sludge generated in Massachusetts will not be able to be accommodated by remaining outlets. Concerns about PFAS have exacerbated the challenges (Tighe & Bond and Brown and Caldwell, 2024a Section 7.1). This report presents the findings of the second part of the PFAS and Residuals Technology and Management Study (referred to as "Part 2"), which aims to provide POTWs, regulators, legislators, and other interested parties with information on potential options for the management of sludge generated in Massachusetts. Part 2 of this study focuses on the impacts of PFAS on sludge management options (Section 2); technologies for treating PFAS in wastewater, sludge, and landfill leachate (Section 3); and sources of PFAS to POTWs (Section 4). Section 5 examines a series of potential scenarios that could reduce sludge disposal capacity (e.g., restrictions on land application, landfills, or incinerators) or positively impact (e.g., PFAS source control, technology innovation, development of regional facilities) sludge management options in the future. Section 5 also includes estimated costs and other impacts associated with these scenarios. Section 6 considers possible options in the Commonwealth based on the contextual foundation laid out in the Part 1 report and previous sections of the Part 2 report.

Figure ES-1 depicts pathways that PFAS can enter and leave POTWs. The diamonds represent points at which interventions can seek to reduce the amount of PFAS circulating in the environment (with references to the section numbers where that intervention is discussed in this report). PFAS can be conveyed to POTWs via sewers along with the wastewater from industrial (including landfill), commercial, institutional, and residential users, or hauled in as part of septage, landfill leachate, organics (such as fats, oils and grease (FOG) and food waste), or sludge from other POTWs. Section 4 of this study reviews MassDEP PFAS data collected from industrial discharges and POTW influent, effluent, and sludge. Although few, the samples were analyzed using Modified Method 537.1 (Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC-MS/MS)) and Method 1633 (Analysis of PFAS in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS), among several proprietary laboratory methods. Available data were used to inform understanding of where PFAS at POTWs

come from. PFAS data from industrial and commercial sources, residential sewage, septage, and other hauled-in waste were analyzed. Industrial sampling data spanned various categories, such as tanneries and leather manufacturers, carpet treaters, commercial car washes, landfill leachate, coating manufacturers, platers and metal finishers, electronic manufacturers, ceramics and plastics, and more. The analysis found that different industries can have distinct "PFAS profiles" and contribute different PFAS concentrations.

Although data on total PFAS, defined as the sum of mass or molar PFAS concentrations in each sample, were largely unavailable, the available data indicated that eight individual PFAS, out of up to 40 individual PFAS measured, were detected in more than half of all POTW influents. The concentrations of several of those PFAS were similar across POTWs, consistent with a common source (e.g., domestic sources; historical contamination of wastewater systems). A subset of POTWs were also evaluated as case studies to provide a more detailed look at likely PFAS sources. Three of the case study POTWs described in Section 4.3.3 provided enough data to calculate mass loadings of certain PFAS in influent to the plant along with mass loadings from current industrial sources. At POTW A, calculated industrial mass inputs were less than five percent for all but two of the tested species while at the other POTWs C and H, industrial contributions of several species were between five and 40 % of the influent mass loading. These varied results indicate that the decision of whether to pursue source reduction through industrial pretreatment programs will need to be evaluated at each POTW individually,

PFAS data from sludge samples showed seven PFAS species of up to 40 measured were detected at more than half of the POTWs. Some were consistent with the influent samples, while others were unique to the sludge samples, which is consistent with the presence of PFAS precursors in the influent or an additional source of PFAS in the treatment process. Seventy-eight percent of POTW sludge samples in this data set had concentrations below 20 ng/g (20 parts per billion or 20,000 parts per trillion) for both PFOA and PFOS. This level has been used as a cutoff for unrestricted land application in some states, including New York, but exceeds risk levels associated with some biosolids exposure pathways as determined in USEPA's Draft Risk Assessment of PFOA and PFOS in Biosolids (USEPA, 2025a). Although the New York threshold is not risk-based and does not address potential impacts to groundwater, surface water or other potential exposure pathways, the current New York values preserve biosolids land application capacity including for biosolids generated in Massachusetts.

Industrial discharges can be addressed through source control (see Sections 4.4, 6.2.3 and 6.3.1). Landfill leachate is of particular importance for POTWs for a few reasons. It tends to have fairly high concentrations of PFAS, so it can represent a significant fraction of the total PFAS load to a POTW. In some places, sludge is disposed in a landfill, which in turn sends its leachate to the POTW—creating a PFAS cycle. Treatment technologies tend to be more efficient at higher concentrations, so treatment of leachate is a promising option for preventing or reducing the introduction of PFAS from landfill leachate to a POTW (Section 3.3, 3.4.5). Treatment at residential or institutional locations tends to be impractical, so a more promising approach to reduce PFAS loadings from these locations—as well as septage, FOG and food waste—is likely restricting the use of PFAS in consumer products (Sections 4.4.1, 6.2.3, 6.3.1).

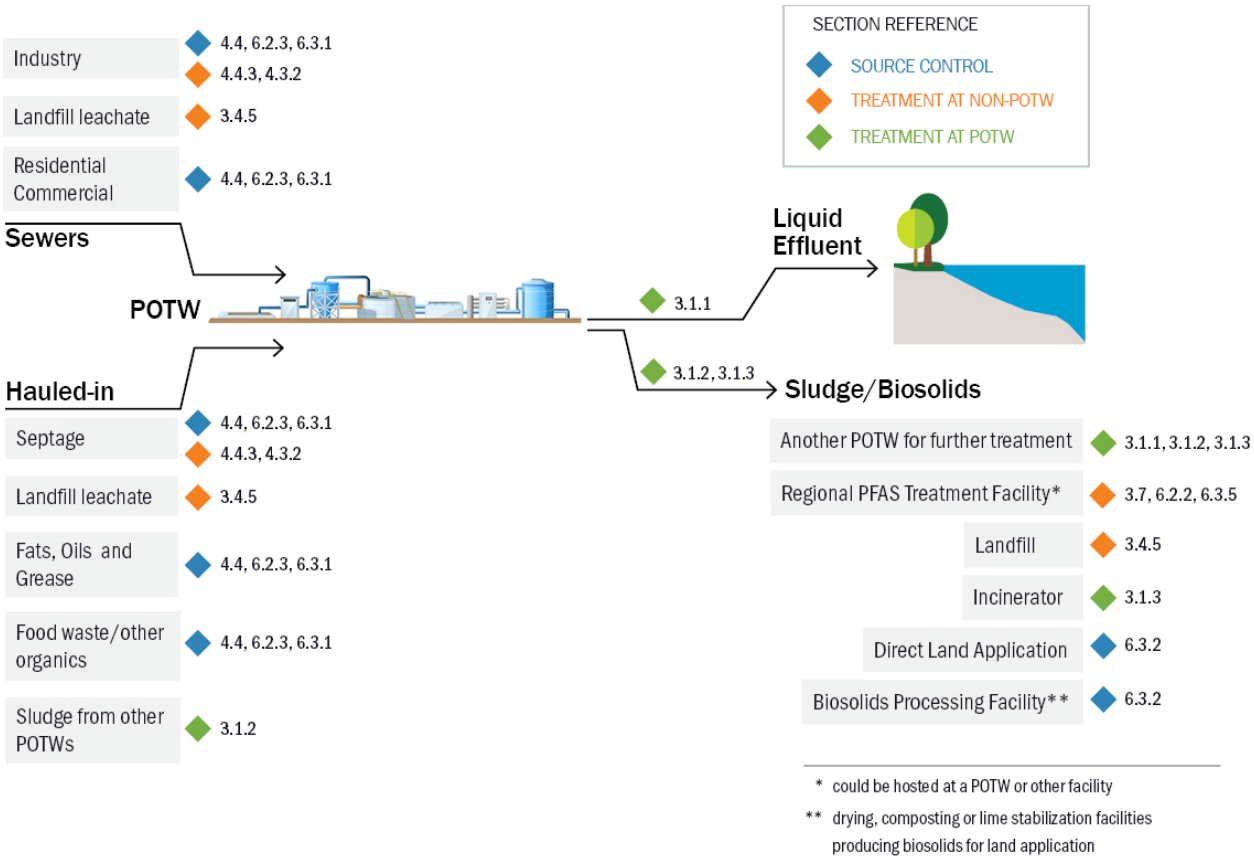


Figure ES-1. PFAS flows into and out of a POTW with control points (and report section numbers)

At the POTW, the options are to treat PFAS in the liquid stream and/or in the sludge (although there are currently no PFAS treatment standards for POTW effluent or sludge). Section 3.1.1 discusses technologies that are showing promise for treating large volumes of relatively dilute streams (such as POTW effluent) for PFAS—granular activated carbon (GAC), ion exchange resin (IX), and some more novel approaches. Capital and operation and maintenance (O&M) costs for installing these technologies at a range of typical POTW sizes in Massachusetts are presented in Section 3.4.3. For instance, the capital cost estimates for installing a GAC system at 1 million gallon per day (mgd) ("small"), 5 mgd ("medium"), and 20 mgd ("large") POTWs are approximately $12M, $53M, and $150M, respectively, with an additional $0.4M, $2.6M, and $9.2M in annual O&M costs.

For sludge, Section 3.1.3 discusses how one mature technology showing promise for PFAS treatment of sludge (incineration) could be immediately used or retrofitted to reduce overall PFAS releases to the environment. Other demonstrated or emerging sludge treatment technologies (pyrolysis, gasification, supercritical water oxidation and others) that may provide effective PFAS treatment are discussed in Section 3.1.2. Capital and O&M costs for sludge PFAS treatment technologies are discussed in Section 3.4.4 along with costs for sludge volume reduction technologies such as dewatering centrifuges, anaerobic digestion and thermal dryers.

To contextualize these costs, they were compared to existing household water and sewer rates. Estimated annual costs to cover capital (i.e., debt service) and O&M costs for these technologies at various POTW sizes were divided by estimates of the number of households in a service area of that size ("Equivalent Residential Units") to approximate the cost per household. These values are shown

in Figure ES-2 as a percentage of the current median annual water and sewer bills paid by households in Massachusetts. The cost of implementing many of these technologies per ratepayer would be significant, particularly at smaller scale facilities. For instance, the annualized cost per ERU for the wastewater PFAS treatment technologies and for belt dryers at small POTWs would represent the equivalent of more than doubling existing water and sewer rates (>100% of existing rates) for those communities. But even at "Large" (20 mgd) POTWs, wastewater PFAS treatment technologies are estimated to be equivalent to a 40-60% increase in median water and sewer rates, sludge volume reduction technologies are a 10-25% increase, and sludge PFAS treatment technologies are a 20-30% increase. ("Incineration retrofit" is a special case not covering a full new installation but rather retrofitting an existing incinerator with technology for PFAS treatment.) If installation of these technologies is cost-prohibitive for smaller facilities, their sludge can be hauled to larger POTWs or regional facilities for processing; however, this option is not practical for wastewater liquid treatment. If smaller facilities are required to treat full-plant liquid flows for PFAS, this analysis suggests that it would not be feasible without significant increases in capital and O&M costs. See Section 3.5 for more details on these calculations, as well as similar comparisons to current POTW operating budgets and median household income.

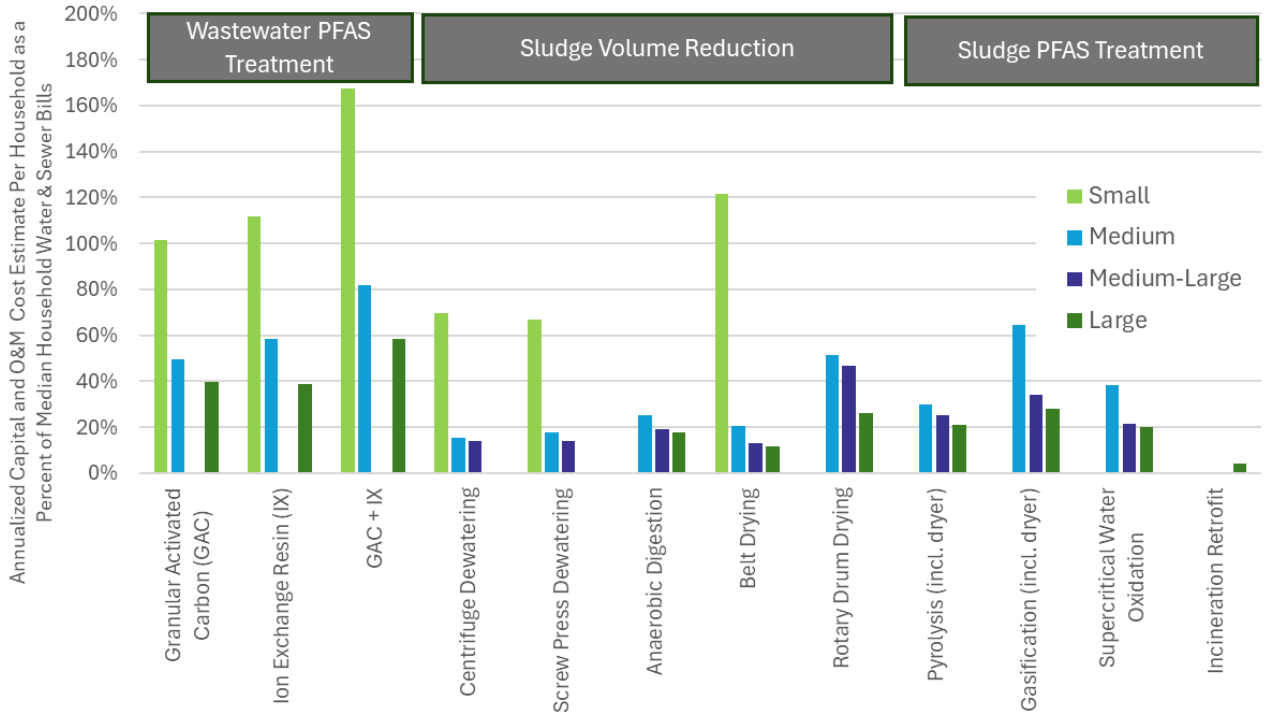


Figure ES-2. Estimated Annual Costs Per Household in the Service Area of Technology Implementation as a Percent of Current Median Annual Household Water and Sewer Bills

Note: Cost estimates were not developed at all POTW sizes for all technologies.
Small = 0.5 mgd; Medium = 5 mgd; Medium-Large = 10 mgd; Large = 20 mgd.

Sludge produced at a POTW could also be treated for PFAS at an offsite facility—either at another POTW with incinerators or newly installed PFAS treatment technology, or at a new regional PFAS treatment facility (such as a regional pyrolysis facility). Section 3.7 discusses the forms that regional facilities can take and considerations for planning and developing such facilities; Sections 6.2.2 and

6.3.5 suggest options that POTWs and regulators/legislators, respectively, may consider for supporting the development of such facilities.

Bills have been introduced in the Massachusetts legislature that would completely or severely restrict the ability to land apply sludge (biosolids) in the Commonwealth (Section 2.5.6). Part 1 of this study shows how fragile the sludge management landscape is even under current rules and regulations allowing land application. Section 5 of this report estimates the potential direct and indirect impacts and estimated costs of biosolids land application restrictions in Massachusetts at nearly $18.1M per year. This cost would be largely borne by the twenty primarily small- and medium-sized communities who currently rely on land application for their biosolids compost or dried material or smaller POTWs that send their sludge to such facilities, likely resulting in significant sewer rate increases. The Massachusetts Water Resources Authority (MWRA), the largest utility in the Commonwealth, does not exclusively land apply in Massachusetts, but would nevertheless be impacted by having to manage a portion of its biosolids further afield. Following the land application ban in Maine and related legislation, the price to manage sludge nearly doubled overnight for some facilities (Part 1 report, Tighe & Bond and Brown and Caldwell, 2024a]). A land application ban would also have climate impacts from increased hauling and by leading to additional tonnage likely being managed through landfilling and incineration, which were shown in Part 1 to release significant amounts of greenhouse gases (Tighe & Bond and Brown and Caldwell, 2024a Section 7.4). The alternative to a ban that many other states have pursued is setting regulatory limits for PFAS concentrations in sludge. Most states that have put in place PFAS limits for sludge (e.g., New York, Michigan, Maryland, Minnesota (draft)) have established a tiered system, whereby biosolids containing the highest levels of PFAS, which can indicate industrial impacts, are not allowed to be applied to the soil, requiring lower application rates or taking steps to reduce industrial impacts for biosolids containing lower levels, and biosolids with the lowest levels having no immediate additional restrictions. (See Section 2.5 for more details on the specifics of other states' regulations.) Massachusetts could develop a similarly tiered approach, which would increase protection of human health and the environment by prohibiting the land application of industrially impacted biosolids or sludge with higher PFAS concentrations, while avoiding the immediate disruption to POTWs and ratepayers of an outright ban. This approach could also allow for the continued benefits of land application (carbon sequestration, recycling nutrients, improving soil health) for sludge that is not impacted by PFAS. The tiered approach also encourages POTWs to work with industries and others in their sewershed to reduce the use of PFAS and clean up legacy contamination.

Table ES-3 provides an overview of this and other possible options for POTWs and for Massachusetts regulators and legislators. Concerns over PFAS can sometimes overshadow fundamental capacity issues that POTWs have been dealing with for decades. There is a basic supply and demand problem for sludge management in New England. New supply for sludge management (i.e., outlets) must be developed, and development of regional facilities should be strongly considered. POTWs can encourage the development of regional projects by considering committing future tonnage once the facility is operational (thereby providing project developers with more certainty about future income, which can help secure financing; see Section 6.2.2). Regulators can facilitate the development of regional facilities by clarifying the permitting procedures and requirements for various configurations of facilities (privately owned, located at a POTW, etc.) and by developing funding mechanisms (Section 6.3.4).

Demand for the available supply of sludge management capacity can be reduced by POTWs installing volume reduction technologies, such as dewatering, digestion and drying. Producing less sludge and sludge that is drier means paying less for unnecessarily hauling water and results in less traffic and fewer greenhouse gas emissions. Generally, the drier and more stable sludge is, the more outlets are available to manage its end use or disposal. For instance, landfills will not accept

thickened “liquid” sludge, and some may not even accept large amounts of dewatered sludge cake, but few have limitations on the amount of dried biosolids they would accept. It is important to note that this approach may be challenging for smaller POTWs (less than 1 mgd of flow, of which there are over 30 in the Commonwealth), for whom the cost of implementing such technologies may be prohibitive. For small POTWs, hauling liquid sludge to a larger nearby POTW or a new regional dewatering facility would likely be more realistic options.

The situation for managing sludge generated in Massachusetts and all states is challenging. POTWs, regulators and legislators will need to apply a range of interventions and develop and implement new approaches to reduce PFAS in wastewater and biosolids and to most cost-effectively expand environmentally preferable options for sludge management and disposal.

	Options (Report Section)	Potential Timeline (Years)	Potential to Increase Sludge Management Options	Potential to Reduce PFAS	Relative Cost	Comments
POTWs	Undertake Local PFAS Source Reduction through Industrial Pretreatment Programs (6.2.3)	0-2		(Low-Med-or High)		Efficacy depends on proportion of PFAS load from industry
POTWs	Consider Pilot Testing Promising PFAS Reduction Technologies (6.2.4)	2-5				Pilots can help determine the treatment performance of new technologies
POTWs	Reduce Sludge Volume (6.2.1)	2-5				Producing less sludge with more potential outlets reduces market risks
POTWs	Consider Commitments to Regional Facilities (6.2.2)	5-10		(Low or High)		PFAS reduction depends on technology
Legislature & Regulators	Limit Biosolids Land Application (6.3.2)	0-2				Can build off the tiered approach of most other states. Compliance could be costly for some POTWs.
Legislature & Regulators	Promote PFAS Treatment Technologies (6.3.3)	0-2				PFAS treatment technology systems typically greatly reduce sludge volume, as well
Legislature & Regulators	Implement PFAS Source Control Measures-Consumer Products & Manufacturing Processes (6.3.1)	2-5	(Low or Med)	(Med or High)		Office of Technical Assistance can assist industries
Legislature & Regulators	Support Volume Reduction and PFAS Treatment Projects (6.3.4)	2-5				Funding needed for full-scale and pilot installations; regulatory certainty needed for pilots
Legislature & Regulators	Promote Regional Facilities (6.3.5)	5-10		(Low or High)		PFAS reduction depends on technology; regulatory certainty and funding needed

KEY

Low Medium High

Figure ES- 3. Options for POTWs, Legislators and Regulators to Improve Sludge Management

Section 1

Introduction

1.1 Project Objectives

The Commonwealth of Massachusetts faces what has been called “a statewide crisis” for wastewater sludge management (Tighe & Bond and Brown and Caldwell, 2024a, Section 3.6). Wastewater utilities face pressure on all fronts when managing sludge and biosolids, necessary byproducts of the process of treating wastewater including diminishing landfill capacity, regional incinerator outages caused by aging infrastructure, and restrictions on land application of biosolids. In recent years, publicly owned treatment works (POTWs) have faced rapidly escalating sludge management costs and occasional temporary shutdowns of offsite sludge management outlets. Increasingly limited end-use and disposal options and solids carryover in treatment plants threaten water quality and permit compliance. In addition, there is better understanding – and increased concern – about the health, environmental, and financial impacts associated with per- and polyfluoroalkyl substances (PFAS), which are present in wastewater and wastewater sludge. In response, the Massachusetts Department of Environmental Protection (MassDEP) commissioned the PFAS and Residuals Technology and Management Study to help inform a sustainable path forward to ensure regulatory compliance, protect human health and the environment, and address the economic, technical, and logistical realities of sludge management. The combined Part 1 and Part 2 PFAS and Residuals Technology and Management Study has the following principal objectives:

1. Conduct a detailed assessment of sludge and septage management practices in POTWs across Massachusetts (Part 1 report, [Tighe & Bond and Brown and Caldwell, 2024a, b], Section 3).
2. Assess Current Sludge Management Practices
    - Landfill Disposal – Examine the capacity and long-term viability of in-state and out-of-state landfills for sludge and incineration ash disposal (Tighe & Bond and Brown and Caldwell, 2024a, Section 4).
    - Incineration – Investigate the current capacity, reliability, and long-term use of in-state and out-of-state incinerators handling Massachusetts sludge ([Tighe & Bond and Brown and Caldwell, 2024a], Section 6).
    - Land Application – Investigate the current capacity, reliability, and long-term use of in-state and out-of-state facilities producing biosolids from Massachusetts sludge for land application (Tighe & Bond and Brown and Caldwell, 2024a, Section 5).
3. Compile data on sludge and septage volumes and costs, and suggest adjustments to waste reporting for POTWs, addressing data gaps from previous studies.
4. Evaluate Technologies
    - Assess PFAS treatment methodologies for POTWs, including concentration, encapsulation, and treatment or reduction technologies for PFAS in leachate, sludge, and septage.

- Evaluate sludge volume reduction technologies, examine PFAS reduction methodologies for POTWs and MassDEP within the legal, regulatory and policy framework.

5. Propose options for short-term and long-term sludge management in Massachusetts, considering utilities of varying sizes.
6. Provide insights to assist POTWs and MassDEP in advancing sludge capital projects, as necessary.

Part 1 of the Study offers a comprehensive analysis of the current and near-term future sludge management landscape in Massachusetts and the region (Tighe & Bond and Brown and Caldwell, 2024a). This report comprises Part 2 of the Study and explores the impact of growing public concern over PFAS in wastewater on the already-stressed sludge management system and provides options for POTWs and regulatory and legislative considerations that could address sludge management capacity and PFAS challenges. While health and environmental impacts associated with the management of wastewater or sludge containing PFAS were a concern leading to the development of these studies, these impacts are not emphasized in these studies.

Note that throughout this report, "sludge" is used to describe any solid, semi-solid, or liquid by-product of the wastewater treatment process from POTWs. "Biosolids" is used to refer to sludge that has been treated to ensure that it can be applied to land as a fertilizer or soil amendment.

1.2 Background

There are 127 POTWs in Massachusetts that collectively treat up to 1,030 million gallons of wastewater on a typical day. POTWs employ physical, biological, and chemical processes to remove pollutants from the wastewater and discharge clean water to nearby groundwater, streams, rivers, or the ocean. All POTWs clean the liquid stream by removing organic matter, nutrients, and other compounds in the form of solids, referred to as sludge, before releasing the liquid flow back into the environment. Sludge is typically disposed of through landfilling or incineration or processed further to produce biosolids. Biosolids-derived soil amendments that meet strict reuse regulations (e.g., compost or dried pellets) sustainably return organic matter and other nutrients to the land. However, there is increasing concern about the potential for contamination by PFAS or other compounds of soil, groundwater, and surface water from land applied biosolids. At the time of writing, there are no wastewater effluent permit limits for PFAS.

The Study's Part 1 report documented that Massachusetts POTWs produced a total of 165,683 dry U.S. tons of sludge in 2023 (Tighe & Bond and Brown and Caldwell, 2024a, Section 3.2), of which 39% was further processed for land application, 37% was incinerated, 14% was disposed of at landfills or monofills, and 10% was managed by another method or its fate could not be determined (Tighe & Bond and Brown and Caldwell, 2024a, Section 3.4). A critical lack of local and regional sludge management outlets was apparent: 60% of this sludge was hauled an average of 96 miles offsite for end use or disposal (Tighe & Bond and Brown and Caldwell, 2024a, Section 3.3). Sludge production was estimated to increase to 172,200 dry U.S. tons by 2028 (Tighe & Bond and Brown and Caldwell, 2024a, Section 3.7). However, very little additional capacity could be identified either at existing facilities or at new facilities of any type within this timeframe, and some existing sludge outlets will no longer be available. Therefore, even without further disruptions, at least 11,826 dry tons of sludge (7%) will have no readily apparent reuse or disposal outlet by 2028 (Tighe & Bond and Brown and Caldwell, 2024a, Section 7.1).

Management of this complex network is decentralized, relying on a combination of municipal/public utilities and private companies that specialize in the management, disposal and/or reuse of

wastewater sludge. While there is some potential capacity for managing sludge outside of the northeastern U.S., further decentralizing the sludge management network will introduce transportation challenges (Tighe & Bond and Brown and Caldwell, 2024a, Section 7.3). Trucking or transporting sludge by rail over long distances requires additional operators, equipment, drivers, and is very costly. With increasing restrictions on sludge management throughout the region and beyond, Massachusetts POTWs will be competing for scarce capacity and resources with POTWs far beyond Massachusetts.

While the quantification of sludge production, reuse and disposal in Part 1 is limited to Massachusetts, that report demonstrates that the aforementioned network extends throughout New England, New York, Canada, and beyond. Disruptions in the multi-state reuse and disposal network have implications and ramifications in all of these states and neighboring Canadian Provinces (Tighe & Bond and Brown and Caldwell, 2024a, Section 7.2). These disruptions can be caused by many factors, including equipment failures at incinerators, reaching capacity at landfills, or changes to reuse regulations. Each disruption incrementally increases the complexity and cost of managing wastewater sludge.

In fact, in recent months and years, concerns for public health due to PFAS have led to major regulatory changes to biosolids reuse regulations in neighboring states (Maine and Connecticut), eliminating the ability to reuse biosolids on agricultural land in those states. This has stressed the sludge management network, in some cases to the point that POTWs have been unable to meet their permitted effluent discharge limits because of a lack of ability to remove sludge.

1.3 Scope of Work

This report, comprising Part 2 of the PFAS and Residuals Technology and Management Study assesses quantities of PFAS in wastewater influent, effluent and sludge, summarizes the regulatory landscape in New England and beyond, and explores controlling PFAS through both source reduction and treatment processes. The chapters that follow offer an analysis of factors contributing to PFAS contamination. However, effectively mitigating health, environmental, and financial risks associated with PFAS will likely include a combination of regulations, strategic source control, changes to current biosolids management practices to reflect risks and public concerns regarding land application, public awareness and action, and implementation of wastewater and/or sludge treatment.

Figure 1-1 depicts how PFAS are transported to and from POTWs. The diamonds represent points at which strategic interventions can reduce the amount of PFAS circulating in the environment, with references to the section numbers where each intervention is discussed in this report. PFAS can be conveyed to POTWs via sewers along with the wastewater from industrial (including landfill), commercial, institutional, and residential users, or hauled in as part of septage, landfill leachate, organics (such as fats, oils and grease (FOG) or food waste), or sludge from other POTWs. Section 4 of this study presents our analysis of available MassDEP PFAS monitoring data to develop an understanding of sources of PFAS to POTWs and their possible transport and transformation within POTWs. Section 3.1.1 discusses promising technologies for treating large volumes of relatively dilute streams (such as POTW effluent) for PFAS—granular activated carbon (GAC), ion exchange resin (IX), and some more novel approaches. Capital and operation and maintenance (O&M) costs for installing these technologies at a range of typical POTW sizes in Massachusetts are presented in Section 3.4.3. For sludge, Section 3.1.3 discusses how incineration, the most mature technology showing promise for PFAS treatment of sludge, could be used or retrofit to reduce PFAS. Emerging sludge treatment technologies (pyrolysis, gasification, supercritical water oxidation and others) are

discussed in Section 3.1.2. Capital and O&M costs for sludge PFAS treatment technologies are discussed in Section 3.4.4 along with costs for sludge volume reduction technologies such as dewatering centrifuges, anaerobic digesters and thermal dryers.

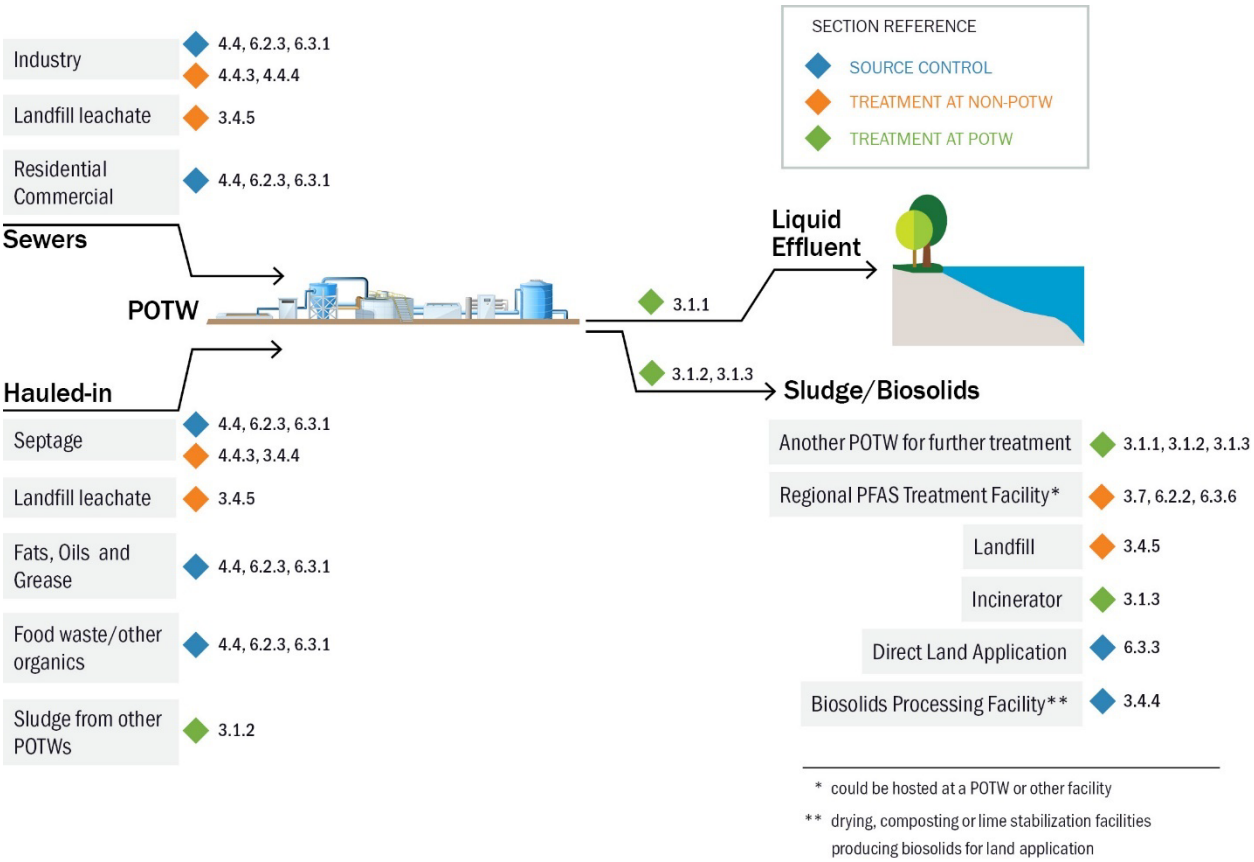


Figure 1-1. PFAS Flows into and out of A POTW With Control Points (And Report Section Numbers)

Section 2

PFAS Impacts on Sludge Management Methods

Recognizing the potential public health and environmental impacts of sludge management, Section 2 aims to identify regulations, legislation, public perception, and other factors relating to PFAS that are currently or assumed to impact sludge reuse or disposal methods in Massachusetts. As documented in Part 1 of this study, the available capacity for end use options such as biosolids recycling and sludge disposal in the region continues to decrease despite already approaching capacity (Tighe & Bond and Brown and Caldwell, 2024a, Section 7.1). Sludge management involves various wastewater industry representatives including landfill operators, incineration facilities, reuse companies, and POTWs. POTWs or private wastewater treatment plants (WWTPs) provide communities with wastewater treatment services and thereby represent all customers paying for sewer fees or having to pump their septic system since the pumped product (septage) is managed at POTWs. POTWs have to sustain their current operations while navigating the direct and indirect impacts of current and pending PFAS requirements, which compound and complicate existing treatment, management, and capacity issues. Since the sludge management outlets in the region are deeply interconnected, any changes affecting capacity or current reuse or disposal practices could lead to reverberating impacts affecting sludge management companies, POTWs, and, ultimately, ratepayers.

Since there are still many unknowns concerning PFAS, the goal of this study is to collect the available information to provide an understanding of how existing and pending regulations affect the current sludge management landscape to shed light on what wastewater and sludge management representatives in the industry currently face.

Section 2 focuses on identifying potential disruptions to the existing sludge management practices throughout Massachusetts and the broader region. These are identified and evaluated through interviews with wastewater industry representatives from POTWs, sludge management companies, and reuse and disposal outlets (Section 2.3); a review of existing and proposed legislation and regulation federally (2.5.4), in Massachusetts (2.5.5), other New England states (2.5.1), New York, and other jurisdictions (2.5.2); and a review of PFAS reduction approaches being implemented in other states (2.6).

2.1 Background

2.1.1 PFAS Background

PFAS comprise more than 12,000 chemical compounds used in the manufacturing of commercial and household products since the 1950s (ITRC, 2023a). As further described by the Interstate Technology & Regulatory Council (ITRC), PFAS have been used in a wide range of applications since their unique chemical and physical properties have the ability to impart practical uses into products such as a resistance to oil, water, heat, or stains. PFAS are sometimes categorized based on their chain lengths as a shorthand way to generalize among species that may behave similarly in the environment (OECD, 2013). For example, “long-chain” generally refers to PFCAs with eight or more

carbons or PFSAs with six or more carbons, while "short chain" generally refers to PFCAs with up to seven carbons and PFSAs with up to five carbons, as shown in Table 2-1.

Table 2-1. Short- and Long-Chain PFCAs and PFSAs[1]

# of Carbons	4	5	6	7	8	9	10	11	12
PFCAs	Short-chain PFCAs				Long-chain PFCAs				
	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
PFSAs	PFBS	PFPeS	PFHxS	PFHpS	PFOS	PFNS	PFDS	PFUnS	PFDoS
	Short-chain PFSAs		Long-chain PFSAs						

1. Table modified from: Interstate Technology & Regulatory Council. 2023b. PFAS Technical and Regulatory Guidance Document and Fact Sheets PFAS-1. Washington, D.C.: Interstate Technology & Regulatory Council, PFAS Team. https://pfas-1.itrcweb.org/2-2-chemistry-terminology-and-acronyms/.

Major sources of PFAS released into the environment include industrial wastewater discharges from facilities that use PFAS chemicals as part of the manufacturing process and through the use of certain firefighting foams, pharmaceuticals and pesticides. PFAS have also been found in commonly used household products such as food packaging, cosmetics, cookware, paints, apparel, and dental floss (ITRC, 2023a).

These materials can end up in landfills, POTWs, or municipal sewage sludge incinerators (Stoiber et al., 2020). Certain PFAS are very toxic, very stable and can persist in the human body and the environment for a very long time. Stoiber et al. (2020) illustrated how the existing disposal options for PFAS such as landfilling and incineration can pass the original PFAS or degraded PFAS products back into the environment creating a cyclical problem. For example, when materials containing PFAS are landfilled, some of the PFAS end up in the liquid landfill leachate. Landfill leachate is commonly sent to POTWs where PFAS end up in the wastewater effluent and sludge, some of which are sent back to the landfill. When biosolids are land applied, PFAS are also cycled back into the environment. The pathways for PFAS in the environment are numerous and interconnected, as shown in Figure 2-1.

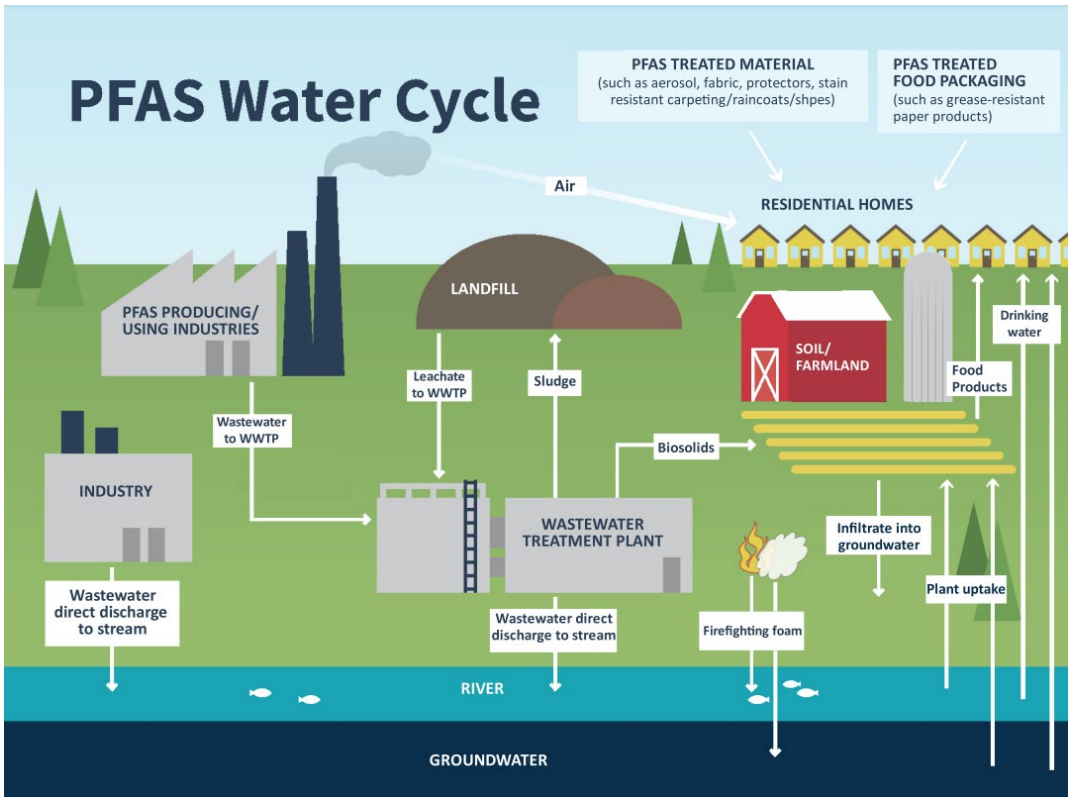


Figure 2-1. PFAS Water Cycle (EGLE, 2020b)

Scientific studies have found that exposure to PFAS is linked to harmful health effects in humans and animals (USEPA, 2016b) Biosolids are applied to 1.2% of the agricultural land in the country (Beecher et al., 2023) and may contribute to human exposures through a number of pathways, including the agricultural food chain, recreational fishing and hunting, and groundwater and surface water. Although the practice of land application is only used on a small percentage of agricultural land, it represents a significant outlet for biosolids, approximately 40% nationwide, and exceeds 50% with the addition of biosolids use in silviculture, land reclamation, and Class A pellets (Beecher et al., 2023).

The U.S. Environmental Protection Agency (USEPA) has recently published a draft risk assessment for perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) in biosolids (USEPA, 2025a), This draft assessment focused on PFOA and PFOS, a subset of PFAS that historically have been produced in the largest amounts in the U.S. (USEPA, 2017). Although USEPA states that the draft risk calculations are not conservative estimates, the assessment found that there may be human health risks exceeding the USEPA's acceptable thresholds for some modeled scenarios when land-applying sewage sludge that contains 1 part per billion (ppb) of PFOA or PFOS. The USEPA also found that there may be human health risks associated with drinking contaminated groundwater from near a surface disposal site when sewage sludge exceeds 1 ppb of PFOA or 5 ppb of PFOS. PFAS have been used in products since the 1950s, and they have gained increased public attention as toxicological assessments have increasingly pointed towards a range of health risks at low levels of exposures (MassDEP, 2019; USEPA, 2025b) and as analytical methods to detect certain PFAS at very low concentrations have become more accessible (ITRC, 2023b). This has led to a growing list of consumer products, as well as the food and water supply, to be identified as containing PFAS. In 2016, high levels of PFAS, specifically PFOS, were found in milk from multiple dairy farms in Maine and led to statewide testing and monitoring for PFAS (Brown and Caldwell, 2023). Results from the

investigation showed a “link between the land application of municipal and industrial sludge and agricultural impacts from PFAS” (Brown and Caldwell, 2023) and in 2022, the land application of municipal and industrial sludge was banned.

Major manufacturers of PFOS and PFOA-related chemicals in the U.S. voluntarily phased out their production by 2002 and 2015, respectively (USEPA, 2017), however, these chemicals remain in the environment. Several states, including Vermont and Michigan, are working to reduce or eliminate the manufacturing of PFAS in commercial products and industrial uses (see Section 2.6.1 for more details). In April 2024, Congress introduced H.R. 8074 to “phase out production of nonessential uses of perfluoroalkyl or polyfluoroalkyl substances, to prohibit the releases of all perfluoroalkyl or polyfluoroalkyl substances, and for other purposes” in ten years (Congress.gov, 2024). PFAS limits, including health-based regulatory thresholds, have been established by federal, state, and international authorities in recent years amid growing concerns regarding PFAS (Hughes, 2023a). As summarized by the Environmental Council of States (ECOS), prior to 2024, the U.S. did not have federally enforceable PFAS standards, leaving states to address PFAS concerns on their own. To fill this vacuum, some states established legally enforceable values for certain PFAS in drinking water, groundwater, surface water, air, or soil while other states have adopted non-enforceable levels such as guidance levels, screening numbers, or health advisories (Hughes, 2023a). Massachusetts adopted standards for six PFAS, including PFOS and PFOA, at hazardous waste sites and in drinking water in 2019 and 2020. The Massachusetts drinking water standard is 20 ppt for the sum of the six regulated PFAS, including PFOS and PFOA.

In 2024, USEPA issued national drinking water standards for several PFAS. The lowest standards were for PFOS and PFOA at 4 ng/L (parts per trillion). These standards are currently scheduled to take effect over the next few years. Across the globe, other countries have also taken action to mitigate risks to PFAS exposure. Denmark, Germany, the Netherlands, Sweden, and Norway proposed to phase out and prohibit the production and use of PFAS in July 2021 (Zhou et al., 2024). Most regulations limit PFAS in soil, however, some countries have also set restrictions specifically for PFAS in sludge and biosolids. Zhou et al. (2024) highlighted the varying permissible PFAS concentrations among different countries. For example, the limit for PFOA in sewage sludge disposal is 46 ug/kg in the United Kingdom (Seow, 2013). In Germany and Austria, biosolids can be land applied when the sum of PFOA and PFOS is below 100 ug/kg (European Commission Directorate-General for Environment et al., 2011). In Australia, limits for PFOA are 1 ug/kg and 2 ug/kg for the sum of PFOS and PFHxS in biosolids (Queensland Government, 2024). Australia’s PFAS limits are documented in their Biosolids End of Waste Code and includes additional PFAS limits for specific PFAS mixtures (Queensland Government, 2024). PFAS regulations in Canada are further described in Section 2.5.3.

2.1.2 Sludge Management in New England

The National Biosolids Data Project (NBDP) led by a team of representatives from the North East Biosolids & Residuals Association (NEBRA), Water Environment Federation (WEF), BioCycle, California Association of Sanitation Agencies, and the Mid-Atlantic Biosolids Association compiled and published 2018 data on biosolids management in the U.S. Figure 2-2 and Figure 2-3 show a summary of state specific charts developed as part of the NBDP and provides an overview of biosolids use and disposal practices in New England and New York. The NBDP study was based on a Mass Sludge Survey conducted by NEBRA for the MA Clean Energy Center. The study highlighted that the State of Massachusetts has a relatively small land area with a dense population in its eastern half and more open space and agricultural land in its western half. Data for Massachusetts have since been updated and can be found in Part 1 of this study (Tighe & Bond and Brown and Caldwell, 2024a, Section 3). The data from NBDP are included here to provide an overview and visual

representation of sludge disposal and recycling conducted in New England and New York, however, are based on data collected from 2018. Refer to Part 1 of this study for updated information on sludge management in Massachusetts.

A separate survey conducted in September 2022 by NEIWPCC (formerly the New England Interstate Water Pollution Control Commission) a not-for-profit interstate agency, released the Northeast Regional End-Use and Disposal Estimate, which summarizes survey results from seven member states located in New England and New York (NEIWPCC, September 2022). The report highlighted deficiencies in wastewater sludge treatment, storage, transportation, end-use options, and the need for additional sludge management capacity. As shown in Figure 2-3, the region relies on incineration, land application, and landfill disposal. Aging incinerators and reduced landfill capacity pose a significant concern of sustainable long term sludge disposal options within Massachusetts and the Northeast.

Additionally, the presence of PFAS compounds in wastewater sludge has led to concerns about how the manner in which it is managed has the potential to adversely impact public health or the environment. These concerns have led to legislation and regulations in some states (e.g., Connecticut and Maine) banning land application, forcing POTWs to rapidly identify and utilize alternative reuse and disposal outlets, often at costs as much as 100% higher than they had been experiencing largely due to having to transport sludge to farther distances and higher tip fees at alternative outlets.

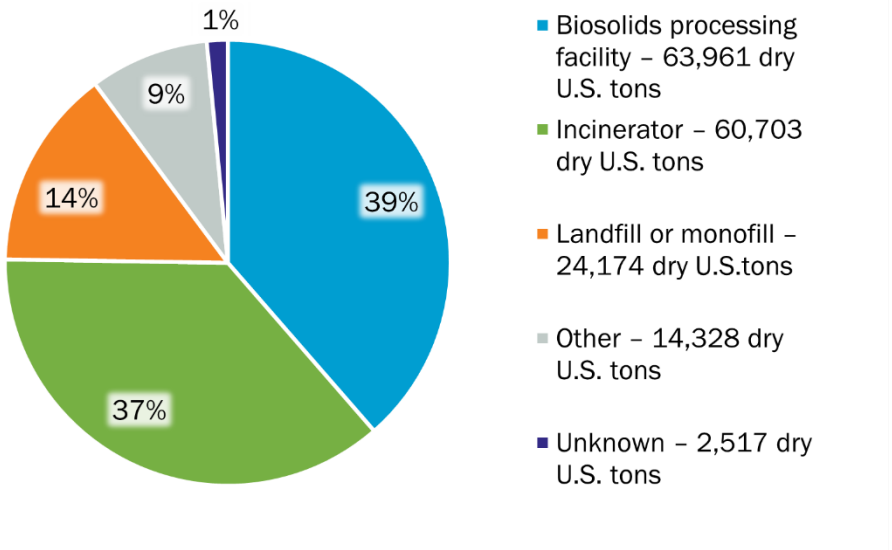


Figure 2-2. Massachusetts sludge (dry U.S. tons) summarized by management method in 2023 from Part 1 Figure 3-12a (Tighe & Bond and Brown and Caldwell, 2024a)

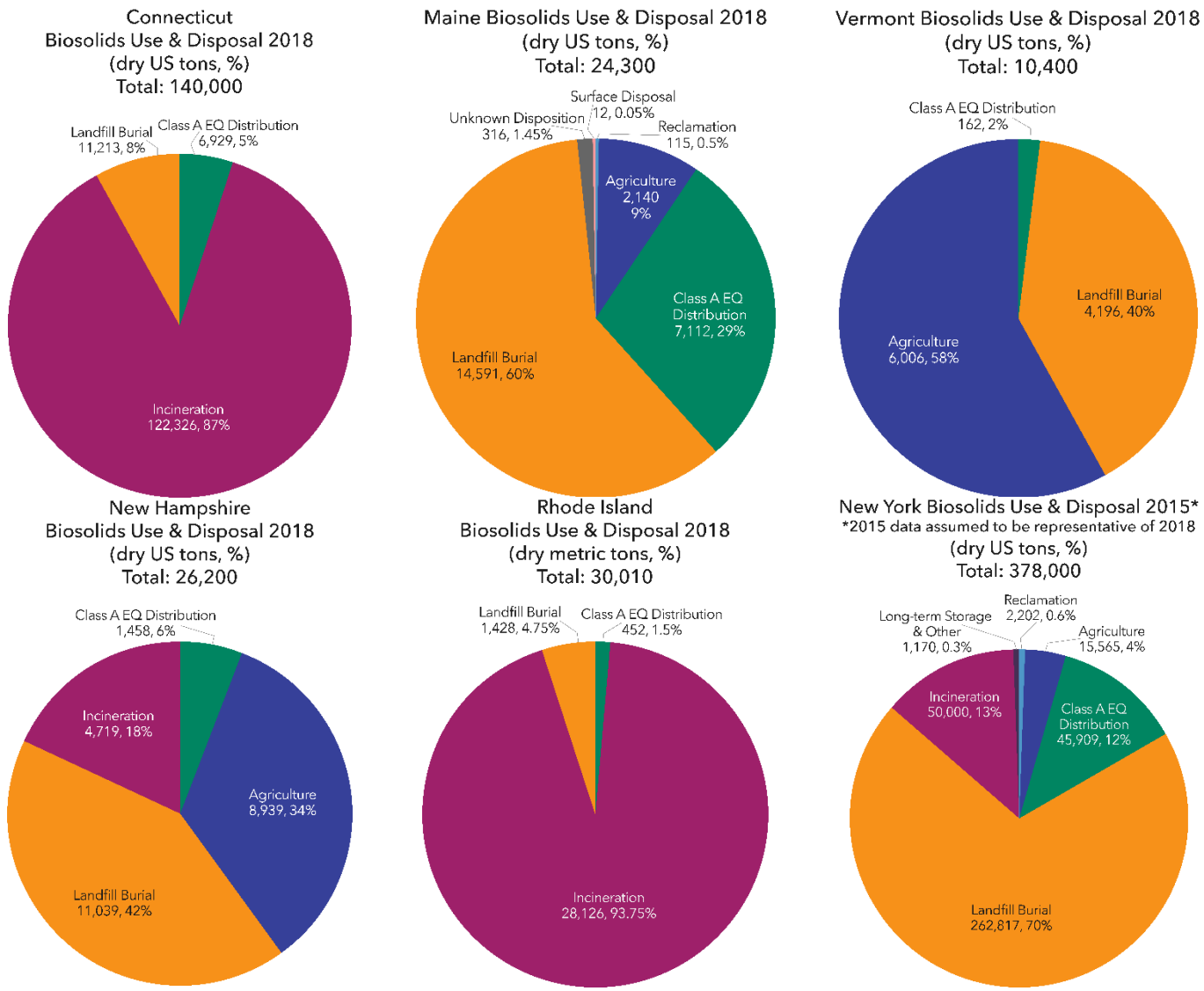


Figure 2-3. National Biosolids Data Project Charts for Other New England States and New York, 2018 (Beecher et al., 2024)

2.2 Identification of PFAS-Related Sludge Management Issues

Section 2.2 investigates the three sludge management strategies utilized in the region and describes existing conditions in Massachusetts, current capacity concerns, and impacts due to the presence of PFAS.

2.2.1 Landfilling

Landfill disposal has been used in the U.S. for many years to manage the disposal of solid waste in general, preventing disease transmission and maintaining clean communities. However, the public can often have concerns about environmental and social impacts including where landfills are built, odors, emissions such as methane and carbon dioxide, truck traffic, and leachate. With pending federal regulations related to PFAS, landfills are coming under increased scrutiny for PFAS in leachate. As a result, there are concerns that landfills could become more reluctant to accept materials such as wastewater sludge, PFAS treatment residuals (spent adsorption media), or other wastes that are known to contain PFAS.

Capacity Concerns

As discussed in Part 1 of this study, landfill capacity in the region is expected to trend downward over the next ten years due to space limitations and facility closures. Approximately 14% of sludge, corresponding to a mass of 21,800 dry U.S. tons, from Massachusetts POTWs is disposed of in seven municipal or sludge landfills within the state, while the majority of landfilled sludge is transported to Maine, New Hampshire, Vermont, and New York (Tighe & Bond and Brown and Caldwell, 2024a, Section 4.4). Although some facilities in Massachusetts reported having more than ten years of capacity in Part 1, some of these facilities are known to only serve a local POTW (Tighe & Bond and Brown and Caldwell, 2024a, Section 4.4).

While some landfill facilities reviewed in Part 1 (Section 4.4) reported the possibility for expansion, opportunities for expansion can take time and resources, especially if additional requirements need to be met. It took nearly seven years to expand a landfill in Maine from application to construction (Brown and Caldwell, 2023). In Massachusetts, the City of Gardner filed an application to expand the City's landfill in 2022, however, the project had been placed on hold due to potential wetland concerns raised by local environmental groups (NEBRA, 2023).

As restrictions are placed on other end use options in the region, such as a ban on biosolids land application due to the presence of PFAS, this further exacerbates the already rapidly decreasing landfill disposal capacity in the region as sludge that was previously land applied would likely have to be disposed of in a landfill or incinerated.

Landfill Stabilization Needs for Dewatered Wastewater Sludge

Dewatered wastewater sludge typically contains 70-80% water which usually cannot be landfilled in bulk on its own because it will not support the weight of compacting equipment. It also tends to stick to compactor wheels. Therefore, wastewater sludge is typically blended with other materials (bulking agents), compacted, and then covered.

As summarized in the Maine DEP biosolids study conducted by Brown and Caldwell (2023), in 2023, a law went into effect in Maine which limited the amount of waste coming from out-of-state and required at least 50% of the waste be recycled (versus landfilled). This impacted the state-owned Juniper Ridge Landfill (JRL) since there was an insufficient supply of bulking agents and with the influx of biosolids due to the land application ban, JRL had to turn away trucks with biosolids. Onsite storage at POTWs quickly filled up and POTWs were at risk of not meeting their wastewater discharge

permits (Brown and Caldwell, 2023). Onsite storage capacity at POTWs is short, measured in days and not in months.

PFAS Concerns for Landfill Disposal

This subsection highlights key concerns with PFAS contamination in landfills and describes some of the impacts the industry is dealing with based on literature reviews, publicly available information, and discussions gathered during wastewater industry representative interviews. Many of the concerns discussed below are not directly related to PFAS, but are concerns caused by PFAS impacts on other parts of the reuse and disposal market that result in a higher demand for landfill space.

Key Concerns with PFAS Contamination in Landfills

- Leachate Contamination: PFAS can leach out of landfills into groundwater, leading to contamination if a liner is damaged. Since PFAS are found in many commercial and household products, it can make its way to landfills when disposed of as solid waste. The National Waste & Recycling Association (NWRA) and Solid Waste Association of North America (SWANA) highlighted varying concentrations of PFAS in landfill leachate dependent on the types of waste disposed and climate. NWRA and SWANA reported "total median PFAS concentrations in U.S. leachate is 5,776 parts per trillion (ppt) with PFOA and PFOS combined representing 836 ppt" (NWRA & SWANA, 2020). A Vermont Department of Conservation (VT DEC) study conducted by Weston & Sampson measured 8 leachate samples from 4 landfills and found "average individual PFAS concentrations from none detected (< 100 ppt) to nearly 3,000 ppt" (Weston & Sampson, 2020).
- Soil and Water Contamination: Once PFAS contaminants enter groundwater, they can spread to soil and surface water, potentially affecting drinking water supplies and ecosystems. A landfill may not be able to restrict the flow of a 100-year flood event and result in leachate. Rainfall runoff from an active landfill may carry contaminants to nearby surface waters.
- Persistence and Mobility: Since PFAS are highly stable and can persist in the environment for decades, their mobility in water means they can travel long distances from their sources, complicating cleanup efforts if leachate contamination were to occur.

Impact on Landfill Gas Emissions

The decomposition of organic matter in municipal solid waste landfills can result in air emissions, primarily composed of methane and carbon dioxide. Some studies have also found PFAS, specifically those that more readily volatize (fluorotelomer alcohols), in the air above landfills. Emissions released can travel and affect near and remote communities. Landfill gas can be collected to generate power, however, any emissions not captured could release PFAS into the air.

Pretreatment of Leachate

Landfill facilities are currently not federally required to pretreat leachate prior to sending it to POTWs. However, POTWs may refuse to accept leachate if contaminated with PFAS or require pretreatment of leachate before it is discharged to the sewer.

2.2.2 Land Application

EPA's Standards for the Use or Disposal of Sewage Sludge Rule (40 CFR Part 503) defines two types of biosolids with respect to pathogen reduction: Class A and Class B. While both types are suitable for land application, Class A requires a higher level of pathogen reduction and can be used with fewer restrictions. Class A biosolids can be applied to crops for direct human consumption with no delay before planting or utilized in commercial settings such as landscaping and gardens. Class B biosolids can also be used on crops, including those for human consumption, but the 503 mandates waiting periods, which, depending on the type of crop, can range from 30 days to 38 months. Thus,

many types of crops are not grown with Class B biosolids due to the impracticality of these waiting periods. In addition to the waiting periods, the EPA enforces protective measures for the land application of Class B biosolids that include buffer distances and restricting public access to the application site.

Massachusetts 310 CMR 32.05 regulates the land application of stabilized sludge, "biosolids," on agricultural fields or in other applications, which provides nutrients, organic matter, moisture, and in certain cases, lime, which all support the growth of plants. Stabilization is required prior to land application to reduce pathogens, reduce vector attraction potential, and help minimize odor generation. There are several methods to produce biosolids by stabilizing wastewater sludge, including:

- Adjustment of pH, or alkaline stabilization
- Digestion
- Composting
- Heat drying

Massachusetts land application regulations for stabilized sludge are intended to allow land application in a manner that will protect public health and the environment from possible contamination which could occur from pathogens, metals, or toxic chemical compounds. Biosolids in Massachusetts are classified as follows:

- Type 1: may be used, sold, or distributed or offered for use, sale, or distribution on any site without further approval of the MassDEP, and which may be used for growing any vegetation.
- Type 2: may be used, sold, or distributed or offered for use, sale, or distribution on a site only with prior approval of the MassDEP, and which may be used for growing any vegetation.
- Type 3: may be used, sold, or distributed or offered for use, sale, or distribution for land application on a site only with prior approval of the MassDEP, which may be used for growing any vegetation not including direct food chain crops, and whose land application to a site must be recorded in the registry of deeds in the chain of title for such site.

An Approval of Suitability (AOS) is currently required from MassDEP prior to use, sale, or distribution of biosolids in Massachusetts. All Massachusetts biosolids used for land application are Type 1 except for biosolids from Erving, Massachusetts, which are from a paper mill and considered Type 2. Sludge from the Town of Erving's Wastewater Department is transported to Canada (Tighe & Bond and Brown and Caldwell, 2024a, Section 3.4).

Land application of biosolids in Massachusetts and the region can be challenging. Connecticut recently became the second state (after Maine) to ban land application, while other states such as Michigan (further described in Sections 2.5.2 and 2.6) have adopted a different approach, implementing PFAS screening limits for the land application of biosolids. Recently, legislation was proposed in Massachusetts to ban the use of biosolids, however, it did not go to the floor for a vote in the 2024 legislative session.

Existing Conditions

In Massachusetts, biosolids can be land applied as Class A or Class B cake and categorized as Type 1, 2, or 3 as previously described depending on pollutant concentrations. Biosolids processing facilities currently manage 39% of Massachusetts sludge (Tighe & Bond and Brown and Caldwell, 2024a, Section 5). There are currently eight facilities in Massachusetts that provide advanced processing of biosolids suitable for land application, two of which thermally dry biosolids.

As identified in Part 1, Massachusetts biosolids were applied in 13 states plus Canada in 2023 (Tighe & Bond and Brown and Caldwell, 2024a, Section 5.3). New York, Massachusetts, and Canada received the most biosolids from Massachusetts, and all New England states except for Maine (which has a ban on land application of sludge) received Massachusetts biosolids. Connecticut passed the second sludge land application ban in the country in June 2024 and sludge and can no longer be distributed in Connecticut for land application.

As identified in Part 1 and shown in Figure 2-4, Massachusetts biosolids were applied in 13 states plus Canada in 2023 (Tighe & Bond and Brown and Caldwell, 2024a, Section 5.3). New York, Massachusetts, and Canada.

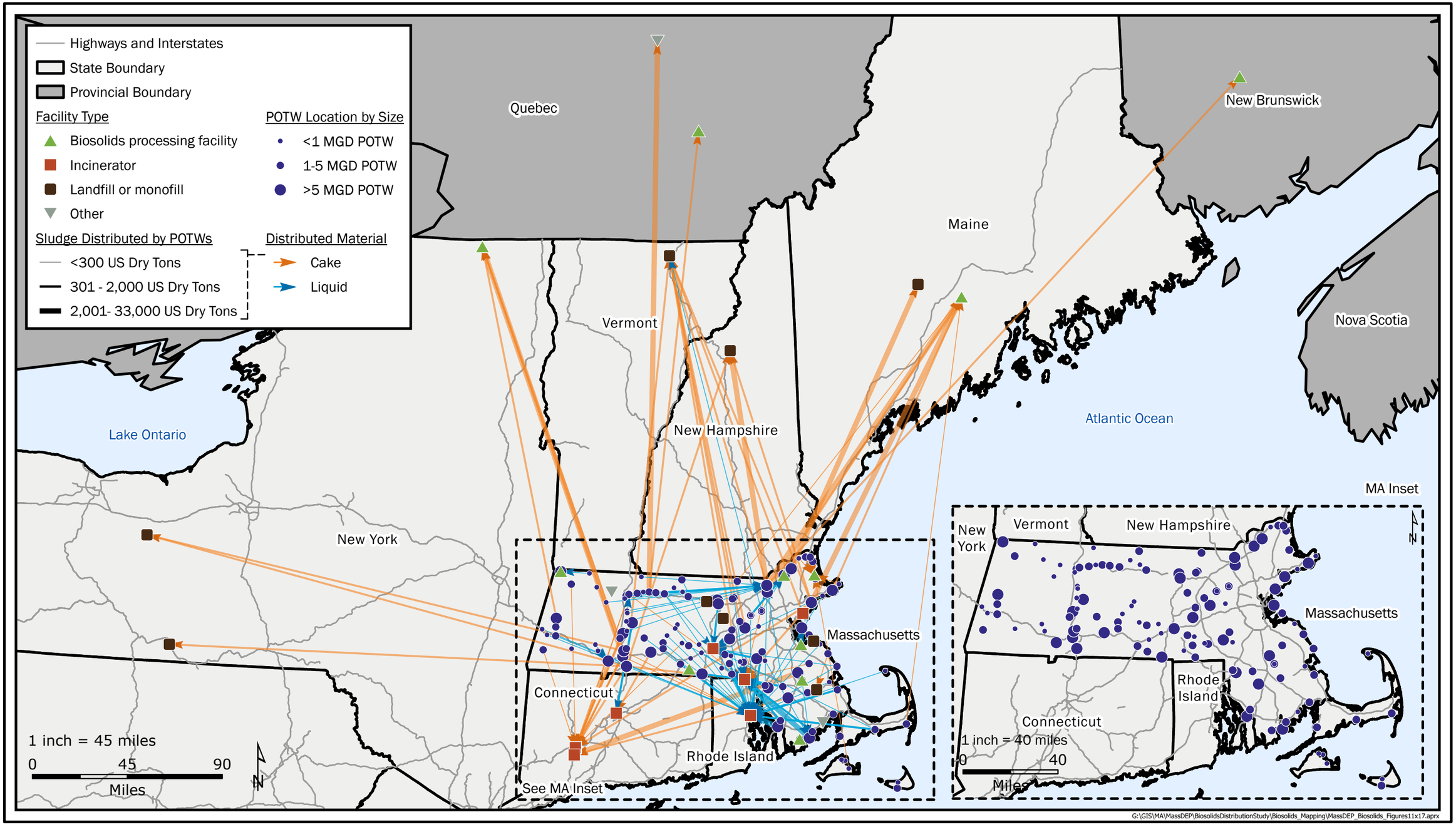


Figure 2-4. Destinations for Wastewater Sludge Produced in Massachusetts

Capacity

There is limited capacity for additional sludge to be processed for land application in Massachusetts. As described in Part 1, the MWRA Deer Island Treatment Plant and the Greater Lawrence Sanitary District (GLSD) facility have anaerobic digesters and heat drying to process biosolids and have sludge capacities of 102,492 and 8,049 dry U.S. tons/year, respectively (Tighe & Bond and Brown and Caldwell, 2024a, Section 5.5). Even though both facilities reported having additional capacity, this is reserved for their respective communities. Only one composting facility in Massachusetts (Hoosac Water Quality District [WQD]) reported having some available capacity for other POTWs. Any potential future upgrades and/or expansion may be contingent on increased regulatory certainty. The City of Fitchburg in Massachusetts is "currently pursuing a vendor for possible anaerobic digestion with gasification for the West Fitchburg WWTP" (Tighe & Bond and Brown and Caldwell, 2024a, Section 3.2).

As previously described, any restrictions placed on any of the disposal and recycling options impact the overall market and in turn, may affect another end-use option. Additional states looking to ban land application would force these biosolids to seek another outlet. This issue is further compounded by seasonal restrictions and the lack of agricultural land available for application.

PFAS-Specific Concerns for Land Application

Key Concerns with PFAS in Land Applied Biosolids

The following concerns are presented in the context of land application of biosolids and do not consider other materials such as commercial compost and fertilizer that are routinely added to soil for nutrient value or for organic content, which may also contain some PFAS, although, depending on the specific feedstocks used, likely at lower levels (MA EEA OTA, 2022; Lee, 2019; Choi et al., 2019; McBurnie, 2022; Portland Water District, 2020; NEBRA, 2022). Other sources of PFAS on farms are also not addressed in this assessment. These may include a range of PFAS sources that can impact any property. Examples include: atmospheric deposition of PFAS attributable to off-site sources such as certain upwind industrial facilities; ground or surface water used for irrigation or drinking water contaminated with PFAS from offsite sources, for example, attributable to AFFF use and some industrial and other waste sites; and historical use of biosolids, other residuals and PFAS-containing products on site (McBurnie, 2022; NEBRA, 2022).

Contamination of Soil and Water:

- Soil Contamination: When biosolids or other soil amendments containing PFAS are applied to soil, these chemicals can accumulate in the soil matrix. Contamination of agricultural and other soils, associated with applications of soil amendments including biosolids, has been noted, although the precise contribution of biosolids is typically uncertain due to the application of mixed residuals.
- Water Contamination: PFAS can leach from soils or applied materials into groundwater or run off into surface water, potentially contaminating drinking water sources and aquatic ecosystems. Contamination of groundwater associated with applications of soil amendments including biosolids, has been reported, although the precise contribution of biosolids is typically uncertain. Environmental fate and transport modeling also indicates that PFAS in land applied biosolids can contaminate groundwater to levels exceeding health criteria (USEPA, 2025a).

As some PFAS are semi-volatile, depending on the PFAS present and environmental conditions, some PFAS air dispersion may occur following land application. Wind-dispersed particulates may also mobilize PFAS from soils.

Plant Uptake and Bioaccumulation:

- Plant Uptake: There is a concern that PFAS in biosolids and other soil amendments might be taken up by crops, with documented cases of the accumulation of these substances in food crops. It should be noted that a small fraction of sludge is used on food crops, representing far less than 1% of all food grown in the U.S. A larger portion of biosolids is used for other row crops, on pastureland, in forestry or for purposes such as lawncare and landscaping. All of these other uses can result in exposures to wildlife, including fish and game consumed by people, surface water and groundwater.
- Bioaccumulation: PFAS can accumulate in plants from PFAS in biosolids and other soil amendments, potentially posing risks to wildlife and human health (Simones et al., 2024).

Litigation on PFAS in Biosolids

In February 2024, the Public Employees for Environmental Responsibility (PEER) filed a notice of intent to sue the USEPA in violation of the Clean Water Act (PEER, 2024). PEER, on behalf of impacted individuals, is accusing the USEPA of neglecting its obligation to regulate PFAS in biosolids fertilizers. PEER points out that the USEPA identified more than 250 pollutants present in biosolids but has only promulgated limits on nine compounds in sewage sludge for land application and that the agency failed to list at least 18 PFAS known to be present in biosolids in its biennial report. PEER also helped facilitate a criminal investigation and legal action against a biosolids manufacturer, in which a group of farmers in Johnson County, Texas are claiming damages from using biosolids containing high levels of PFAS for land application (NEBRA, 2024a) showing that land application lawsuits do occur.

2.2.3 Incineration

POTWs located throughout southern New England primarily rely on incineration for sludge management (NEBRA, 2011). There are two incineration technologies used in this region: fluidized bed incineration and multiple hearth incineration. Incineration of wastewater sludge involves drying the sludge by raising the temperature to evaporate water followed by combustion to remove the volatile solids and convert the remaining material into inert ash. Ash generated from the incineration process is typically landfilled. Some facilities use the ash as alternative daily cover at landfills, in road construction, or as a filler in cement and brick manufacturing (USEPA Office of Water, 2003) (Incineration is very effective at volume reduction but requires relatively high energy usage and likely generates significant amounts of greenhouse gases (GHGs).

Existing Conditions

As of 2024, 37% of sludge from Massachusetts POTWs is incinerated (Tighe & Bond and Brown and Caldwell, 2024a, Section 3.4). There are 14 municipal wastewater facilities that incinerate sludge in New England and New York, including two in-state and 12 out-of-state facilities listed in Part 1 (Tighe & Bond and Brown and Caldwell, 2024a, Section 6.2).

In 2024, Woonsocket, Rhode Island passed local ordinances that restricted use of its regional sludge incinerator by phasing out the acceptance of liquid sludge to the facility by the end of 2026, reportedly, at least in part, to reduce truck traffic within the community thereby reducing the amount of liquid sludge management capacity in the region. We are unaware of how the phase-out is being implemented by the contract operator. As identified in Part 1, this potentially impacts 31 Massachusetts POTWs that send sludge to the Woonsocket, RI incinerator. These POTWS would likely need to either identify alternative liquid sludge outlets or utilize dewatering equipment to be able to manage cake still accepted by the Woonsocket, RI facility (Tighe & Bond and Brown and Caldwell, 2024a, Section 3.3).

Capacity

Most of the facilities operating in New England and New York surveyed in Part 1 reported having no additional capacity for incineration (Tighe & Bond and Brown and Caldwell, 2024a, Section 6.3). Three utilities (Waterbury, New Haven, and Lynn) will be undergoing upgrades within the next 5-10 years which will increase the remaining life; however, they will not increase the existing capacity. The increase in Massachusetts sludge generation during this period cannot be managed by the existing incineration facilities in the region. Meanwhile, Upper Blackstone Clean Water is evaluating alternatives to transition from onsite incineration of their sludge to another sludge management technology.

Another aspect of capacity relates to an incinerator's throughput, which is partially dependent on the ability to evaporate water prior to combusting the organic content of the sludge. Incinerators that accept dewatered cake rely on the dewatered sludge to be at around 20% solids content or more to meet their normal throughput. If cake from one facility arrives at a lower solids content, the throughput of the incinerator could be reduced, and the acceptance of sludge being delivered from other facilities could be delayed, resulting in delivery trucks sitting idle at an incineration facility while waiting for an opportunity to unload.

Reliability Concerns

The number of years incinerators in this region have been operating vary, with the two of the oldest incinerators surveyed (in Albany County, New York) coming online in the 1970s. Based on survey responses collected in Part 1, the estimated remaining life expectancy of the incinerator facilities surveyed in Part 1 range from one year to 30 years, wherein continued use is dependent on planned repairs (Tighe & Bond and Brown and Caldwell, 2024a, Section 6.3). Respondents shared that most incinerators are operating in good condition, with some recently upgraded, while others have reported (especially for those installed in the 1970s) needing repairs. Responses to the type of repairs include upgrades needed to maintain compliance with 40 CFR Part 60 Subpart MMMM which establishes federal air quality requirements for SSI units (USEPA, 2011). As with all mechanical equipment, the service life of various components is limited and each incinerator train must be periodically shut down for maintenance and replacement of worn parts.

Unplanned outages when equipment unexpectedly fails are more disruptive and force rapid adjustments in the sludge management marketplace as operators shift sludge from one incinerator to another. Survey respondents from Part 1 reported having an average downtime of 3 to 208 days a year. A wastewater sludge incinerator operator interviewed, as discussed in Section 2.3, indicated that because of these types of issues, nearly every day requires active management of sludge from which POTW is going to which facility within New England. Out of necessity, competitors in the sludge management market routinely must help one another out with handling sludge.

PFAS-Specific Concerns

Incineration has been identified as a potential method for disposing of PFAS compounds in sewage sludge and other materials. The research into the fate and transport of PFAS in SSIs at different operating conditions—temperature, residence time and turbulence—is on-going.

Key Concerns with PFAS with Incineration

The following are concerns with incinerating sludge containing PFAS:

- **Byproducts**:
  - Decomposition Products: PFAS may decompose during incineration into other compounds, fluorinated or otherwise. More research is required to determine what may form and whether it poses toxicity or environmental concerns, building off of a USEPA (2023) pilot-

scale study on aqueous film forming foam and a study on sewage sludge incinerators by Winchell et al. (2024).

- **Air Emissions**:
  - Emission Control: Effective air pollution control systems, such as scrubbers, filters, and catalytic converters, are necessary to capture and treat gases and particulates that might contain PFAS or their byproducts. Based on the literature review, studies have found that existing incinerators achieve a high level of removal, but some PFAS can escape (Winchell et al., 2024). Inadequate control can lead to environmental and health risks.
  - Health Risks: The release of PFAS or their byproducts into the atmosphere may pose risks to human health, particularly if exposure occurs over long periods or in high concentrations. Additional research is needed to better document emissions.
- **Ash Residue**:
  - Contamination of Ash: Incineration produces ash that may contain PFAS. Additional research is required to better understand the PFAS content of ash and, if present at concerning levels, develop management programs to prevent leaching and contamination of soil and groundwater associated with ash disposal.
- **Energy and Cost Considerations**:
  - Energy Requirements: Incinerating sludge can use significant energy compared to other traditional solids processing technologies, which can have environmental and economic implications. Increased temperatures, residence time at temperature, or other changes may be necessary to increase PFAS treatment.
  - Cost: The cost of advanced incineration technologies and pollution control systems can be high, impacting the overall expense of managing sludge as additional constituents must be monitored and tested. Strict air limits and monitoring requirements for PFAS could decrease the existing incineration capacity in the region if the cost to upgrade some of these facilities is too high for utilities to afford.

2.3 Wastewater Industry Representative Interviews

Key wastewater industry representatives specifically representing biosolids management companies, landfill operators, incineration facilities, and wastewater industry groups were invited to participate in one-hour, virtual interviews to understand their perspectives on how current and pending PFAS regulations have or could impact their current operations. These wastewater industry representatives either process, haul, dispose of and/or recycle sludge in the region and were asked to share past, current, and anticipated challenges regarding PFAS. In addition, regulators from states actively managing PFAS were asked to share what they have learned from strategies being implemented in their respective states to potentially share practices that could be implemented elsewhere. Nine out of the ten proposed wastewater industry representatives agreed to participate. Information gathered from the interviews and industry perspectives are summarized in this section. A list of sample questions used to drive the conversation is included in Appendix A.

Common themes heard from multiple wastewater industry representatives include:

- The need to set reasonable PFAS standards using the best available data and science versus implementing an outright land application ban.
- Shared concerns if pending PFAS regulations become too onerous, it may significantly alter how companies do business and, in some cases, put them out of business. Some facilities have also deferred or altered existing plans for capital improvement upgrades due to regulatory uncertainty.

- PFAS will continue to persist in the environment unless they are removed from production/manufactured products that are commonly used throughout society.
- PFAS measured in biosolids are typically below levels of concern. A long-term solution that addresses potential risks through scientifically derived application limits across all classes of products that are used as soil amendments are needed.
- Some existing regulatory programs and studies in other states have shown positive results. For example, data from Michigan shows PFAS levels decreasing for what is being land applied under an interim strategy and as the result of source control and industrial pretreatment programs (IPPs).
- There is no additional capacity for sludge management in the region. If limitations are placed on any of the current sludge management strategies, this will further decrease the existing capacity in the region and pose significantly increased costs as sludge is hauled farther distances.
- Improvements made to the sludge quality, such as drying, can help decrease the sludge volume and improve sludge management company/utility's operations to minimize equipment downtime.
- As additional constituents are added to permit requirements, testing, monitoring, and treatment needs may differ for the different constituents and could end up being costly for facilities already funding capital improvements to sustain normal operations.

These impacts, including other potential concerns, are further discussed in the following subsections.

2.3.1 Limited Contracting Agreements and Flexibility

For POTWs without sludge management contracts already in place, finding outlets for sludge management has become increasingly difficult. Some sludge management companies providing services discussed having to alter or be highly selective in making contractual agreements, especially if the sludge contains higher levels of PFAS. One POTW expressed concern that even if sludge management services were to go out to bid, it is likely that no one would respond.

Based on findings from Part 1, although 71% of respondents have longstanding management contracts, some large and medium POTWs in central and western Massachusetts reported having issues identifying sludge outlets, while POTWs in the southeast region reported "challenges driven by the availability of incinerators in Rhode Island and Connecticut" (Tighe & Bond and Brown and Caldwell, 2024a, Section 3.4). Additionally, 21% of the respondents in Part 1 reported not having a backup plan for sludge management and are at risk of not having an end-use outlet.

2.3.2 Lack of Commercially Available Technology

Multiple biosolids management companies expressed their willingness to invest in PFAS treatment technologies if proven to be commercially viable. One biosolids management company shared that because they are a publicly traded company, they are conservative in how they approach integrating new technologies into their processes. The company shared how most studies currently being conducted on PFAS treatment and treatment or reduction are pilot tests with few full-scale operations. Some of these full-scale operations have faced challenges. One example shared was a $20M thermal drying and pyrolysis project in Schenectady, New York which experienced issues during start up. The company shared how this is an area where the government can help provide support by investing in PFAS treatment technologies and testing their effectiveness.

2.3.3 Lack of Public Support and Approval

Public perception on the use of biosolids is varied and the acceptance of recycling biosolids in sustainable ways remains a challenge. One biosolids management company interviewed spoke about using biosolids to help build up the soil used for a tree farm. They had invested in public outreach and education through canvassing and printed resources to highlight the benefits and low-level risk of accumulation. Despite their efforts, some residents still opposed the use of biosolids and the practice was eventually abandoned. Meanwhile, one POTW shared that even if a new incineration facility were to be pursued to expand capacity, residents likely will not support a new facility being built near where they live. If a new incineration facility were to be developed, not only does the process take time but it could also be difficult for a new facility to obtain the local permits required for construction.

All POTWs interviewed stressed the need to remove PFAS from all products being manufactured and believe this is an area where legislators can help. One POTW expressed that even though information has been shared with customers on the relative risk of PFAS in biosolids versus drinking water via exposure, it is difficult to change public opinion when biosolids are already tagged as “bad."

2.3.4 Potential Impacts of Land Application Bans

One biosolids management company shared if a ban were to be placed on Massachusetts sludge, it would likely force them to close their composting facility in Maine, since majority of the sludge processed at their facility (approximately 65% based on findings in Part 1) is distributed in Massachusetts (Tighe & Bond and Brown and Caldwell, 2024a, Section 5.2). When the Maine land application ban took effect, the same biosolids management company was forced to change their business model and distribute biosolids in other states such as New Hampshire, Massachusetts, Rhode Island, and Connecticut. It is important to note that Connecticut has now banned the use of biosolids (effective October 2024) and biosolids can no longer be land applied as outlined in Connecticut Senate Bill 292 (SB-292) further discussed in Section 2.5.1. The biosolids management company also shared a concern that they could potentially risk permit violations if they are not able to find alternate uses for their product since their facility cannot store biosolids onsite for more than 12 months.

Even if biosolids could be sold in other states where biosolids are still accepted for use or land application, this could still pose challenges to biosolids management companies. Biosolids management companies could experience increased operating costs if the biosolids needed to be hauled farther distances. If a site-specific permit were required in Massachusetts, this could limit the flexibility of where biosolids are recycled. Sludge can also be processed into dried pellets. One POTW spoke about how they used to sell pellets in Connecticut, but the recent ban would likely increase costs since the pellets would need to be shipped further away.

Similarly, if a ban or further restrictions on land application were to be implemented in New Hampshire, a different biosolids management company responded that the ban would likely place them out of business since they would be forced to haul their product to Canada. The biosolids management company based in New Hampshire, are currently not eligible to distribute their Class A biosolids in Maine or Vermont and are already facing pressure on their capacity to recycle in New Hampshire. Any further restrictions or a ban in Massachusetts would negatively affect their capacity to continue recycling biosolids. This biosolids management company expressed not being interested in performing disposal services since it does not align with their current business model, focused on land application and keeping a small carbon footprint.

The same biosolids management company in New Hampshire lost some Class B site permits due to more stringent regulations on biosolids imposed in neighboring states and expressed that if

screening standards become too low, it essentially acts as a ban since it would be difficult to meet and continue recycling biosolids. The biosolids management company's Class B site permits are similar to the Land Application Certificate (LAC) required to land apply Type II biosolids in Massachusetts. Both require additional site-specific permitting. The LAC requires Board of Heath Approval and additional site restrictions. If Massachusetts House Bill 4486 (discussed in Section 2.5.5) were to require site specific approval for all biosolids including Type I, it could negatively impact the biosolids market.

One POTW who currently sells their pelletized products outside of Massachusetts expressed concern that if some nearby states are no longer accepting or ban the use of biosolids, other states could follow suit and decide to eliminate the use of biosolids.

2.3.5 Impacts to Current Capital Improvement Plans

One POTW that operates its own incinerator and accepts liquid sludge from other plants has a long-term goal to improve sustainability by eventually phasing out their dependence on incineration and moving towards energy recovery and the land application of biosolids. The uncertainty of current and pending PFAS regulations have slowed their current capital planning efforts. The POTW did not think it was in their best interest to proceed with capital upgrades until PFAS-related requirements are known and shared that while engineers can design to a regulated limit, a blanket ban impedes any potential future solutions. As stated by the POTW Director, "The Clean Water industry has been successfully treating wastewater and protecting our nation's waterways for decades. We are also making great progress in improving sustainability by expanding our capacity to recover resources from wastewater in the form of energy, nutrients, and organic matter. Returning nutrients and organic matter to the soil is vital to protecting our country's soil health. It's far more sustainable to return nutrients like phosphorus to the soil in the form of biosolids than to rely on mined phosphors from across the globe. An outright ban on land application practices would halt these advancements in sustainability."

In addition, POTWs could be faced with a variety of PFAS based restrictions and may need to comply with multiple permit requirements such as air and National Pollutant Discharge Elimination System (NPDES) permits. For example, another POTW expressed that if more stringent requirements are placed on emissions from sludge dryers, there is uncertainty if the pellets they produce can continue since they currently do not have the resources to explore what would need to be implemented at their facility if more stringent requirements were placed on air emissions to meet these requirements.

2.3.6 Increased Operational Costs

Multiple wastewater industry representatives interviewed expressed incurring additional costs. Some of these costs are the results of:

- Hauling sludge or shipping biosolids to farther distances.
- Increased testing and monitoring of PFAS in the POTW influent, effluent, and biosolids.
- Increased competition for a limited supply of sludge management sites.

One POTW that generates pelletized products expressed how fewer and fewer people are wanting to accept the materials. PFAS regulations in Maine and now Connecticut which ban the use and sale of sludge or sludge-derived material have contributed to rising costs. Even though wastewater treatment plants are passive receivers of PFAS, they are bearing the costs to manage the end products. As quoted by the Executive Director of the POTW, "If PFAS compounds are not eliminated from waste streams through product substitution and elimination on the manufacturing side, and

instead POTWs are forced to bear the cost to remove it without a new source of funding, the ability to properly maintain and upgrade basic core functions of the POTWs will suffer."

Multiple POTWs and sludge management companies expressed spending more time and money to continuously test for and monitor PFAS. For POTWs, the frequency of sampling is dependent on what is required in a facility's NPDES permit. Permits containing PFAS sampling requirements have only been issued more recently and depending on when a permit was renewed, some facilities would not need to report their data until 2025. One concern raised is that it can be difficult to develop good policy and set reasonable standards when there is limited data.

MassDEP does have some PFAS data and, since the USEPA published Method 1633 in 2024, approximately 104 Massachusetts POTWs with NPDES permits have either already been testing or will begin testing by quarter four of 2024 (USEPA, 2024a). The data are publicly available through the Massachusetts Executive Office of Energy and Environmental Affairs' Energy & Environmental Affairs Data Portal (MA EEA, n.d.). More POTWs will have PFAS monitoring requirements as NPDES permits are renewed.

2.3.7 Different Regulations Across States

Multiple wastewater industry representatives expressed that the lack of federal guidance has made it difficult to figure out how to best handle PFAS in sludge and biosolids. While the EPA performs the biosolids risk assessment, certain states have already enacted PFAS regulations and shared how other municipalities have implemented their own standards. For wastewater industry representatives who manage sludge across states, having to meet different requirements in each state makes operations more complex, especially as more constituents like PFAS are added.

Most of the wastewater industry representatives have pointed to Michigan and the regulatory approach they have taken to addressing PFAS in wastewater and biosolids. Michigan has adopted an interim strategy and uses a screening level for biosolids being land applied. Michigan is also working to ensure biosolids data is readily available and has numerous educational resources accessible to the public. Michigan's goal was to target industrial users through their Industrial Pretreatment Programs (IPPs) and use source control and best management practices to manage PFAS levels in sludge. Michigan's IPP has shown decreasing levels of PFAS in biosolids as the result of active source control further discussed in Section 2.6.1.

2.3.8 Potential Opportunities

One biosolids management company shared how the biosolids they produce are recycled for non-agricultural reuses. The Vermont Agency of Transportation uses the blended product produced by the biosolids management company for use in roadside projects.

In Massachusetts, the same biosolids management company that provides biosolids to Vermont also distributes biosolids to Massachusetts end-users utilizing biosolids and short paper fiber in soil blending projects. The company highlighted the program has been successful in Massachusetts but is only sustainable when the ratio of biosolids and short paper fiber (in most cases 6:1) can be maintained. They also mentioned that there is currently a surplus of biosolids compared to paper fiber and by keeping diversified outlets, including soil blending and land application, they can maintain the necessary balance of materials to ensure the program remains sustainable.

2.4 Literature Review of PFAS Impacts from Sludge Management

Multiple research studies are currently being done to better understand the effects of PFAS on sludge management methods. One of the primary reasons for these research studies is to better

understand the fate of PFAS since it is very stable and can persist in the environment for a very long time.

2.4.1 Incineration

The degree of PFAS degradation or potential treatment or reduction has yet to be fully understood in incinerators. Studies have shown incomplete combustion of PFAS could result in air emissions containing PFAS or be disposed of in the form of ash from incineration through the disposal of ash contaminated with PFAS. Based on a recent literature review of currently available data conducted by Winchell et al., in order to convert PFAS into carbon dioxide, water vapor, hydrogen fluoride, and other compounds, current guidelines suggest incinerator temperatures must be at least 1,000 degrees C and, in some cases, greater than 1,400 degrees C based on theoretical and bench scale evaluations. It is generally assumed that the longer the PFAS chain, the higher the temperature is needed to degrade the carbon-fluorine bonds (Seay et al., 2023). In addition to temperature, the amount of available oxygen, residence time (length of time it takes to combust the material incinerated into volatilize and oxidize components), and turbulence experienced during combustion under normal operations, all contribute to the degradation and potential destruction of PFAS (WEF, 2009).

An early study by Seay et al, attempted an approximate mass balance on up to 30 PFAS compounds and inorganic fluoride measured at the inlet and outlet of a POTW operating a fluidized bed incinerator in the U.S. (Seay et al., 2023). Using earlier analytical methods, the study attempted to understand the degree of PFAS degradation and destruction under normal fluidized bed incinerator operating conditions and measure how much PFAS is released into the air. The findings showed that some mineralization of longer chain PFAS (perfluoroalkyl carboxylic acid (PFCA)) was occurring but their results were complicated by quality control issues.

The following is a summary of a study conducted by Winchell et al. (2024) to study the fate of PFAS through two full-scale facilities: a multiple hearth incinerator and a fluidized bed incinerator FBI in the U.S. (Winchell et al., 2024). The major sources of PFAS into these facilities included not just the dewatered wastewater sludge, but also the treated wastewater effluent used in the wet scrubber system. The researchers performed an approximate mass balance of PFAS through the system taking into consideration the fate of PFAS in the dewatered wastewater sludge, combustion air, ash, flue gas (byproduct of combustion), and wet scrubber supply and drain. The researchers found that the dominant PFAS chemical in the dewatered wastewater sludge was PFOS, but many other PFAS compounds were detected.

The two selected facilities are based on what the researchers refer to as “existing” facilities versus “newer” facilities which are subject to more stringent air emission limits (Winchell et al., 2024). Newer facilities have additional air pollution control measures in place which are intended to reduce the release of contaminants into the air. Air pollution controls such as activated carbon are used to reduce mercury and believed to also reduce PFAS.

The researchers found that most of the PFAS from the dewatered wastewater sludge were not released from the multiple hearth incinerator stack emissions and found no reportable PFAS leaving the fluidized bed incinerator, though sample contamination limited the number of PFAS measured in the fluidized bed incinerator emissions (Winchell et al., 2024). PFAS that was measured in the wet scrubber supply water (used to treat the flue gas) left the system through the drain. The researchers did not find any consistent PFAS levels in the combustion air and bottom ash. The researchers also found that most of the PFAS leaving the air were composed of short chain alkyls, unlike the longer chains found in dewatered wastewater sludge, suggesting that transformation of PFAS does occur. In the multiple hearth incinerator, only 5% of what was found originally measured in the dewatered wastewater sludge was released as shorter chain PFAS at the stack. Due to the quality and limited

amount of data, the researchers had difficulty comparing the performance of a multiple hearth incinerator to a fluidized bed incinerator. The researchers believe that the fluidized bed incinerator likely performed better because there was more PFAS measured in the sludge and yet no PFAS measured from the stack.

The Seay et al. study also compared their results to an earlier study conducted by Loganathan et al, where Loganathan et al. found that the PFAS concentrations in the influent sludge were approximately 2 to 10 times higher compared to what was measured in ash, suggesting some removal through incineration (Loganathan et al., 2007; Seay et al., 2023).

The studies reviewed above highlight the need for additional research, particularly because the quality of data is based on the available test and analysis methods. Stoiber et al. state that there is still a lack of understanding of byproducts from combustion and referenced a study in Canada which found that there was a "plethora of unidentified and unreported materials" in their analysis of fluoropolymer incineration (Ellis et al, 2023; Stoiber et al., 2020). Meanwhile, a study conducted in Japan found that some PFAS compounds volatilized and escaped during their final analysis (Wang et al., 2019; Stoiber et al., 2020).

2.4.2 Landfill Disposal

The concerns around landfill disposal and PFAS vary. Landfills serve as an endpoint for different types of waste. Studies have shown that PFAS concentrations in leachate can differ depending on landfill use and the specific waste disposed of in that landfill. For example, municipal solid waste landfills have been found to have an increased amount of PFAS in the landfill leachate compared to landfills where only ash as an incineration byproduct is disposed of since there is likely some degradation of PFAS occurring from the combustion process (Stoiber et al.., 2020).

In 1976, Congress passed the Resource Conservation and Recovery Act (RCRA) focused on improving the management of industrial and municipal solid waste and included minimum design criteria for landfills (USEPA, 2024d). In 1991, the new federal standards were established for municipal waste landfills and included liner requirements (USEPA, 2002). Although landfills in the U.S. are now required to be lined and have a leachate collection system, there is still a concern that PFAS can still leach from landfills either through leakage or runoff (Stoiber et al., 2020). Not all landfills that predate the RCRA requirements are lined in Massachusetts as outlined in MassDEP's list of active landfills (MassDEP, 2024). Stoiber et al noted that with changing climate, increased precipitation from storms not only affects the stability of landfills but can also lead to increased releases of PFAS (Stoiber et al., 2020).

One study found that overall, landfill leachate typically did have more PFAS (approximately 10 times higher in concentration) compared to what was detected in the wastewater influent, however the effluent between POTWs that received landfill leachate and those that did not have similar PFAS concentrations (Masoner et al., 2020). This is likely due to the fact that the volume of leachate at most POTWs tends to be small compared to influent volume, and thus the PFAS loading from leachate does not have a significant impact on overall influent PFAS concentrations (Masoner et al., 2020). A study conducted by Gallen et al. (2017) confirmed this, finding that the contribution of leachate to the total amount of PFAS entering POTWs is minimal compared to domestic wastewater (Gallen et al., 2017).

Eleven Massachusetts landfill facilities, including five municipal solid waste landfills and six sludge or ash monofills, reported having leachate collection systems, out of 14 Massachusetts respondents to the Part 1 landfill survey. The majority of these facilities send their leachate away for treatment or discharge leachate to sanitary sewers in the area. While a review of the literature suggests that the best way to treat landfill leachate is via onsite treatment, many commercially available technologies

such as activated carbon, ultrafiltration, and reverse osmosis generate a waste product for disposal (e.g., spent media) Moreover, due to the complex nature of leachate, these treatment methods may not be as effective at treating PFAS as compared to less complex liquid streams, like raw water (Busch et al., 2010; Yan et al., 2015; Stoiber et al., 2020). In a study conducted by Murray et al. (2024), with specific PFAS compounds designated as hazardous, spent media and other treatment residuals could result in an increased amount of wastes sent to hazardous landfill facilities or incineration facilities, which in turn would likely cost more due to the much higher tipping fees and longer transportation distances (Murray et al., 2024).

Other areas needing additional research identified by Stoiber et al. include a better understanding of how inactive landfills, like those in Michigan, could still potentially contribute to the release of PFAS into the environment (Stoiber et al., 2020). Stoiber et al. (2020) describe that Michigan is starting to find potential PFAS released from inactive landfills containing wastes discarded decades prior (e.g. when PFAS was first manufactured). Gallen et al. (2017), however, identified that mean concentrations of specific PFAS compounds were higher in landfills in operation compared to those that are inactive (Gallen et al., 2017).

Other concerns with PFAS in landfills include gas emissions. Stoiber et al. (2020) highlighted how PFAS can volatize into the air above landfills as shown in studies conducted in China, Germany, and Canada (Stoiber et al., 2020).

2.4.3 Land Application

Substantial research on the fate of PFAS in land application is underway and has yet to be published at this time. This section describes research published to date, acknowledging that some of the knowledge gaps or ambiguities may be addressed by research results scheduled for publication in the next few years. To date, several studies have linked the contamination of PFAS in plants and groundwater to the land application of industrially impacted biosolids. Industrially impacted biosolids contribute to increased PFAS contamination compared to typical municipal biosolids (Ehsan et al., 2024).

PFAS can leach into the soil over an extended period of time and can occur over months or even years, depending on factors including soil type, depth to groundwater and specific PFAS evaluated (Ehsan et al., 2024). Studies conducted in the vicinity of PFAS contaminated areas have shown elevated concentration levels of PFAS in nearby groundwater sources and in crops from fields that have historically land applied industrially impacted biosolids. The presence of PFAS can affect the natural environment and microbial interactions occurring in soil ecosystems (Ehsan et al., 2024).

As described by municipal biosolids in Southern Arizona were historically used as fertilizer for over 30 years and compared to soil samples with no agricultural activity, detectable levels of PFAS were measured in some of the samples collected (undetected to 4.1 ng/g) however, such PFAS concentrations are relatively low when compared to existing interim land application PFAS limits implemented in some U.S. states like Michigan (Ehsan et al., 2024).

A study conducted by Moodie et al. (2021) summarized studies conducted on biosolids around the globe and found that the PFAS concentrations, specifically PFOS, can vary greatly based on manufacturing use, industrial and domestic influences, as well as the level of economic development (Zhang et al., 2013; Moodie et al., 2021). For example, the Decatur WWTP in Alabama accepted industrial waste from local PFAS manufacturers and land applied these biosolids over a 10-year period (Moodie et al., 2021). Elevated concentrations of PFOS and PFOA were ≤ 410 ng/g (ug/kg) and ≤ 320 ng/g (ug/kg), respectively, in these industrially impacted biosolids. Land application of these biosolids impacted the soils and associated crops.

Moodie et al. (2021) collected biosolids samples from 19 Australian POTWs to better understand PFAS concentrations from urban, rural, and industrial discharges and found a correlation between PFAS and industrial waste contributions suggesting increased PFAS concentrations impacted by industrial use. PFAS measured in agricultural byproducts such as pig slurry, poultry and dairy cattle manure were relatively low compared to those found in more urban and industrial wastes such as sludge from paper mills, wastewater sludge, and residential composts (Munoz et al., 2022; as quoted in Ehsan et al., 2024).

Ehsan et al. (2024) found that the highest concentration of PFAS in soils were those "exposed to aqueous film-forming foam (AFFF), PFAS manufacturing plants, and biosolids, compared to landfills, atmospheric deposition, and industrial discharge" and that an assessment ought to be conducted prior to any remediation performed to understand the sources and distribution of PFAS in a specific location (Ehsan et al., 2024).

2.4.4 Other Studies

Other studies have shown that POTWs have also been found to release PFAS into the air, specifically above the aeration basins, which could extend the range of contamination (Stoiber et al., 2020). Vierke et al. (2011) found that PFAS is higher over the aeration tanks due to the turbulence within the tank (Vierke et al., 2011; Stoiber et al., July 2020). POTWs are by no means the sole source of PFAS releases to air, and studies have shown that PFAS can also accumulate in more remote areas through atmospheric deposition. For example, PFAS has been found in a Canada's remote northern region likely from several emissions sources (Ehsan et al., 2024).

In 2024, NEIWPCC created a BioHub as an idea for a research facility to test and prove PFAS treatment technologies' effectiveness. It has since shifted to serve as an information clearinghouse on research and funding for piloting, planning, and permitting treatment of PFAS in municipal biosolids. As part of this effort, NEIWPCC created a crowd-sourced information platform intended to help regulators and clean water practitioners find solutions for PFAS-contaminated biosolids (sludge) (NEIWPCC, 2024).

2.5 Evaluation of PFAS-Related Limitations on the Management of Massachusetts Sludge

Regulatory agencies, relevant statutes and regulations, and planned actions are summarized for New England states (Maine, New Hampshire, Vermont, Connecticut, and Rhode Island) and eight other states (New York, Pennsylvania, New Jersey, Minnesota, Michigan, Wisconsin, California and Maryland) in Table 2-2 and Table 2-3, respectively. Publicly available information on state websites as well as state codes and regulations were reviewed in conjunction with virtual interviews conducted with various staff members of the respective regulating agencies and the department that oversees biosolids management. While every state evaluated mentions biosolids in their PFAS strategy documents, most are awaiting the results of the USEPA Biosolids Risk Assessment (see Section 2.5.4) to determine how to move forward with PFAS updates to their biosolids management programs and related permits.

Biosolids management in the United States primarily relies on three main methods: incineration, disposal in landfills, and land application. The breakdown of management options for each state varies, but most have not seen significant changes directly related to the emergence of PFAS concerns. Even before PFAS became a pollutant of concern, some states and some individual landfills stopped accepting biosolids due to the slope stability and other safety or operational issues they can cause. Table 2-2 and Table 2-3 summarize the regulatory structure for the states evaluated, focusing on areas of interest to this study, such as future PFAS regulations. Most states have not

updated their solid waste management laws to address PFAS but many of the regulatory agencies have issued rules and released interim strategies for addressing PFAS in biosolids. Most of the strategies require PFAS testing using EPA Method 1633 and providing those results to the receiver prior to land application. At this point, most states seem focused on collecting data to set a baseline of PFAS concentrations on their biosolids and use that data to focus on source investigations. Almost every state evaluated relies on land application to manage their biosolids. Limitations placed on land application further exacerbates the ongoing struggle of limited landfill capacity.

2.5.1 Sludge Regulations in New England States

As previously described (Section 2.2.1), in 2022, Maine banned the land application, sale, or distribution of "sludge and sludge derived products." As a result of the Maine legislature's actions, the majority of biosolids generated in the state are landfilled. Maine biosolids can be transferred out-of-state for disposal or land application if the receiving state criterion can be met. Vermont requires the stricter state's regulations to be met for land application resulting in Maine's biosolids no longer being allowed in Vermont at this time.

Vermont began testing groundwater of land application sites in 2019 and issued new Solid Waste Rules in 2020 setting the PFAS groundwater screening standard at 20 ppt. Should that threshold be exceeded, all land application must cease until remediated. Prior to the rule, there were about 30 active land application sites in the state and there are currently four that still have active permits. This has resulted in an increase in more of the state's biosolids being sent out-of-state. The one in-state landfill receives minimal waste from out-of-state and all the sludge from the POTWs in the state are collected by one contractor and transported to New York for management, 65% of which is recycled.

New Hampshire has no plans to end land application and has seen Sludge Quality Certification applications start to come in from more producers in Maine. They have just begun preparations to update their Sludge Rules with promulgation set for June 2026. They anticipate the Class A rules to become stricter, specifically in the notification aspect to increase awareness of where the biosolids are being used. They do not anticipate releasing maximum contaminant level (MCL) for sludge, but viable screening levels based on data intrinsically tied to groundwater leaching probability.

The Connecticut legislature followed the Maine legislature by banning the use of biosolids for land application. The regulation, SB-292, bans biosolids soil amendments as well as other PFAS-containing products, and was brought forth by environmental lobbyists and subsequently advanced to final passage on June 5, 2024. The Connecticut Department of Energy & Environmental Protection (CTDEEP) was not a part of the promulgation process and did not provide input to the rule. As nearly 90% of the biosolids in state are incinerated, the law impacts a limited number of in-state biosolids programs. Connecticut is still determining how to fund enforcement of the law.

Rhode Island does not currently have any plans to ban land application, however this strategy is not currently used to a measurable degree in the state; 91% of the biosolids generated in state are being incinerated. There is not a formal permitting process for sludge management, and every facility has a Sludge Contingency Plan that requires a primary and secondary management site in case the primary incinerator or landfill typically used cannot take the waste. If any major process changes are occurring, a Letter of Approval is required.

Overall, the availability of land application of biosolids has significantly decreased in New England since 2020. As described in Part 1, the Maine and Connecticut land application bans have impacted the distance that Massachusetts biosolids must travel to reach their final destination and any future changes would further impact the land application market and broader Massachusetts sludge management market (Tighe & Bond and Brown and Caldwell, 2024a, Section 7.2).

Table 2-2. Summary of Biosolids Information in New England

State	Agency/ Department	Accepts Out-of-State Biosolids?	Allows Land Application?	Allows Landfill Burial?	Biosolids Laws	Biosolids Rules	Current Biosolids PFAS Regulations	Summary of Planned and Proposed Next Steps
Maine[1]	Maine Department of Environmental Protection (MEDEP)	Yes	No	Yes	Public Law 2021, Chapter 614, Legislative Document 1911 (LD 1911) – Act to Prevent the Further Contamination of Solids and Waters of the State with So-Called Forever Chemicals Public Law 2021, Chapter 626, Legislative Document 1639 (LD 1639) -An Act to Protect the Health and Welfare of Maine Communities and Reduce Harmful Solid Waste		LD 1911 Banned the land application, sales, and distribution of any products made with or mixed with biosolids and commercial and industrial sludges. LD 1639 is a companion bill to LD 1911 limits the tonnage that solid waste processing facilities could send to landfills to no more than what the facility accepts from in-state sources.	Public Law 2023, Chapter 283 allows solid waste processing facilities to continue sending up to 25,000 tons per 12-month period of oversized bulky waste that was generated out of state to state-owned landfills until July 1, 2025.
New Hampshire[2]	New Hampshire Department of Environmental Services (NHDES)	Yes	Yes	Yes	Chapter 149-M - SOLID WASTE MANAGEMENT - does not mention PFAS (only applicable once at landfill) Chapter 485-A -WATER POLLUTION AND WASTE DISPOSAL - includes PFAS testing, no limits Chapter 485-H PER AND POLYFLUOROALKYL SUBSTANCES (PFAS) FUND AND PROGRAMS	PFAS Removal Rebate Program Env-WQ-800 - does not include language on PFAS Interim Best Management Practices for Emerging Contaminants in Certified Biosolids	Currently requires testing for PFAS for land application, but no limits.	**An RFQ was released to determine appropriate screening levels for PFAS in biosolids. The first meeting on the update of the Sludge Rules for interested parties will be in June 2025. Promulgation for new rules is set for June 2026.**
Vermont[3]	Vermont Department of Environmental Conservation (VTDEC)	Yes	Yes	Yes	Title 10: Conservation and Development Chapter 159: Waste Management - does not mention PFAS Title 24 Appendix: Municipal Charters Chapter 403: Central Vermont Solid Waste Management District - does not mention PFAS	20P-005 Solid Waste Management Rules - requires monitoring of PFAS **Interim Strategy for Mitigating PFAS Risks Associated with Residuals Management** Interim strategy includes PFAS screening values for residual materials. Approval for land application of biosolids from out of state is based on the stricter state's regulations. Therefore, Maine's land application ban automatically meant none of the biosolids from Maine can be applied in Vermont.	Currently requires testing for PFAS for land application. Has established interim guidance. This includes testing groundwater, and if exceeds 20 ppt, can no longer land apply until remediated.	Landfill leachate used to go to three or four WWTPs, is now treated onsite at the landfill specifically for PFAS via foam fractionation. No proposed MCLs, the screening standards may become rules but would not include a leaching standard. Currently plan to update the Solid Waste Rules in 2025 which were last updated in 2020. **Have seen a shift in using biosolids diluted with sand and creating fill and manufactured topsoil as products specifically used by VTDOT.**
Connecticut[4]	Connecticut Department of Energy & Environmental Protection (CTDEEP)	Yes	No	Yes	CHAPTER 446d - SOLID WASTE MANAGEMENT (Sec. 22a-220) SB-292 - bans the use of biosolids		40% of the states POTWs influent, effluent, and sludge were tested for PFAS across 2021 and 2022. Various levels were found. Land application of biosolids is banned effective October 1, 2024.	The municipal wastewater group is currently drafting a general permit that will include PFAS monitoring for influent, effluent, and sludge. No PFAS limits at this time. However optional criteria for 10 PFAS compounds will be published by the Remediation group in the next year.
Rhode Island[5,6]	Rhode Island Department of Environmental Management (RIDEM)	Yes	Yes	Yes	250-RICR-150-10-3 - Sludge Management - Does not mention PFAS		Biosolids mentioned in action plan, no current limits for land application.	RIDEM program now requires quarterly PFAS sampling, first one due April 15, 2024 but does not include sludge. No current plans to develop PFAS MCLS for Sludge or limit land application.

1. *Maine. (2024). PFAS and Maine DEP. https://www.maine.gov/dep/spills/topics/pfas/maine-pfas.html, accessed August 2024.*
2. *NHDES. (2024). Biosolids. Retrieved from https://www.des.nh.gov/land/biosolids, accessed August 2024.*
3. *VTDEC. (2024). Residuals & Emerging Contaminants Program. Retrieved from https://dec.vermont.gov/waste-management/residuals-management, accessed August 2024.*
4. *CTDEEP. (2024). Identifying and Addressing Sources of PFAS Contamination. Retrieved from https://portal.ct.gov/deep/remediation--site-clean-up/contaminants-of-emerging-concern/minimize-future-pfas-releases, accessed August 2024.*
5. *RIDEM. (2024). Office of Land Revitalization and Sustainable Materials Management. Retrieved from https://dem.ri.gov/environmental-protection-bureau/land-revitalization-and-sustainable-materials-management, accessed August 2024.*
6. *RIDEM. (2024). Wastewater Treatment Facilities (WWTF). Retrieved from https://dem.ri.gov/environmental-protection-bureau/water-resources/permitting/wastewater-treatment-facilities-0, accessed August 2024*

2.5.2 Sludge PFAS Regulations Outside New England

Legislation from states outside of New England is summarized in Table 2-3 to provide reference to what neighboring states in the region have done, as well as states who have taken an early approach to addressing PFAS contamination. Legislation in New York, Pennsylvania, New Jersey, Minnesota, Michigan, Wisconsin, California, and Maryland is included in Table 2-3. The information provided in Table 2-3 is current as of the writing of this report and continues to evolve.

The graduated approach in Michigan is being referenced by the majority of states interviewed, especially those who relied on land application for almost half of their biosolids management. While waiting for the USEPA to release the Biosolids Risk Assessment, many states have begun internal discussions and prepared drafts of how they plan to update their biosolids permits. Some, like Pennsylvania, have already decided to extend their existing permits so that they can incorporate PFAS into the new permits once they have enough information to do so. As a result, most states are in data collection phases with some having required PFAS sampling through rules or orders, like California. Other states issued voluntary requests of POTWs to sample and analyze for PFAS, with mixed results. Many of these eventually decided either to fund sample collection and testing, or for the regulatory agency to collect and analyze the samples themselves (e.g. Wisconsin). New Jersey facilities have voluntarily included sludge in their PFAS sampling. Most commonly, per USEPA guidance, as NPDES permits are being reissued, PFAS sampling for influent and effluent is being added, with some states including sludge. In New York, regulatory changes include pending draft regulations for PFAS in leachate. More specifics can be found in Table 2-3.

Wisconsin was the only other 40 CFR Part 503 delegated state, aside from Michigan, that was reviewed. Land application permitting is a portion of their Wisconsin Pollution Discharge Elimination System (WPDES) permit and any permits that had a biosolids component are being re-issued since the drinking water MCLs were set, with monitoring requirements for PFAS in biosolids now being included.

Maryland recently issued a discharge permit for a specific wastewater treatment plant which requires PFAS monitoring in the effluent and biosolids. The Maryland Department of Environment (MDE) is working with utilities to conduct PFAS sampling at POTWs known to have associations with industrial users that may be discharging high levels of PFAS to POTWs.

At the state level, there is not a general push to limit land application among the states surveyed, but in states where local input/approval is required for land application site permits, the situation can be more complex and difficult as awareness of PFAS among the general public increases. New land application sites are having a harder time gaining local public approval.

Table 2-3. Summary of Biosolids Information in Other States

State	Agency/ Department	Accepts Out-of-State Biosolids?	Allows Land Application?	Allows Landfill Burial?	Biosolids Laws	Biosolids Rules	Current Biosolids PFAS Regulations	Summary of Planned and Proposed Next Steps
New York[1]	New York State Department of Environmental Conservation (NYSDEC)	Yes	Yes	Yes	6 NYCRR Part 361, Materials Recovery Facilities: 361-2 Land Application and Associated Storage Facilities 361-3 Composting and Other Organics Recycling Facilities	DMM-7, Biosolids Recycling in NYS – Interim Strategy for the Control of PFAS Compounds	**Biosolids acknowledged in PFAS strategy documents and interim strategy identifies limits and testing requirements for land application.** Class A requires an approval process every 5 years to distribute and must submit an annual report.	Discussing sludge MCLs but in the collecting data phase. Once limits issued, plan to allow four years to allow facilities to get into compliance. Landfills program is currently drafting language to require PFAS leachate treatment prior to discharging to POTW.
Pennsylvania[2]	Pennsylvania Department of Environmental Protection (PADEP)	Yes	Yes	Yes	Title 25 CHAPTER 271 -Subchapter J. BENEFICIAL USE OF SEWAGE SLUDGE BY LAND APPLICATION **Title 25 CHAPTER 275. - LAND APPLICATION OF SEWAGE SLUDGE** Title 25 CHAPTER 285 - STORAGE, COLLECTION AND TRANSPORTATION OF MUNICIPAL WASTE		Biosolids acknowledged in PFAS strategy documents but no current limits for land application or testing required.	General permits expiring in November 2024 - have internal draft for PFAS testing and possible limits under review by executive level. Will extend existing permits for now until they can come to a consensus on how to move forward. Have no plans to ban land application nor to stop receiving from other states. However, some landfills have stopped accepting biosolids for burial due to slope stability issues, not PFAS related.
New Jersey[3]	New Jersey Department of Environmental Protection (NJDEP)	Yes	Yes	No	N.J.A.C. 7:14A-20 – Standards for the Use or Disposal of Residual – Does not mention PFAS N.J.A.C. 7:14A-20 – Standards for the Use or Disposal of Residual Administrative Order (No. 2023-01) – Data sharing to identify sources of PFAS		Biosolids acknowledged in PFAS strategy documents but no current limits for land application or testing required.	NJDEP has requested influent, effluent PFAS levels, but not sludge yet. However, many facilities have been testing anyway. None of the landfills currently meet surface water discharge regulations and already all transport their leachate to a MUA. A new composting facility that went online earlier in 2024 will significantly increase the state's biosolids capacity.
Minnesota[4,5]	Minnesota Pollution Control Agency (MPCA)	Yes	Yes	Yes	400.16 SOLID WASTE AND SEWAGE SLUDGE MANAGEMENT REGULATIONS – does not mention PFAS		**Biosolids acknowledged in PFAS strategy documents and interim strategy identifies limits and testing requirements for land application.**	Getting ready to publish interim strategy, declined to participate in the interview, but answered some of the questions provided.
Michigan[6]	Michigan Department of Environment, Great Lakes, and Energy (MI EGLE)	Not Verified	Yes	Yes	Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 – PA 451, as amended.	Part 24 Administrative Rules, Land Application of Biosolids, Rule 2404(1) Interim Strategy – Land Application of Biosolids Containing PFAS (2024) *(Considered a modification to the approved Residuals Management Program (RMP))*	**Biosolids acknowledged in PFAS strategy documents and interim strategy identifies limits and testing requirements for land application.**	Municipal NPDES Permitting Strategy for PFAS (Revised 3/2023) - Requires POTWs with sources of PFAS to meet effluent requirements through a number or measures that focus on source reduction within the sewer service area.
Wisconsin[7]	Wisconsin Department of Natural Resources (WI DNR)	Yes	Yes	Yes	CHAPTER 281 WATER AND SEWAGE - Does not mention PFAS CHAPTER 283 POLLUTION DISCHARGE ELIMINATION - Does not mention PFAS CHAPTER 287 SOLID WASTE REDUCTION, RECOVERY AND RECYCLING - Does not mention PFAS	Chs. NR 500-599; Solid Waste Management Administrative Rules – Dept. Of Natural Resources NR-204 (Domestic Sewage Sludge); NR-214 (Land Treatment of Industrial Liquid Wastes, By-Product Solids and Sludges) INTERIM STRATEGY FOR LAND APPLICATION OF BIOSOLIDS AND INDUSTRIAL SLUDGES CONTAINING PFAS - limits land application	**Biosolids acknowledged in PFAS strategy documents and interim strategy identifies limits and testing requirements for land application.**	Permit applications will require biosolids and/or industrial sludge sampling and PFAS monitoring if needed to supplement permit application sampling. Continue to implement pretreatment initiatives and control strategies at WWTFs for PFAS.
California[8]	California State Water Resources Control Board (CSWRCB)	Yes	Yes	Yes	Title 14 Division 7 Chapter 12 - § 18983.1 - Landfill Disposal and Recovery	Water Quality Order No. 2004-12-DWQ - Does not mention PFAS	Biosolids acknowledged in PFAS strategy documents but no current limits for land application but testing requirements have been laid out.	**About 40% of biosolids from highly urbanized areas are sent to Arizona, and there has been a recent push back from Arizona.**

Table 2-3. Summary of Biosolids Information in Other States

					Title 14 Division 7 Chapter 3.1 - § 17852 – Land Application SB 1383 - prohibits local ordinances that unreasonable restrict or prohibit the land application of biosolids	ORDER WQ 2020-0015-DWQ - required POTWs to sample for PFAS and complete a questionnaire		**As a result of the CalRecycle requirements to lower GHG emissions by lowering organics by 75%, many landfills have begun to stop accepting biosolids.** The addition of PFAS testing in biosolids will be up to the regional waterboards.
Maryland[9, 10]	Maryland Department of Environment (MDE)	Yes	Yes	Not Verified	HB 1153/SB 956 Protecting State Waters from PFAS Pollution Act – implements biosolids guidance	Code of Maryland Regulations 26.04.06.06C and 26.04.06.40A(7) requires PFAS sampling of PFOS and PFOA at specified frequencies **Code of Maryland Regulations 26.04.01C**	**Biosolids acknowledged in PFAS strategy documents and interim strategy identifies limits and testing requirements for land application.**	MDE recently issued a discharge permit to require monitoring of PFAS in the effluent and biosolids. MDE is working with utilities on plans to collect PFAS samples from selected POTWs associated with industrial users.

1. *NYSDEC. (2024a, August 9). Biosolids Management. Retrieved from https://dec.ny.gov/environmental-protection/recycling-composting/organic-materials-management/technologies/biosolids-management*
2. *PADEP. (2024, August 7). Biosolids Program. Retrieved from https://www.dep.pa.gov/Business/Water/CleanWater/WastewaterMgmt/Biosolids/Pages/default.aspx*
3. *NJDEP. (2024, August 7). Residuals, Sewage Sludge, and Biosolids. Retrieved from https://dep.nj.gov/dwq/residual-management/*
4. *MNPCA. (2024, August 9). Land application of biosolids. Retrieved from https://www.pca.state.mn.us/business-with-us/land-application-of-biosolids*
5. *MNPCA (2024, November 18). Minnesota biosolids PFAS strategy. Retrieved from https://www.pca.state.mn.us/sites/default/files/wq-wwprm2-113a.pdf.*
6. *MI EGLE. (2024, August 12). Michigan Biosolids PFAS-related information and links. Retrieved from: https://www.michigan.gov/egle/about/organization/water-resources/biosolids/pfas-related*
7. *WIDNR. (2024, August 8). WATER QUALITY PFAS INITIATIVES. Retrieved from https://dnr.wisconsin.gov/topic/PFAS/WaterQuality.html#biosolids*
8. *CASWRCB. (2024, August 9). Biosolids. Retrieved from https://www.waterboards.ca.gov/water_issues/programs/biosolids/*
9. *MDE. (2024, November 17). Maryland and PFAS. Retrieved from https://mde.maryland.gov/PublicHealth/Pages/PFAS-Landing-Page.aspx*
10. *MDE. (2024, November 17). PFAS in Biosolids Regulatory Update – August 20, 2024. Retrieved from https://mde.maryland.gov/PublicHealth/Pages/PFAS-in-Biosolids-Regulatory-Update.aspx*

2.5.3 Sludge PFAS Regulations in Canada

Canada does not have a federal regulatory structure around biosolids land application; biosolids are instead regulated at the provincial level. Nevertheless, when biosolids are imported or sold in Canada, they are regulated as fertilizers under the *Fertilizers Act*, which is overseen by the Canadian Food Inspection Agency (CFIA) (Government of Canada, 2023).

In 2024, the CFIA adopted a standard of less than 50 parts per billion (ppb) of PFOS in domestic and imported biosolids represented as commercial fertilizers. When biosolids are imported or sold in Canada as fertilizer, a certificate of analysis for PFAS is required with confirmation from the responsible party that the certificate is valid. The certificate of analysis and the attestation of validity apply to all biosolids represented as fertilizers including products that are exempt from registration that meet the definition of "municipal biosolids" and biosolids fertilizers that are not eligible and require registration. "Municipal biosolids" is defined under the List of Primary Fertilizer and Supplement Materials.

The CFIA considered potential impacts of a regulatory limit and reviewed the land application of biosolids and data on PFAS levels in biosolids collected by Environment and Climate Change Canada. Analysis of the data received showed the majority of domestic biosolids (approximately 92%) had PFOS concentrations below 50 ppb.

CFIA had also considered approaches and regulatory controls used by other departments and jurisdictions and has concluded that the approach used by the Michigan EGLE in March 2021 was a balanced, feasible and targeted approach.

Quebec

In 2023, Quebec placed a temporary moratorium on U.S. biosolids imported to Canada. A joint warning was issued over the use of U.S. biosolids particularly due to PFAS and highlighted the risks around imports from Maine where high levels of PFAS contamination were discovered in soil, milk, and manure (Environmental Science and Engineering Magazine, 2023). The temporary moratorium was issued as a cautionary measure while Quebec worked to establish control mechanisms and thresholds for PFAS (Environmental Science and Engineering Magazine, 2023).

The temporary moratorium has since been revoked and Quebec has recently updated their code and guidance on using biosolids including proposed PFAS thresholds and sets forth classification criteria and rules for sampling and analyses (Gazette Officielle Du Quebec, 2024; NEBRA, 2024b). Materials can still be imported into Quebec for composting; however, it needs to continue to be "pathogen-free" as outlined by the Fertilizers Act, prohibiting the import of Class B biosolids from the U.S. for land application (NEBRA, 2024b). The draft code also specifies what conditions are needed to store and spread biosolids or fertilizing residual materials, responsibilities for operators or promoters using such reclamation materials in projects, and certain provisions for using the material for domestic use (Gazette Officielle Du Quebec, 2024). Le Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP) was responsible for developing the code and rule amendments, as well as providing guidance on how to manage residual fertilizing materials (MRF) (Quebec MELCCFP, 2024).

The updated guidance proposes limits for 13 PFAS compounds. PFOS and PFOA are limited to 11 ppb and 8 ppb, respectively, and a limit of 120 ppb for the sum of 11 other PFAS as shown in Table 7 of the draft regulations (Gazette Officielle Du Quebec, 2024).

2.5.4 Federal Steps to Address PFAS

Regulations have been established by both federal and state authorities for specific PFAS compounds in drinking water. Regulations have also been developed in other countries highlighting PFAS concerns on a global scale. In 2024, the USEPA established federally enforceable standards for specific PFAS compounds in drinking water however, there are currently no other federally enforceable standards for PFAS found in other sources or matrices (USEPA, 2024f). This has left states to address PFAS contamination on their own and "some states have established legally enforceable values for PFAS in drinking water, groundwater, surface water, soil, or other environmental media" (Hughes, 2023a). Other states have instead chosen to implement non-enforceable values such as guidance levels, screening numbers, or advisories (ECOS, 2024).

Safe Drinking Water Act – PFAS Drinking Water Standards

On April 10, 2024, the USEPA established legally enforceable Maximum Contaminant Levels (MCLs) for six PFAS in drinking water (individual MCLs and mixtures containing at least two or more of four of the six compounds using a Hazard Index MCL) (USEPA, 2024f). MCLs are the maximum allowable level a contaminant can be in drinking water. Health-based, non-enforceable maximum contaminant level goals (MCLGs) were also finalized for MCLs are the maximum allowable level a contaminant can be in drinking water. these PFAS as shown in Table 2-4. The regulations for PFOA and PFOS are based on the reporting limits for the chemicals since the health-based values fall below those reporting limits. These MCLs replace previous health advisories levels in drinking water for PFOA and PFOS originally established in 2016.

Table 2-4. U.S. EPA National Primary Drinking Water Regulation (NPDWR) for PFAS

Compound	Final MCLG	Final MCL (Enforceable Levels)
PFOA	0	4.0 ppt (also expressed as ng/L)
PFOS	0	4.0 ppt
PFHxS	10 ppt	10 ppt
PFNA	10 ppt	10 ppt
HFPO-DA (commonly known as GenX Chemicals)	10 ppt	10 ppt
Mixtures containing two or more PFHxS, PFNA, HFPO-DA, and PFBS	1 (unitless) Hazard Index	1 (unitless) Hazard Index

The final rule requires public water systems (PWSs) to monitor for PFAS. PWSs have three years to complete their final monitoring, followed by ongoing monitoring. If MCLs are exceeded, PWSs have five years (2029) to implement solutions to reduce PFAS levels. At the same time (beginning in the five years), PWSs who have violated the MCL are required to provide public notification.

Under the Safe Drinking Water Act, the USEPA is required to review the National Primary Drinking Water Regulations (NPDWR) every six years. In Massachusetts, MassDEP is responsible for implementing regulations for drinking water contaminants under the NPDWR as delegated by the USEPA. The NPDWR are legally enforceable and set forth primary standards and testing methods for public water systems to limit contaminants in drinking water and protect public health. Specific to Massachusetts, contaminants in drinking water are regulated under the drinking water regulation 310 CMR 22.00. Effective October 2020, 310 CMR 22.00 was revised to include an MCL for the sum of six PFAS.

EPA Risk Assessment leading to Limits in Biosolids

On October 18, 2021, the USEPA laid out the agency's approach to addressing PFAS in the "PFAS Strategic Roadmap: EPA's Commitments to Action 2021-2024" (USEPA, 2024c). The roadmap sets forth timelines for the USEPA to take specific actions to safeguard public health, protect the environment, and hold polluters accountable. The USEPA's integrated approach focuses on research, restriction, and remediation.

Included as part of the action items listed on the roadmap, the USEPA committed to publish a risk assessment for PFOA and PFOS in biosolids that will serve as the basis for determining whether adding regulatory limits for PFOA and PFOS in biosolids is appropriate. A risk assessment is key in determining the potential harm with human exposure to chemicals. The USEPA released a draft of this risk assessment in early 2025 (USEPA, 2025a). Although EPA states that the draft risk calculations are not conservative estimates, EPA found that there may be human health risks exceeding the EPA's acceptable thresholds for some modeled scenarios when land-applying sewage sludge that contains 1 part per billion (ppb) of PFOA or PFOS. The EPA also found that there may be human health risks associated with drinking contaminated groundwater from near a surface disposal site when sewage sludge exceeds 1 ppb of PFOA or 5 ppb of PFOS.

CERCLA Designation of PFOA and PFOS

On April 19, 2024, two PFAS, PFOA and PFOS, were designated as Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) hazardous substances (USEPA, 2024b). Prior to this designation, a hearing was held by the U.S. Senate Committee on Environment and Public Works to discuss the liability concerns for passive receivers of PFAS such as POTWs and landfills (U.S. Senate Committee on Environment & Public Works, 2024). Several panelists with different perspectives were invited to testify before the Committee; landfill operators noted that if PFAS were designated as hazardous substances under CERCLA, some landfills would likely start refusing biosolids.

As stated in an USEPA memorandum from the Assistant Administrator for Enforcement and Compliance Assurance, the USEPA's approach to PFAS under CERCLA is to hold those who have played a significant role in the release or spread of PFAS into the environment accountable (USEPA, 2024b). This includes PFAS manufacturers and those that have used PFAS in the manufacturing process. The USEPA does not plan to pursue community water systems, POTWs, municipal separate storm sewer systems, publicly owned municipal solid waste landfills, publicly owned airports, local fire departments, and farms where biosolids are land applied (USEPA, 2024b). While the USEPA might not pursue these entities, other groups or individuals could choose to pursue legal action under CERCLA, at which point USEPA's interpretation would be tested in court.

Since PFOA and PFOS are now designated as hazardous substances under CERCLA, this poses additional risks, and sludge management companies may be hesitant to accept, receive, or haul sludge since there is a likelihood it will contain PFOA and/or PFOS for which they could ultimately be liable.

Final Effluent Limitations Guidelines Plan 15

The current effluent guidelines program plan continues to assess ways to limit PFAS discharges from multiple industrial categories (USEPA, 2024e). The USEPA released its final Effluent Limitations Guidelines (ELGs) Plan 15 in January 2023 and included a determination that revised ELGs and pretreatment standards to reduce PFAS in landfill leachate, with assessments of other industrial categories ongoing. Under Plan 15, the EPA also announced the expansion of an ongoing study that investigates PFAS discharges from textile manufacturers and plans to conduct a new, nationwide study on industrial discharges of PFAS to POTWs (USEPA, 2024e).

Other Federal Actions Taken by the EPA to Address PFAS

Other proposed USEPA actions to address PFAS are provided below. A complete list of actions and actions already taken can be found on the "Key EPA Actions to Address PFAS" website (USEPA, 2024d).

- Under the Toxic Substances Control Act (TSCA), the USEPA released a framework to address new PFAS in June 2023. Prior to the use and entry of these new chemicals entering the market, the USEPA will perform an extensive evaluation to ensure they pose no harm to humans or the environment.
- The USEPA released the first set of data collected under the fifth Unregulated Contaminant Monitoring Rule (UCMR 5) in August 2023. UCMR 5 includes monitoring data on 29 PFAS in drinking water systems.
- The USEPA finalized its "National Enforcement and Compliance Initiatives for 2024-2027" in August 2023. The initiative focuses on implementing the roadmap and hold PFAS manufacturers including those that use PFAS as part of the manufacturing process, federal facilities, and other industrial users who have contributed to significant releases of PFAS into the environment responsible.
- In 2024, the USEPA released three methods to measure PFAS in the environment:
  - Final EPA Method 1633 to test 40 PFAS in different matrices such as surface water, wastewater, groundwater, soil, leachate, and fish tissue.
  - Final EPA Method 1621 screens for the presence of carbon-fluorine bonds in chemical substances including PFAS in wastewater.
  - Other Test Method 50 (OTM-50) measures 30 volatile fluorinated compounds in the air.

Other key actions taken by the USEPA include preventing companies from using 329 PFAS compounds that have not been utilized for many years, adding seven additional PFAS compounds to the Toxics Release Inventory, and proposing to add nine PFAS to the RCRA list (USEPA, 2024d).

2.5.5 Proposed Massachusetts Legislation

There are currently three bills filed as part of the Massachusetts 193rd Court that include language pertaining to biosolids. Bills and laws can be found on the "193rd General Court of the Commonwealth of Massachusetts" website (Commonwealth of Massachusetts, 2024). The state legislature sits in a biennial session, which begins in January of the odd-numbered years. All formal business must be concluded in November of that year. The legislature then sits in an informal session in January of the second year (even numbered years) at which time the legislature begins formal sittings until July and finishes the remainder of the session in an informal sitting. Currently, the legislature is in an informal sitting in the second year of the 193rd Court. Bills can only pass if the legislature is called back for a formal sitting and there is unanimous consent for a bill. The three bills are:

- Senate Bill 2053 (S.2053) An Act Establishing a Moratorium on the Procurement of Structures of Activities Generating PFAS Emissions
- House Bill 4288 (H.4288) An Act Protecting our Soil and Farms from PFAS Contamination
- House Bill 4486 (H.4486) An Act to Protect Massachusetts Public Health from PFAS

The following subsections provide brief summaries of the bills and the bills' status as of the writing of this report in 2024.

Senate Bill 2053

An Act Establishing a Moratorium on the Procurement of Structures of Activities Generating PFAS Emissions

This bill was filed and referred to the Joint Committee on State Administration and Regulatory Oversight. If enacted, the bill would require MassDEP to establish and enforce as necessary a moratorium prohibiting the procurement of PFAS-emitting structures or activities. The bill also would not allow MassDEP to grant approval for any proposed new or modifications to a structure where emissions containing PFAS would be generated. The moratorium would be in effect until promulgation of PFAS emissions standards by the USEPA and MassDEP.

As of November 2023, a hearing was held and has been reported favorably by Committee. The bill has been referred to the Committee on Senate Ways and Means.

The passing of this bill could pose challenges for new or upgraded incinerators, gasification and other technologies, especially those looking to expand as the available capacity of incinerators continues to decrease. An additional management challenge is posed if POTWs are unable to land apply, as one of the primary available options is to incinerate biosolids for disposal.

House Bill 4288

An Act Protecting our Soil and Farms from PFAS Contamination

House Bill 4288 was referred to the Joint Committee on Agriculture in 2023 and is intended to protect individuals or entities engaged in farming from suits or civil liabilities from claims based on harm caused by PFAS present in the soil, water, or agricultural products.

The bill would require MassDEP to test for the presence and amount of PFAS in any fertilizer, or other soil amendment sold in the retail market and all biosolids transported for land application. The bill would require that biosolids being transported from the point of origin for land application be tested by MassDEP. Testing results and records of the location where ten or more tons of the biosolids were land applied would be kept and maintained by the transporter, given to land or facility owners, and submitted to MassDEP.

The legislation would require that fertilizer, compost, mulch, topsoil replacement or other soil amendments be tested for PFAS before the Commissioner issues a license. MassDEP would be required to set maximum levels for the amount of PFAS contained in these products. The bill would also require a warning label for products with any detectable amounts of PFAS that states, “Warning: This product is made from sewage sludge (treated human or industrial waste). This product has been tested and found to contain perfluoroalkyl and polyfluoroalkyl substances (PFAS), which may be absorbed in plants and can cause harmful health effects at very low levels.”

If enacted, the bill would also establish a separate fund (Agricultural Relief Fund) to assist farmers impacted by the presence of PFAS and can be used for testing of soil, water, or agricultural products for PFAS, adapting management or business practices, the development of educational resources, mental and physical needs due to PFAS exposure for farm owners and personnel, remediation or infrastructure costs to eliminate PFAS, and to develop testing capacity at the University of Amherst Center for Agriculture, Food, and the Environment.

As of January 2024, the bill was reported favorably and referred to the House Ways and Means. The Committee on House Ways and Means did not send to the floor for a vote during this session.

The passing of this bill would require MassDEP to test for the presence of PFAS on any biosolids or soil amendments and require warning labels to be placed on products with any level of detectable PFAS.

House Bill 4486

An Act to Protect Massachusetts Public Health from PFAS

The bill was filed and referred to the Joint Committee on Public Health. A hearing was held and was reported favorably by the Committee and referred to the Joint Committee on Health Care Financing.

The bill would require MassDEP to include effluent limitations and treatment requirements for PFAS in groundwater discharge permits upon renewal. There are a number of POTWs in Massachusetts that are groundwater dischargers. The bill would also require MassDEP to promulgate regulations to implement a schedule to phase out the use, sale, or distribution, or offer for use, sale, or distribution of sludge without the Department's site-specific approval and does not include the disposal or placement of sludge at a solid waste landfill, hazardous waste landfill, or sludge landfill.

As of June 2024, the Committee recommended the bill ought to pass and referred to the Committee on House Ways and Means. The Committee on House Ways and Means did not send to the floor for a vote during this session.

The passing of this bill could significantly impact and disrupt current sludge management practices and capacity in the region. Without having MassDEP's site approval, the bill would phase out the use of biosolids and land application. Limitations on land application would place a strain on the existing disposal capacity since biosolids would either need to be disposed of by incineration or landfill disposal (see Section 2.2.2 for a further discussion of the potential impacts of a land application ban in Massachusetts). This could also make it very difficult for biosolids management companies in the area to cost-effectively manage biosolids generated in the Commonwealth. POTWs could face a greater risk of not meeting permit requirements if alternative disposal outlets are unavailable and biosolids are stored onsite for an extended period of time.

Finally, this bill would likely have a strong negative impact on facilities composting Massachusetts sludge, as these facilities typically rely on smaller local land application sites where site-specific approval is likely not practical. Further, long-distance hauling of compost product is typically not practical. Therefore, some Massachusetts composting facilities might cease operation.

2.6 Wastewater and Sludge PFAS Reduction Approaches in Other States

The following states have taken an early active approach to address PFAS contamination. The following summaries were taken from state and regulatory agency websites.

Since there are currently no federal limits to PFAS in biosolids, some states have implemented an interim strategy that utilizes a tiered approach for land application. The PFAS limits outlined in most of the interim strategies are based on extensive sampling used to inform studies and identify elevated PFAS risks, especially biosolids with elevated PFAS considered to be industrially impacted. Table 2-5 below summarizes the existing interim strategies used by states reviewed and interviewed as part of this study and categorized as follows:

- No Restriction – Biosolids can be land applied. Typically involves no further action or additional requirements as long as permit/monitoring/reporting requirements are met.
- Restriction – Biosolids can still be land applied however, requires additional response.
- Prohibition – Biosolids generally considered industrially impacted and an alternate management strategy is required.

Table 2-5. Summary of Current Land Application PFAS Strategies in Other States Using a Tiered Approach

State	No Restriction		Restriction		Prohibition	
	PFOS or PFOA in Biosolids (ug/kg or ppb)	Action/Response	PFOS or PFOA in Biosolids (ug/kg or ppb)	Action/Response	PFOS or PFOA in Biosolids (ug/kg or ppb)	Action/Response
New York[1]	≤ 20	No action	> 20 but < 50	• Additional sampling required • DEC will take steps to restrict recycling after one year if PFOS or PFOA levels are not reduced to below 20 ppb • DEC may also require analyses using the Synthetic Precipitation Leaching Procedure (SPLP) to determine if biosolids can be recycled	≥ 50	• DEC will take action to prohibit recycling until PFOS or PFOA concentration is below 20 ppb
Minnesota[2]	≤ 19 (Tier 1)	No additional requirements	20-49 (Tier 2)	• Notify farmer and landowner • Create and implement a PFAS Pollutant Management Plan (PMP) or continue implementation of existing PFAS PMP • Report land application rate to MPCA	≥ 125 ppb (Tier 4)	• Immediately notify MPCA • WWTP must sample and analyze wastewater plant effluent for PFAS, if not already required • Create and implement a PFAS source reduction PMP or expedite efforts of an existing PMP • Site specific requirements may be necessary
			50-124 (Tier 3)	• Notify MPCA, farmer, and landowner • Create and implement a PFAS PMP or continue implementation of existing PFAS PMP • Reduce land application rate to 1.5 dry tons per acre or provide an alternative risk mitigation strategy • Report land application rate to MPCA		
Michigan[3]	< 20	No additional requirements after submission of results via MiEnviro Portal and communication of results to the landowner or farmer	≥ 20 but < 100	• Notify Water Resources Dept. (WRD) Biosolids Staff of PFAS results by submittal via MiEnviro Portal • Reduce land application of 1.5 dry tons per acre or submit an alternative risk mitigation strategy for EGLE approval at a minimum of 14 days prior to land application • Sample biosolids source effluent (within 30 days) • Implement a source reduction plan including an investigation of PFOS and/or PFOA to the sanitary wastewater and resulting biosolids	≥ 100	• Notify Water Resources Dept. (WRD) Biosolids Staff of PFAS results by submittal via MiEnviro Portal • Sample biosolids source effluent (within 30 days) • Implement source reduction plan including an investigation of potential PFOS and/or PFOA sources to the sanitary wastewater and resulting biosolids
Wisconsin[4]	< 20 (sum of PFOA and PFOS below 20 ppb)	Land application per normal approach consistent with chapter NR 204 or NR 214 of the Wisconsin Administrative Code	> 20 but < 50 (sum of PFOA and PFOS generally above 20 ppb but below 50 ppb)	• If median concentration is above 20 ug/kg but below 50 ug/kg, implement PFAS source investigation and reduction efforts including effluent sampling • Prior to land application at a site, provide landowner or farmer (if different) and DNR contact information and additional information sources related to PFAS work in WI • Track application rates on each land application site • If the proposed application rate is greater or equal to 8 tons per acre, consult with DNR to detail concentrations and recommended tonnages per acre	≥ 150 (sum of PFOA and PFOS generally at or above 150 ppb)	• DNR should not approve new or transfer land application sites when combined values are above 150 ug/kg PFOA/PFOS. Future permits may include language prohibiting the authorization of the land application of biosolids and industrial sludges if PFAS is above 150 ug/kg. • Immediately notify DNR Staff • Sample effluent and investigate potential PFAS sources to develop a source reduction program if WWTP have not already done so
			> 50 but < 150 (sum of PFOA and PFOS generally above but below)	• Immediately notify DNR staff • Sample effluent and investigate potential PFAS sources to develop a source reduction program if WWTP have not already done so • Reduce land application rates to no more than 1.5 dry tons per acre (or submit to DNR an alternative risk mitigation strategy for approval in an updated sludge management plan prior to land application) • Prior to land application at a site, provide landowner or farmer (if different) and DNR contact information and additional information sources related to PFAS work in WI • Track application rates on each land application site and report to DNR if land applied • WWTF may decide if appropriate to arrange for alternative treatment or disposal		

Table 2-5. Summary of Current Land Application PFAS Strategies in Other States Using a Tiered Approach

State	No Restriction		Restriction		Prohibition	
	PFOS or PFOA in Biosolids (ug/kg or ppb)	Action/Response	PFOS or PFOA in Biosolids (ug/kg or ppb)	Action/Response	PFOS or PFOA in Biosolids (ug/kg or ppb)	Action/Response
Maryland[5]	< 20	No action or additional requirements after submission of results	≥ 20 but < 50	• Recommended application rate must be lowered to 3 dry tons per acre or less • WWTP shall notify MDE of the PFOS or PFOA concentrations 30 days after receipt of sample results • WWTP should implement a source reduction plan which may include sampling at the WWTP influent and effluent, and identify potential industrial discharges into the sewer system	≥ 100	• WWTP shall notify MDE of the PFOS or PFOA concentrations 30 days after receipt of sample results • WWTP should implement a source reduction plan which may include sampling at the WWTP influent and effluent, and identify potential industrial discharges into the sewer system • Biosolids with concentrations 100 ug/kg or above should either be disposed of in a permitted refuse disposal system or treated through a technology known to mitigate PFAS
			≥ 50 but < 100	• Recommended application rate must be lowered to 1.5 dry tons per acre or less • WWTP shall notify MDE of the PFOS or PFOA concentrations 30 days after receipt of sample results • WWTP should implement a source reduction plan which may include sampling at the WWTP influent and effluent, and identify potential industrial discharges into the sewer system		
Vermont[6]	PFHpA < 0.84 PFNA < 0.44 PFHxS < 0.38	Requires PFAS testing for EQ and Class B biosolids, stabilized septage, and soil, groundwater, and crops at certified land application sites Land application onto hydric soils is prohibited Seasonal high groundwater depth must exceed 3 ft Distance from application site to water supplies must be ≥ 300 ft	PFOS ≥ 3.40 PFOA ≥ 1.60 PFHpA ≥ 0.84 PFNA ≥ 0.44 PFHxS ≥ 0.38	• Pre-application composite soil samples must be analyzed for PFOS, PFOA, PFHpA, PFNA, and PFHxS (one per 10-15 acres). • If soil concentrations are less than the screening values, the land applier must include either of the following in quarterly reports: ○ Calculate post-application soil PFAS content Post-application soil composite tests	For both biosolids and soil samples: PFOS ≥ 3.40 PFOA ≥ 1.60 PFHpA ≥ 0.84 PFNA ≥ 0.44 PFHxS ≥ 0.38	

1. *NYSDEC. (7 September 2023). DMM-7 Biosolids Recycling in New York State – Interim Strategy for the Control of PFAS Compounds. Retrieved from https://extapps.dec.ny.gov/docs/materials_minerals_pdf/dmm7.pdf. Accessed 25 November 2024.*
2. *MPCA. (November 2024). Minnesota biosolids PFAS strategy. Retrieved from https://www.pca.state.mn.us/sites/default/files/wq-wwprm2-113a.pdf. Accessed 25 November 2024.*
3. *MI EGLE. (2024). Michigan Biosolids PFAS – related information and links. Retrieved from https://www.michigan.gov/egle/about/organization/water-resources/biosolids/pfas-related. Accessed 25 November 2024.*
4. *WI DNR (1 March 2024). Interim Strategy for Land Application of Biosolids Containing PFAS. Retrieved from https://dnr.wisconsin.gov/sites/default/files/topic/PFAS/PFAS_BiosolidsInterimStrategy.pdf. Accessed 25 November 2024.*
5. *MDE. (August 2024). PFAS in Biosolids – What You Need to Know. Retrieved from https://mde.maryland.gov/programs/land/RMP/Documents/Fact%20Sheet%20PFAS%20in%20Biosolids%20For%20Web%20Aug%202024.pdf. Accessed 25 November 2024.*
6. *VTDEC (1 April 2024). Interim Strategy for Mitigating PFAS Risks Associated with Residuals Management. Retrieved from https://dec.vermont.gov/sites/dec/files/documents/VTDEC.Final_.PFASResiduals.InterimStrategy.2024April.pdf. Accessed 7 March 2025.*

2.6.1 Michigan

Michigan has been addressing PFAS in wastewater biosolids since early 2018 by addressing sources of PFAS in wastewater, largely through their Industrial Pretreatment Program Initiative. Their efforts have included robust sampling and analysis to characterize the presence of PFAS in wastewater and biosolids, field sampling of land application sites, direct support for POTWs with influent industrial sources of PFAS, and public communication and outreach. In particular, their IPP initiative, described further below, has led to significant decreases in influent PFAS concentrations to POTWs, demonstrating the efficacy of targeted pretreatment programs.

As part of the IPP Initiative, EGLE studied 95 WWTPs to identify, reduce, and eliminate sources of PFAS (PFOA and PFOS) entering wastewater collection systems. EGLE was able to identify seven WWTPs with elevated PFAS in biosolids, considered to be industrially impacted, and temporarily restrict land application until PFAS concentrations, specifically PFOS, were decreased.

Based on EGLE's report findings, of the nearly 100 plants surveyed, only about 10% were shown to be industrially impacted (AECOM, 2021). By implementing industrial pretreatment at the most impacted plants, they were able to achieve significant reductions in influent PFAS concentrations at those facilities (90-99%) (AECOM, 2021). The significance of effective industrial pretreatment is shown in Table 2-6 below, reproduced from the April 2021 report.

Table 2-6. Substantial PFOS Reduction with IPP at WWTP with Exceedances taken from Table 9 of EGLE April 2021 (AECOM, 2021)

Municipal WWTP	Recent PFOS* Effluent (ng/L)	PFOS Reduction (highest to most recent)	Actions Taken to Reduce PFOS
Bronson WWTP	5	99%	Treatment (GAC) at source
Howell WWTP	5	96%	Treatment (GAC/Resin) at source
Ionia WWTP	<6	99%	Treatment (GAC) at source
Kalamazoo WWTP	5	90%	Treatment (GAC) at source, change of water supply
KI Sawyer WWTP	9	96%	Eliminated leak of AFFF
Lapeer WWTP	8.2	99%	Treatment (GAC) at source
Wixom WWTP	34	99%	Treatment (GAC) at source

*Data received as of December 31, 2020

EGLE's management strategy is adaptive and continues to evolve as more data are collected. For example, in 2024, EGLE lowered the threshold for industrially impacted biosolids to 100 ug/kg of PFOS or PFOA.

2.6.2 Minnesota

Minnesota's coordinated and strategic approach to PFAS is outlined in "Minnesota's PFAS Blueprint: Protecting families and communities from PFAS pollution," which recognizes that PFAS pollution "must be prevented from the outset through restrictions or bans on PFAS uses and assistance and financial support for reformulation" (MCPA et al., 2021).

Minnesota's plan takes into consideration short- and long-term approaches to manage PFAS and identified ten priorities in the Blueprint to protect communities and families. Selected priorities are summarized below:

- Working towards understanding risks from PFAS air emissions.
- Quantifying PFAS risk to human health through risk assessments.
- Managing PFAS in waste by preventing them from entering waste streams to begin with, acknowledging that PFAS contamination is difficult and expensive for passive receivers (solid waste facilities and WWTPs) to address.

Minnesota's proposed biosolids strategy applies to all wastewater facilities that intend to land apply biosolids. It includes sampling of biosolids, set to begin in Fall 2025, and a response plan based on the sample results. The response plan is analogous to Michigan's tiers, where biosolids with measurable PFOS and PFOA concentrations above 125 ug/kg are considered industrially impacted and may not be land applied until levels decline. There are discrete response actions for each of Minnesota's four tiers, except for Tier 4, where biosolids have PFOS or PFOA concentrations below 19 ug/kg, for which no additional response is required. Further, the biosolids strategy defines Class A exceptional quality (EQ) biosolids as those that meet Class A EQ standards and where the sum of PFOS and PFOA is below 19 ug/kg. As NPDES/State Disposal System permits are issued, the biosolids section will include a reference to this strategy. Finally, the strategy notes that updates will likely be required when EPA completes its biosolids risk assessment for PFOS and PFOA.

2.6.3 New York

New York State became the first state in the U.S. to regulate PFOA as a hazardous substance in January 2016, followed by the regulation of PFOS in April 2016 (NYSDEC, 2024b). The adoption of PFOA and PFOS as part of the 6 NYCRR Part 597 Final Rule, effective March 3, 2017, enabled the state to use its legal authority and resources to advance investigations, clean up impacted sites, and hold polluters accountable when PFOA and PFOS contamination is found.

In 2017, former Governor Cuomo signed a $2.5 billion Clean Water Infrastructure Act of 2017 to help communities upgrade aging drinking and wastewater infrastructure. The Act also directs DEC, in consultation with DOH, to build a comprehensive database and evaluate and prioritize over 1750 inactive solid waste sites to determine any potential impacts due to PFAS and/or other emerging contaminants of concern to drinking water sources.

New York State's Interim Strategy for Control of PFAS Compounds (DMM-7) directly references Michigan EGLE's work and requires biosolids sampling, analysis and reporting for PFAS using Method 1633. NYSDEC has undertaken the initial round of sampling and analysis and subsequently established the monitoring frequency for each biosolids source, largely based upon volume generated and relative PFAS concentrations. As with Michigan and Minnesota, the Interim Strategy establishes a tier – in this case, biosolids with PFOS above 50 ug/kg – at which biosolids may not be land applied until concentrations decline. The Interim Strategy notes that the Part 361 regulations for biosolids land application will be revised to incorporate risk-based standards developed by EPA, should those be promulgated, and at that point the Interim Strategy would be considered obsolete.

2.6.4 Wisconsin

The Wisconsin PFAS Action Council (WisPAC) was created in 2019 to coordinate the state's response to PFAS by Governor Evers who issued Executive Order No. 40 (Wisconsin PFAS Action Council, 2020). Members of WisPAC include nearly 20 state agencies and the University of Wisconsin system. WisPAC developed the PFAS Action Plan to address PFAS contamination.

Some of the action items adopted in the WisPAC plan include (but not limited to):

- Pollution Prevention: Partnering with the firefighting community to minimize discharges and exposures to PFAS in firefighting foam. Develop and apply best management practices for handing PFAS-containing wastes and identifying and minimizing PFAS discharges to wastewater treatment plants through sampling, collaboration, and pollution prevention.
- Identify and Address Historic Discharges: Includes developing new tools to address PFAS contamination such as requiring responsible parties to establish financial assurance, creating a PFAS-specific natural resources damage claims provision; and creating a Department of Natural Resources PFAS action fund for settlements of PFAS contamination cases.

Wisconsin's interim strategy limits land application of municipal biosolids and industrial sludges impacted by PFAS. Similar to the other states previously discussed, the core of this approach is sampling and analysis of municipal and industrial sludges generated in the state (with industrially impacted biosolids defined per Michigan EGLE's initial tier of greater than 150 ug/kg of PFOS), followed by targeted source identification and reduction. The strategy establishes four tiers, based upon the sum of PFOS and PFOA concentrations, with associated management actions. The strategy is adaptive and allows for adjustments as more data are collected.

2.6.5 Maine

While the legislature's ban on biosolids land application remains in place, multiple state agencies including Maine DEP, the Department of Agriculture, Conservation and Forestry, Department of Inland Fisheries and Wildlife, and the Department of Administration and Financial Services are working together to monitor and address PFAS concerns in sludge, septage, leachate, water, soil, milk, animal wastes, and other agricultural products. The agencies are also working together to monitor and evaluate the potential use of new technologies for treatment of PFAS (Maine DEP, 2024b).

While Maine is still working to find readily available treatment technologies within reasonable costs that will resolve statewide treatment needs, Maine has identified a number of initiatives to address these issues.

Some of the Maine DEP initiatives related to sludge management and disposal include:

- Maine DEP and the Maine Water Environment Association (MEWEA) collaborated on a joint study on sludge generation, disposal capacity, and treatment and disposal options led by Brown and Caldwell completed in 2023. The report was developed to help inform future policy and decision-making on sludge management.
- Wastewater treatment facilities and other communities generating sludge are looking into large-scale drying centers to reduce moisture from sludge waste products. Dryer waste streams are easier to transport and may help landfill operators more easily accommodate such waste streams.
- The State of Maine, Anson Madison Sanitary District, and ECT2 are working together with the support of Maine's Congressional District to develop a regional treatment center for PFAS in sludges or liquids. This would provide a regional facility for handling waste sludges, manure wastes, and other semi-liquid wastes for PFAS treatment.
- The Bureau of General Services submitted a final report to the Maine legislature in January 2023 on treatment options for PFAS in landfill leachate for two state-owned landfill facilities Juniper Ridge Landfill and Dolby Landfill (130th Legislature, LD 1875).

2.6.6 Vermont

The Vermont Agency of Natural Resources' (ANR) Department of Environmental Conservation updated the State's PFAS Roadmap in 2023 which outlines continued efforts to address PFAS sources and contamination (VTDEC, 2023).

Since the discovery of PFAS in water supply wells in Bennington and North Bennington, Vermont, the Vermont ANR has undertaken significant actions to reduce or eliminate PFAS exposure while investigating and identifying new exposure sources. These efforts include:

- Testing and remediating public water systems.
- Responding to known contamination sites.
- Evaluating PFAS concentration in surface waters, wastewater treatment facilities, common household products, and agricultural inputs.

Vermont has also adopted an interim strategy for mitigating PFAS risks from multiple sources and includes a variety of updated sampling and analysis requirements as well as pollution prevention efforts. The strategy also includes specific actions for residual materials:

- Exceptional Quality (EQ) Biosolids.
- Short Paper Fiber.
- Manufactured topsoil (MFT) or soil amendments containing EQ biosolids and/or short paper fiber.

Prior to the creation of the interim strategy, DEC identified several sites in the state for which PFAS levels were above the groundwater enforcement standard; these sites were directed to halt land application and required the development of remediation plans. Subsequent PFAS testing of drinking water supplies adjacent to permitted sites has thus far confirmed no PFAS impacts attributable to land application.

Vermont's interim strategy includes screening limits for five PFAS compounds in residual materials. The screening limits for PFOS and PFOA are 3.40 ppb and 1.60 ppb, respectively. These limits are low compared to other tiered approaches used by other states and many biosolids will not be able to meet these levels.

As stated in Vermont's interim strategy, municipalities have invested in biosolids processing, and such investments would become obsolete if biosolids recycling is banned or restricted to a point it is untenable. As such, Vermont has established screening standards for five PFAS compounds; residuals with levels below these screening standards are exempt from a number of management requirements. Residuals with PFAS levels above the screening standards must perform additional soil sampling both before and after land application. The interim strategy also includes mandated best practices such as required buffer distances and farmer notification.

2.6.7 Maryland

Maryland HB 1153/SB 956 was signed into law on May 9, 2024. The law sets forth an implementation timeline for the MDE to identify significant industrial PFAS users, develop PFAS monitoring and testing protocols for significant industrial users, develop action levels for addressing PFAS contamination from industrial discharge for pretreatment permits, develop mitigation plans, and implement measures to reduce PFAS discharge levels to WWTPs (MDE, 2024).

MDE has established recommended tiers for land applying biosolids to reduce elevated risks posed by Class A and Class B biosolids while still allowing for land application rates depending on PFAS concentrations (MDE, 2024).

Maryland's PFAS Action Plan also identifies strategies, actions, and funding alternatives to identify, regulate, and mitigate the presence of PFAS in the environment (MDE and MDH, 2023). The PFAS Action Plan prepared by the MDE and Maryland Department of Health summarizes proposed actions, identifies the agency conducting the action, and sets a time frame for implementation to address PFAS in drinking water, fish consumption, air emissions, WWTPs, biosolids, spray irrigation facilities, landfills, septic systems, pesticides, and industrial facilities. The action plan also includes proposed product bans, developing and implementing a framework to identify ongoing and historic PFAS releases, and bringing on and/or developing new PFAS analytical services.

Actions specific to biosolids include:

- Conducting PFAS monitoring of all WWTPs that have biosolids used for land application.
- Placing a hold on issuing new sewage sludge utilization permits until a policy decision is made on what levels of PFAS are acceptable for land application.
- Requiring all out-of-state sewage sludge utilization permittees to submit PFAS data on their biosolids.
- Consider conducting PFAS monitoring of municipal WWTPs that have their biosolids utilized in commercial fertilizers and composting facilities (Class A) if future research shows these sources pose a risk to public health and the environment.
- Conduct a comprehensive review of all biosolids data and determine the next steps for land application.

2.7 Section Summary

There are still many unknowns regarding PFAS. As methods for detection and analyses improve, additional information will become available to help provide a better understanding of the risks involved. Such information can help make more informed decisions and encourage both short-term and long-term solutions while minimizing adverse impacts to POTWs and other wastewater industry representatives.

The USEPA is concluding a risk assessment to understand potential health risks associated with the presence of PFOS and PFOA in biosolids. PFAS can be found in many household items, not just biosolids, and until these substances are removed from production and use, they will continue to be introduced to the environment. POTWs are passive receivers of PFAS and must bear the costs, particularly where there are limited end-use options for sludge. Landfill capacity is decreasing, incinerators are aging, and the ability to recycle biosolids through land application is becoming more challenging as nearby states restrict the practice. POTWs are having to haul sludge farther distances resulting in increased operational budget costs ultimately affecting ratepayers, as well as increasing greenhouse gas emissions.

States like Michigan have taken an early and active approach to managing PFAS and have shown that source control can be an effective measure to reduce PFAS. Michigan also implemented a tiered approach interim strategy for biosolids and continues to allow the land application of biosolids if the criteria are met. Other states have also adopted a similar approach that allows biosolids to continue being land applied if limits are not exceeded, thereby reducing elevated risks posed by biosolids. Meanwhile, Maine and Connecticut have banned the use and land application of biosolids. Such legislation has impacted wastewater industry representatives in the region, including POTWs in Massachusetts, which have been forced to find alternative end-use options in an already fragile system where existing sludge management options and capacity are strained.

Even though some technologies have shown promising results of treating and destroying PFAS, many of these technologies are still limited in full-scale operations and can be costly to POTWs, especially

smaller facilities working to sustain normal operations while maintaining current capital improvement plans where funding is limited. Regional solutions have been proposed to help share costs. As shared by multiple wastewater industry representatives interviewed, this is an area where government can help by finding ways to fund and test new treatment technologies. Technologies for PFAS reduction and management in wastewater and sludge are further discussed in the following section.

Section 3

Sludge Volume Reduction and PFAS Treatment Technologies for Wastewater and Sludge

The analysis done in this section highlights the cost and non-cost factors for both PFAS treatment and sludge volume reduction technologies. A detailed evaluation of capital costs, operations and maintenance costs, and 20-year life cycle costs was done for selected technologies for POTWs of multiple scales.

POTWs receive PFAS-containing waste streams; POTWs do not use PFAS in their processes. Effective PFAS control and reduction will typically be most effective at the source of production or use. After upstream source control and reduction, there are few options for treatment at POTWs, most of which are emerging technologies which show promise at reducing PFAS in wastewater and sludge but are still being tested in terms of longevity and overall effectiveness. The PFAS treatment technologies for the liquid wastewater stream at POTWs explored in Section 3.1 include GAC, ion exchange (IX) resin, a combination of GAC and IX, novel adsorbents, nanofiltration (NF), reverse osmosis (RO), and foam fractionation. For sludge, supercritical water oxidation (SCWO), pyrolysis, and gasification were selected as the most developed technologies, with hydrothermal carbonization and hydrothermal liquefaction also discussed as more emerging technologies. Sections 3.1.2 and 3.1.3 provide detailed cost analyses for these technologies for different facility sizes. Additionally, in Section 3.1.3, the possibility of retrofitting sewage sludge incinerators for PFAS treatment was considered.

Sludge volume reduction addresses capacity and hauling challenges in the Northeast. Unlike PFAS reduction technologies, there are several mature, commonly implemented sludge volume reduction technologies which could prove beneficial for implementation in Massachusetts POTWs. Section 3.2 covers sludge volume reduction, which can be achieved through thickening, dewatering, digestion and drying, with each method resulting in different solids concentrations. Dewatering technologies such as centrifuge, screw press, belt filter press, and rotary press are commonly used in North American municipal wastewater treatment markets. Additionally, mesophilic anaerobic digestion (MAD) is a commonly used, conventional process that reduces solids and pathogens while producing biogas, which can be used as a fuel source.

Section 3.3 explores leachate treatment technologies for PFAS, including RO and foam fractionation (FF). RO is highly effective but incurs high operational costs, while FF is simpler and more cost-effective for lower flow capacities. SCWO is discussed as a possible treatment technology for the byproduct of foam fractionation.

Finally, life cycle costs were determined for each of these technologies (Section 3.4), and the overall impact of implementing and operating these technologies on rate payers is highlighted in Section 3.5.

3.1 PFAS Treatment Technologies Overview

The development and deployment of PFAS treatment technologies is an active area of research and innovation. PFAS treatment technologies span the gamut between experimental bench top concepts to applications of widely accepted approaches. In the context of POTWs, often as passive recipients of PFAS-containing waste streams and not contributors of PFAS, the first line of defense in mitigating the implications of PFAS treatment is effective PFAS source identification and control. Onsite treatment may play a critical role in reducing PFAS concentrations in wastewater since source control alone is unlikely to meet PFAS objectives. The following sections describe the current state of separation and destructive technologies. Section 3.1.1 details PFAS treatment technologies designed for the liquid phase while Section 3.1.2 describes technologies that can be applied to biosolids and raw solids.

3.1.1 Wastewater Liquid Fraction

For full-scale PFAS treatment across a variety of aqueous matrices, separation technologies have been most widely implemented and are more readily accepted by regulating entities. Common separation technologies with a track record of success for PFAS treatment are discussed in the following sections with additional in-depth descriptions in Appendix B. However, it is important to note that active research and development of innovative separation approaches is ongoing, and technologies not included in the discussion below are rapidly gaining traction in the water treatment arena. Therefore, it is important to reevaluate viable alternatives as the need arises.

As of this writing, none of the PFAS treatment technologies described in this report have been implemented at full-scale to treat wastewater. Wastewater generally has a higher concentration of organics and suspended solids compared to drinking water. Consequently, the operating life of media and membranes for wastewater applications may be significantly shorter than what is typical for drinking water applications. There is currently no wastewater quality standard for PFAS. All PFAS treatment alternatives identified would be best implemented on the final wastewater effluent, with dewatering supernatant recycled to the head of plant. As such, there would be no effect on the concentration of PFAS in biosolids and any sludge disposal problems would likely be unimpacted. Implementing PFAS treatment at other points in the wastewater treatment train would be very challenging from an O&M perspective due to the high loading rate of solids and organics. Wastewater treatment trains incorporating advanced BOD removal in secondary treatment and tertiary filtration will likely require less frequent changeout of media and membranes used for PFAS treatment. It is anticipated that only ion exchange and perhaps the high-pressure membrane alternatives will require a dedicated pre-treatment process in addition to the existing wastewater treatment process.

Granular Activated Carbon

Granular Activated Carbon (GAC) is a filter media made from coal or organic materials like coconut husks. The activation process creates a complex pore structure with a high surface area, making GAC effective at removing contaminants through adsorption. GAC is non-selective and effectively removes organic compounds in general, including PFAS. Waters rich in organics tend to exhaust GAC more quickly as organics in general are often present in much higher concentrations than PFAS. In particular, long-chain organic compounds tend to block GAC pores that serve as adsorption sites. GAC is particularly good at removing non-polar, hydrophobic compounds. PFAS most commonly detected in the environment typically have a nonpolar, hydrophobic tail and a polar, hydrophilic head, making them inherently well suited for adsorption by GAC. GAC can be installed in either pressure vessels or gravity contactors. Pressure vessels are often more economical for systems with a lower design flow while the opposite is true for contactors. Pressure vessels are typically run in a series

configuration with a lead and lag vessel in each train. Gravity contactors are typically run in a parallel configuration.

Typical PFAS removal rates vary depending on factors such as water quality, loading rate, and type of GAC used. A GAC PFAS treatment facility would be most feasibly implemented on at the final treated wastewater effluent. Due to the higher concentrations of suspended solids seen in wastewater compared to drinking water, GAC contactors would likely need to be backwashed regularly in wastewater applications. Backwashing the contactors risks disrupting the mass transfer zone of the media, which can make predicting remaining media life more difficult. Backwash wastewater wouldn't carry elevated PFAS concentrations and could be recycled to the head of the treatment process. PFAS removal efficiencies for many PFAS compounds are in the high 90% range, resulting in concentrations below detection limits. For PFOS and PFOA, maximum removal efficiencies are greater than 99%, also below analytical detection limits. Shorter-chain compounds tend to be removed less effectively and tend to break through first once the media becomes exhausted. Spent GAC can be reactivated via thermal treatment or landfilled. Disposal may be limited to hazardous waste designated landfills depending on PFAS concentrations in the spent media. GAC is less expensive than IX on a comparative weight basis; however, GAC also removes less PFAS for an equivalent weight of media than IX. As such, in drinking water applications, GAC facilities tend to have larger footprints than IX facilities. However, for wastewater applications, IX facilities would likely need a robust pretreatment system, and may actually require more space overall. Footprint requirements for GAC facilities with capacities of 0.5, 5, and 20 MGD are 1,200, 1,600, and 18,000 ft^2, respectively. There are no known full-scale applications of GAC for wastewater treatment. The pros and cons of GAC for PFAS treatment are summarized in Table 3-1.

Table 3-1. Pros and Cons of GAC for PFAS Treatment

Pros	Cons
• Long track record of success with numerous installations (for drinking water applications) • Effective with various influent water qualities • Non-selective media removes multiple contaminants in addition to PFAS • Least expensive treatment media by volume or weight • Media can be reactivated	• Requires longer empty bed contact time (EBCT) than other methods • Larger media vessels needed compared to other methods • Lower efficiency in waters with high concentrations of other organic compounds • Can release PFAS and other compounds as adsorption sites decline • Media must eventually be disposed. It cannot be reactivated indefinitely. • Larger footprint compared to IX, but could be offset by robust pretreatment IX would likely require

Ion Exchange Resin

Ion exchange (IX) resins capture PFAS through electrostatic forces, unlike GAC which relies on hydrophobic interactions. IX resins are designed to selectively target PFAS, making them more selective than GAC. IX resins are also non-steady state, requiring replacement when exchange sites are consumed. Biofouling is a risk with ion exchange resin especially when treating waters with a high concentration of organics. Spent IX resin is typically incinerated, destroying the resin and PFAS. It is possible to regenerate and reuse ion exchange media; however, this is less common for PFAS treatment since the regeneration process produces a PFAS-laden waste stream. Typical PFAS removal rates vary but are similar to GAC. Removal efficiencies for many PFAS compounds are in the

high 90% range and to levels below detection limits. For PFOS and PFOA, maximum removal efficiencies are greater than 99%, also to below analytical detection limits. Both GAC and IX are more effective at removing long chain PFAS; however, some IX resins are likely more effective at removing certain short-chain PFAS compared to GAC. IX vessels are typically installed in a series configuration to provide a backstop against PFAS breakthrough and maximize operating life of the resin. IX resins typically have significantly shorter design empty bed contact times compared to GAC and consequently have smaller footprints. The pros and cons of IX for PFAS treatment are summarized in Table 3-2. Footprint requirements for IX facilities with capacities of 0.5, 5, and 20 MGD are 1,200, 1,600, and 20 ,000 ft^2, respectively.

Table 3-2. Pros and Cons of IX for PFAS Treatment

Pros	Cons
• Selective targeting. IX is designed to efficiently remove PFAS with less competition from other constituents • Faster process with shorter EBCT • More effective on short-chain PFAS than other methods	• More expensive than GAC on a volume or weight basis • Smaller resin size causes more frequent blockage which leads to greater operational challenges (i.e., more frequent rinsing required, decreased effluent quality, and greater sensitivity to temperature and flow variations) • Spent resin is destroyed during incineration and cannot be reused • Risk of biofouling especially when treating waters with a high concentration of organics

Granular Activated Carbon and Ion Exchange in Series

Another PFAS treatment alternative is to utilize a hybrid approach with both GAC and IX. Water would flow through GAC contactors/vessels before proceeding to IX treatment. The less selective GAC media removes the bulk of organics from the water up front, mitigating possible biofouling of the IX media. Having IX installed after GAC provides a PFAS-targeted polishing step, which can allow the GAC media to operate at a higher PFAS effluent concentration, thus extending its operating life. Typical PFAS removal rates for this setup would be in line with those provided for GAC and IX. Footprint requirements for GAC-IX facilities with capacities of 0.5, 5, and 20 MGD are 1,200, 1,600, and 18,000 ft^2, respectively.

Novel Adsorbents

In addition to the GAC and IX, there are several novel, but promising, sorption technologies for PFAS treatment in wastewater, commonly referred to as “novel adsorbents.” Examples are coated sand, zeolites/clay minerals, plant-based, and biochar.

Coated sand consists of coarse grains of sand that have been coated with graphite oxide. This coating increases the sand’s surface area and introduces functional groups that can interact with PFAS molecules. The coating increases adsorption capacity of the sand and attracts a wider range of PFAS compounds compared to uncoated sand. Coated sand has been shown to remove PFOS and PFOA at similar rates to GAC and features a high regenerability for reuse of the media.

Zeolites are microporous, aluminosilicate minerals with a high surface area and unique sieving properties. They are widely used in chemical separation and purification due to their high surface area and small uniform pore size. Clay minerals, including natural and surface-modified are also used as absorbents and are similar to zeolites, but have a different crystalline or chemical structure.

Zeolites have a high thermal resistance and are suitable for regeneration and reuse. Clay minerals remove PFAS in a similar manner to zeolites. Examples that can be used for PFAS treatment include bentonite and kaolinite. These minerals have layered structures which can adsorb PFAS through surface interactions. Both zeolites and clay minerals are promising for PFAS treatment but exhibit widely varying PFOS and PFOA adsorption capacities. PFAS adsorption performance should be assessed for each specific zeolite or clay-based media.

Similar to GAC, activated biochar has a high surface area and porous structure which makes it effective at removing PFAS molecules from water. Like GAC and IX, activated biochar is more effective at removing longer chain PFAS. Biochar is often produced from waste biomass from agriculture or forestry, making it a cost-effective and sustainable technology.

High Pressure Membranes – Nanofiltration (NF) and Reverse Osmosis (RO)

High-pressure membranes like Nanofiltration (NF) and Reverse Osmosis (RO) are used to treat water contaminated with PFAS by forcing it through semi-permeable membranes. These membranes selectively remove compounds based on their size and charge, generating a permeate stream of treated water and a residual concentrate stream high in PFAS. NF and RO membranes vary in selectivity, with NF being less selective than RO. While effective, these processes require pretreatment and routine cleaning to minimize fouling. The pros and cons of NF and RO for PFAS treatment in wastewater are summarized in Table 3-3.

Table 3-3. Pros and Cons of NF and RO for PFAS Treatment

Pros	Cons
• Highly effective at removing PFAS, including shorter-chain compounds • Non-selective so many other larger contaminants and salts will be removed • Long history of use for other trace organic constituents	• Highest capital cost among common separation technologies • Higher electrical and operating costs than other methods • Produces a concentrated liquid waste stream that requires management

Foam Fractionation

Many PFAS are amphiphilic, meaning they possess both hydrophobic and hydrophilic properties. As such, these PFAS tend to congregate on the boundaries between water and oil or water and air. Continuous foam separation via foam fractionation is a physicochemical process that leverages this tendency to treat contaminated water. By injecting a steady stream of air or gas into the water, bubbles form and carry PFAS to the surface, creating a foam that is then skimmed off. This method has been implemented at the pilot- and full-scale level to remove PFAS in groundwater, leachate, and industrial water. The foamate formed by this process could pass through a secondary foam fractionation process to concentrate PFAS even further. The foamate formed from one or multiple stages of foam fractionation can be sent to one of a number of aqueous PFAS destructive processes, such as supercritical water oxidation (SCWO), discussed further in Section 3.1.2 in the context of sludge treatment. The pros and cons of foam fractionation for PFAS treatment in wastewater are summarized in Table 3-4.

Table 3-4. Pros and Cons of Foam Fractionation for PFAS Treatment in Wastewater	
Pros	**Cons**
• Effective at removing high PFAS concentrations • Can handle water with co-contaminants • Relatively low cost • Requires minimal energy	• Additives might be necessary for low PFAS concentrations • Less effective for short-chain compounds • Less effective for non-amphiphilic PFAS that lack a hydrophilic functional group • Produces a concentrated liquid waste

Wastewater Liquid Fraction – Selected Technologies for Further Analysis

For the purposes of this study, GAC and ion exchange (IX) are the alternatives recommended for further evaluation in the form of life cycle cost analysis. Foam fractionation is most applicable to smaller liquid volumes and higher PFAS concentrations. As such, it is likely more cost-effective when applied for use on industrial waste or landfill leachate (see Section 3.3) as opposed to municipal wastewater. While effective at removing PFAS, high pressure membrane technologies such as reverse osmosis and nanofiltration are also not particularly well suited for municipal wastewater applications. These technologies utilize membranes with microscopic pores, which require pretreatment and are susceptible to biofouling in the nutrient-rich waters that would be treated at a municipal wastewater facility. Other potential treatment technologies lack full-scale installations or do not capture PFAS but rather concentrate them in the reject water. This produces a much larger volume of PFAS-laden waste to dispose of. See Section 3.4.3. for a life-cycle cost evaluation and Section 3.6.1 for a discussion of non-cost factors for the selected technologies.

Destructive Technologies

The PFAS treatment technologies described so far are separation technologies that are designed to remove PFAS from water and concentrate the PFAS compounds into a solid or liquid waste stream. By contrast, destructive technologies break PFAS molecules down into either shorter-chain PFAS and/or other byproducts such as mineral salts and carbon dioxide. A discussion of destructive technologies for PFAS in wastewater is relevant from two perspectives: 1) as a means of addressing the residuals resulting from the above discussed separation treatment technologies (i.e., GAC, IX, NF/RO), and 2) with respect to permanently disrupting the PFAS cycle in the environment.

When selecting a destructive technology, it is important to understand whether complete PFAS destruction, or partial destruction/transformation (i.e., generating shorter chain PFAS molecules), is occurring. The effectiveness of various destructive technologies in achieving complete PFAS destruction (i.e., mineralization of the elements in PFAS to carbon dioxide, water, hydrofluoric acid, and other thermodynamically stable products) is an active area of study in the scientific community. Targeted PFAS analysis only provides information on the concentrations of PFAS that can be quantified (e.g., 40 PFAS under EPA Method 1633). To confirm that a treatment process does not simply transform PFAS into other related degradation products (without potentially unknown toxicological endpoints), it is important to leverage industry best practices for existing destructive methods and leverage non-targeted analytical methods to provide greater confidence that the target compounds completely mineralized in the destructive process. While several technologies are currently being developed and are being tested in the field, as of the writing of this report, there are no known full-scale installations of PFAS focused destructive technologies being used in municipal wastewater applications.

3.1.2 Sludge – Emerging Technology

PFAS treatment technologies covered thus far are designed to treat PFAS in the liquid phase; however, PFAS can also accumulate in biosolids, and raw solids produced by wastewater treatment facilities (WWTFs). The current technologies for destroying PFAS in biosolids with the highest degree of certainty are generally limited to thermal treatment. The applicability and cost of these methods is highly dependent upon the character of the material to be treated. Thermal processes use energy in the form of heat and turbulence to volatilize and combust materials through thermal oxidation reactions. Despite the highly oxidized nature of PFOA and PFOS, these and other PFAS display a relatively high thermal reactivity (Winchell et al., 2020; Lee et al., 2012).

Due to the energy-intensive nature of thermal processes, destructive thermal treatment alternatives are only applicable to concentrated residual streams, such as dried biosolids, and are not considered a viable treatment alternative for dilute streams. The primary difference between the different thermal treatment processes involves the oxygen content and turbulence in the thermal reactor, the temperature of combustion, and the residence time.

This section focuses on emerging technologies, those showing promise for reducing PFAS concentrations but with a limited or mixed track record at full scale. See Section 3.1.3 for more on a mature thermal sludge treatment technology—incineration. Appendix C, PFAS Mitigation Technologies – Sludge, goes into additional detail on the technologies introduced below.

Pyrolysis and Gasification

Although there are few full-scale installations operating in the U.S., and none in New England, pyrolysis and gasification are thermal processes that may destroy PFAS in wastewater sludge, especially if coupled with a thermal oxidizer to address PFAS in the air emissions. Pyrolysis occurs in the absence of oxygen at high temperatures (200°C to 1,100°C), producing biochar and pyrolysis gas. Gasification involves limited oxygen at high temperatures (typically 800°C to 1,000°C), converting solids to ash and syngas (and some configurations can produce oil and tar). Both methods are gaining interest due to regulatory challenges with incinerators. Limited data exist on PFAS removal, prompting further research. If PFAS volatilizes in the syngas, a thermal oxidizer may be needed to ensure complete destruction. Thermal oxidizers are already validated for 99.99% PFAS emission reduction (Focus Environmental Inc., 2022).

Supercritical Water Oxidation

SCWO, mentioned in Section 3.1.1 for treatment of the byproduct from foam fractionation) for PFAS treatment of sludge has advanced beyond bench scale to pilot scale, with two pilots operating in the U.S. A 6 wet ton per day (wtpd) demonstration unit recently started up in Orange County, Florida and is capable of processing roughly 5% of the facility's daily sludge production. SCWO can be used to treat any flowable material (including wastewater sludge) and relies on the unique reactive properties of water above its critical point (i.e., high temperature and pressure). To limit fouling and other operating challenges, PFAS-containing wastes may require screening prior to entering the SCWO reactor. Additionally, the energy requirement for complete PFAS mineralization in a SCWO reactor limits the economic viability of the technology to high-concentration, low-volume wastes. The leading manufacturer has conducted test runs supporting high PFAS conversion (>99%) for both short and long chain PFAS but further peer-reviewed information is required to validate these findings.

Hydrothermal Carbonization

Hydrothermal carbonization (HTC) is a form of pyrolysis performed in the presence of water, known as wet pyrolysis. The process treats sludge at 200°C, producing a solid product called hydrochar,

which reduces solids volume. While HTC shows potential for addressing PFAS, data on its effectiveness is limited. Some studies suggest that PFAS could be modified or destroyed during the reaction, but more research is needed to confirm this. An installation in Finland has shown some promise, but continuous operation with sewage sludge has not been fully tested. A full-scale installation is being constructed in Phoenixville, Pennsylvania.

Hydrothermal Liquefaction

Hydrothermal liquefaction (HTL) subjects solids to high temperatures and pressures to generate liquid biocrude oil. This process can convert materials like wastewater sludge into sustainable fuels. Laboratory experiments have shown varying levels of PFAS degradation, with over 99% transformation efficiency for compounds with carboxylate functional groups, but less than 34% for sulfonic acid compounds (Winchell et al., 2020). Both original PFAS compounds and intermediary products were found in the biocrude oil, indicating a need for further research to understand their fate. Adding reactive amendments like potassium hydroxide has shown potential to increase PFAS removal efficiency. A pilot HTL facility is anticipated to be constructed at Metro Vancouver (Canada), which would represent the first pilot-scale implementation of this technology.

Wastewater Sludge – Selected Technologies for Further Analysis

Pyrolysis and gasification as well as SCWO were selected for further evaluation due to their relative maturity in the market (as opposed to hydrothermal carbonization and hydrothermal liquefaction), and the lack of regulatory pressure (as seen for incineration emission limits and administrative requirements). See Section 3.4 for a life cycle cost evaluation and Section 3.6.2 for a discussion of non-cost factors for the selected technologies. These three technologies are compared in Table 3-5.

Table 3-5. Wastewater Sludge Technology Comparison

	Super Critical Water Oxidation (SCWO)	Gasification	Pyrolysis
PFAS reduction effectiveness	• Limited peer reviewed information available	• Limited peer reviewed information, but initial results look promising in gas, liquid, and solid streams	• Limited peer reviewed information, but initial results look promising in gas, liquid, and solid streams
Throughput capacity	• 183-9,185 dry-lb/hr	• 1,000-2,000 dry-lb/hr	At 80%TS (range covers different configurations): • Maximum: 265-880 dry-lb/hr • Minimum: 110-365 dry-lb/hr
Degree of commercialization and timeline for full-scale installations	• Currently no full scale installations. Pilot scale installation in Florida.	• Ecoremedy has the only fully commissioned gasification system processing only on biosolids in the U.S. (installed summer 2021; startup 2024) • Aries Clean Energy facility in Linden, NJ attempted start-up in 2022 but was halted after experiencing cake conveyance difficulties. Hoping to fully commission in 2025.	• Since 2017, Bioforcetech had the longest operating biosolids pyrolysis system in the U.S. at Silicon Valley Clean Water (SVCW) • The pyrolizer at SVCW was recently replaced with a new model and is commissioning • Bioforcetech primarily focuses on smaller wastewater treatment facilities although it has a partnership with WM that may lead to developing large scale systems
Reliability	• Currently no full-scale installations, only lab scale	• Too early to determine full-scale installation reliability	• Too early to determine full-scale installation reliability
Energy consumption or recovery	• 300-320 kW	• Electricity use at 2,000 dry-lb/hr throughput - approximately 155 – 160 kW	• Electricity use - 60-80 kWh/wt ton
Biproduct	• Produces ash	• Typically produces ash. Some units can produce a biochar.	• Produces biochar
Impacts on air quality	• Minimal air quality impacts	• Minimal air quality impact with proposed emissions controls	• Minimal air quality impact with proposed emissions controls
Facilities Considerations	• Most effective at facilities without digesters • Relatively small footprint • Facility attributes like availability of pure oxygen, activated sludge, and PFAS levels do not affect SCWO effectiveness	• Digestion: Reduces energy available for drying step, but digestion makes materials handling and drying easier • Larger footprint than SCWO • Facility attributes like availability of pure oxygen, activated sludge, and PFAS levels do not affect gasification effectiveness	• Digestion: Reduces energy available for drying step, but digestion makes materials handling and drying easier • Larger footprint than SCWO • Facility attributes like availability of pure oxygen, activated sludge, and PFAS levels do not affect pyrolysis effectiveness

Table values based on input from 374Water (SCWO), Ecoremedy and Aries (gasification), and Bioforcetech (pyrolysis)

Wastewater Sludge – Selected Technologies Case Studies

As mentioned in the previous section, SCWO has no current full-scale installations. Table 3-6 summarizes the full-scale and demonstration installations of gasification and pyrolysis technologies, followed by some more detailed case studies.

Table 3-6. Full-Scale or Demonstration Scale Biosolids Pyrolysis and Gasification Facilities

Note. Adapted from "The Sate of Full-Scale Implementation – Biosolids Pyrolysis and Gasification" by DJ Wacker, 2024

Company	Location	Feedstock	Type	Scale	Status	Biosolids Capacity (WT/d)
Ecoremedy	Edmonds, WA	Biosolids	Gasification	Full-scale	2024	40
Ecoremedy	Hershey, PA	Biosolids	Gasification	Full-scale	2025 (expected)	60
NE Biochar Solutions	TBD	Biosolids + Wood Waste	Pyrolysis	Full-scale	2026 (expected)	720
Bioforcetech	Redwood City, CA	Biosolids	Pyrolysis	Full-scale	2017-2023 (original pyrolyzer) 2025 (expected)	8.3
Bioforcetech	Ephrata, PA	Biosolids	Pyrolysis	Full-scale	2025 (expected)	11
Bioforcetech	Redding, CA	Biosolids	Pyrolysis	Full-scale	2025 (expected)	8.3
Bioforcetech	Brentwood, CA	Biosolids	Pyrolysis	Full-scale	2025 (expected)	22
Eartbcare	Bethel, PA	Biosolids, poultry manure & spent hens	Gasification	Full-scale	2024	80 (dry)
Aries Clean Energy	Linden, NJ	Biosolids	Gasification	Full-scale	2025 (expected)	430
Anaergia	Rialto, CA	Biosolids	Pyrolysis	Full-scale	TBD	420
CHAR Technology	TBD	Biosolids	Pyrolysis	Demo	2025 (expected)	9 (dry)
CHAR Technology	London, ON	Biosolids + residuals	Pyrolysis	Demo	Decommissioned 2022	5 (dry)
Heartland Water Technology	Murfreesboro, TN	Biosolids	Gasification	Demo	2023	4 (dry)
Biowaste Pyrolysis Solutions	Schenectady, NY	Biosolids	Pyrolysis	Full-scale	Decommissioned 2022	100

Ecoremedy Facility – Edmonds, WA

The City of Edmonds, Washington, embarked on a significant project to enhance its POTW through an energy services performance contract with Ameresco. This facility, located near Seattle, processes up to 14,250 wet tons (wt) of dewatered sludge annually, converting it into ash. The project, which began in 2020, involved replacing the aging fluidized bed incinerator with Ecoremedy's Fluid Lift Gasification process. The new system was installed within the existing space of the former incinerator.

The project is nearing completion, with key milestones achieved. These include a mass and volume reduction of over 92%, and the effective reduction of PFAS measured in the solids product. The project has also met air emission standards set by regulatory agencies. Ameresco, the general contractor, has confirmed substantial completion of the project and is finalizing the remaining tasks with the city.

Bioforcetech Facility – Redwood City, CA (Silicon Valley Clean Water)

In 2012, Bioforcetech, an Italian firm, approached Silicon Valley Clean Water (SVCW) with an innovative process for drying biosolids using minimal energy. After successful pilot testing, SVCW and

Bioforcetech entered into a public-private partnership to develop a full-scale installation. By June 2017, the first "Biosolids to Energy" plant began operations, processing up to 3,000 tons of biosolids at 20% TS annually.

The facility integrates three BioDryer units with a P-FIVE pyrolysis system with space for two additional BioDryer units. The BioDryers remove moisture from the biosolids, consuming 25-35 kWh/ton. The pyrolysis system then converts the dried biosolids into biochar and generates up to 160 kW (at 80%TS out of the BioDryer) of energy continuously, which powers the facility. This system reduces the biosolids volume by 90% and produces biochar, which can be used in agriculture, construction, and various industrial applications. The partnership has proven economically beneficial for SVCW due to the rising cost of hauling biosolids. The onsite processing also eliminates over 500 truck trips annually, significantly reducing the carbon footprint associated with biosolids management. Currently, the pyrolysis system is not in continuous operation. BFT is completing upgrades to the pyrolysis system, including replacing the pyrolysis unit itself, to ease maintenance and reduce equipment downtime. The pyrolysis upgrades are expected to be completed in early 2025.

Heartland Water Technology Demo Facility – Murfreesboro, TN

Heartland Water Technology has established a demonstration facility in Murfreesboro, Tennessee. This 30,000-square-foot pilot test uses the HelioStorm™ ultra-high temperature ionic gasifier to process biosolids. This technology operates at temperatures exceeding 3,000°C, enabling it to convert organic materials into a clean, hydrogen-rich syngas. The high temperature also allows for the reduction in PFAS and volatile organic compounds (VOCs). The syngas can be used for power generation, hydrogen recovery, or carbon conversion into products like carbon black.

For future full-scale facilities, Heartland has a design, build, own and operate business structure and hopes to sign two agreements for commercial facilities by the end 2024 or early 2025 with the first project being operational by the end of 2025. In the interim, the Murfreesboro facility can be used to pilot the treatability of specific sludges.

3.1.3 Sludge – Mature Technology

Given the pressure on land application and landfilling and unproven reliability of emerging PFAS treatment technologies, the wastewater industry is reconsidering incineration as a PFAS solution. Sewage sludge incinerators (SSIs) have been used for decades around the country. Guidelines for PFAS destruction often mention temperature requirements of 1,000°C or above while failing to note the equally critical residence time and turbulence parameters. Incinerators in the U.S. must meet strict emissions criteria, often using various scrubbing and oxidizing technologies to capture flue gas pollutants, which may also control PFAS. Hazardous waste combustors have documented 99.9999% PFAS removal (Clean Harbors, 2017). However, data gaps remain. Further research is ongoing to understand PFAS removal within incineration applications.

Incineration Retrofit for PFAS Mitigation

PFAS can be thermally degraded although limited information is published on the extent of degradation achieved in sewage sludge incinerators (SSI) (Winchell et al., 2021). Winchell et al. (2024) found that only five percent of the PFAS molar load within the dewatered sludge entering the incineration process exited the stack from a multiple hearth site while a similar evaluation of a fluidized bed site was complicated by sampling contamination. Furthermore, the PFAS observed in the stack samples were generally shorter chain versions compared to that in the dewatered sludge, suggesting degradation had occurred. While the complexity of PFAS does not allow for definitive conclusions from this limited information, the researchers believe that if additional PFAS treatment is required at existing facilities, two retrofit options exist to address air emissions, thermal oxidation

or activated carbon. Despite showing promise in other applications, these technologies require full-scale performance testing to verify PFAS treatment with SSIs. The following discussion evaluates these technologies to retrofit the existing SSIs in Massachusetts.

The following sections describe the two PFAS treatment options considered. Thermal oxidation is well established organic pollutant destruction technology and activated carbon similarly is well established for pollutant capture. These technologies come with capital and operating and maintenance costs discussed later. Every effort should be made to eliminate the source of PFAS to the treatment facility prior to making such an investment. In Michigan, the Department of Environment, Great Lakes, and Energy has successfully reduced sludge PFAS levels by reducing use at industrial and commercial dischargers.

Thermal Oxidation

Combustion is the physical chemical reaction upon which incineration is based. It is a broadly used approach for many recreational, consumer, and industrial processes. In an SSI, the sludge is combusted which oxidizes the volatile, or combustible, fraction of the sludge yielding flue gas and the nonvolatile fraction remains a solid and is referred to as ash.

Combustion efficiency, measured by generation of products of incomplete combustion like soot or carbon monoxide, is based on three main tenets, temperature, residence time, and turbulence, often referred to as the “3 Ts." Each of these will have a profound impact on the efficiency or destruction in the case of PFAS treatment. While a lay understanding might assume that increasing temperature is required to increase PFAS destruction, a potentially equally effective approach would be to increase the time the PFAS is at temperature or increase the turbulence of the reactor.

Target conditions for the 3 Ts in a thermal oxidizer treating PFAS in wastewater sludge have not been established. To increase PFAS treatment in SSIs, additional combustion equipment can be designed to achieve arbitrarily selected target conditions.

Given that wastewater sludge ash can melt at relatively low temperatures, increasing the temperature in the core furnace of the process, beyond the typical 850°C, where ash is present comes at risk of slagging equipment which leads to shutdowns and maintenance expenditures. A second combustion unit process strategically placed in the treatment train can mitigate this concern. These downstream processes are typically referred to as thermal oxidizers but based on the same combustion principles as the primary furnace in the incineration train. While there are other types of thermal oxidizers, a regenerative thermal oxidizer (RTO) offers a low risk, commercially proven, and energy efficient option.

An RTO would be installed downstream of other air pollution control equipment in the incineration system equipment train and therefore will not receive significant loads of ash. With the ash removed, the RTO can be designed to achieve temperatures over 1,000°C, often quoted temperature for PFAS destruction and incorrectly omitting conditions of the other two tenets of the 3 Ts, primarily residence time. Turbulence can be difficult to quantify and generally is withheld by technology vendors as trade secrets.

RTOs consist of multiple chambers, typically two, filled with a heat retaining media. Flue gas from the incinerator flows into one chamber, followed by a plenum connected to the second chamber, and then through the second chamber and out of the RTO. A burner system (typically natural gas fired) provides heat in the connecting plenum to achieve the desired operating condition. As the hot flue gas flows out through the second chamber, some of its acquired heat transfers to the media. After several minutes the heat retaining media in the second chamber can accept no more heat and the flow through the equipment is switched. Cold, untreated flue gas now enters the second chamber first and absorbs heat from the media. In this manner RTOs are able to recycle the heat from the

burner system and achieve greater than 95% thermal efficiency. Despite the lack of publicly available data, the additional combustion step offered by use of an RTO that can be designed for relatively elevated temperatures and residence times is expected to increase PFAS treatment efficiency where warranted.

Vapor Phase Activated Carbon

Activated carbon is a widely used sorbent for all types of pollutant control applications. In SSI applications, activated carbon is often used to control mercury, dioxin and furan emissions. While there is no published information on the efficacy of activated carbon to remove PFAS from gas streams, it is widely used in drinking water treatment applications. As such, activated carbon can be expected to remove some PFAS from the flue gas of an incineration process.

In flue gas applications, activated carbon is often blown into the flow stream or held in a static bed where the flue gas passes through the space between carbon particles. Only one SSI blows carbon into the flue gas while more than 10 use carbon beds across the United States and Canada, per the author's experience. Other novel, carbon-based technologies are available but were not considered for this project. Due to their popularity and ability to retrofit existing incineration trains without requiring additional particulate capture equipment, carbon bed technology was considered for this project.

In comparison with an RTO, a carbon bed does not destroy PFAS. Carbon will adsorb PFAS and eventually become exhausted of PFAS capturing capacity. At this point the carbon needs to be changed out. The PFAS laden carbon could be landfilled but will likely contribute to future PFAS emissions (Winchell et al., 2021). If PFAS destruction is desired, the carbon needs to undergo thermal treatment, which is often used to regenerate the carbon for another use.

Incineration – Selected Technologies for Further Analysis

A life cycle cost analysis of activated carbon bed system was not included in this analysis in part because of the lack of published PFAS performance data. RTO was chosen as the representative technology for incineration moving forward.

The additional technologies will drive up treatment costs for utilities. Some of the costs associated with incineration or enhanced air pollution controls can be offset in several ways. Energy recovery from the heat generated is a well-established approach that can generate enough power to operate the process and potentially be exported for other uses (WEF, 2009). The energy recovery system will also include costs and must be carefully evaluated to confirm a net benefit. Nevertheless, if incineration enhancements result in more available heat energy recovery should be considered.

Massachusetts Sewage Sludge Incinerator Retrofit Options

Two wastewater sludge incinerating utilities currently operate in Massachusetts. The Upper Blackstone Clean Water (UBCW) in Milbury processes roughly 50 dry tons per day (dtpd) and the Lynn Water and Sewer Commission in Lynn treats roughly 18 dtpd at the Lynn Regional Water Pollution Facility.

There are also at least five decommissioned multiple hearth style SSIs in Massachusetts that could be evaluated for rehabilitation that may reduce costs compared to constructing and permitting a new facility. An evaluation of new or rehabilitated SSIs and the associated siting and permitting is beyond the scope of this study. This project focuses on the possibility of retrofitting existing, operating SSIs in Massachusetts with technology to reduce associated PFAS air emissions.

Upper Blackstone Clean Water

The UBCW treatment facility uses two multiple hearth furnaces to process dewatered wastewater sludge. Aside from the furnace, each incineration train includes a wet scrubber and RTO to mitigate air emissions. With the inclusion of a new RTO specifically designed for PFAS treatment, the PFAS emissions from the UBCW incinerators would be less than that measured by Winchell et al. (2024).

The existing RTOs (for conventional air emission treatment) were installed in roughly 2017 and operate at 1,024°C with a one second residence time. The two RTOs currently sit in a roughly 90-foot by 50-foot area. The original equipment manufacturer indicated that the existing units could be operated at higher temperature, which would result in a reduced residence time, as an attempt to increase PFAS treatment. The higher temperature will decrease equipment service life and may require replacement of some components to achieve the more severe condition.

The life cycle cost evaluation presents a replacement of the existing RTOs with new versions designed for 1,090°C with a two second residence time. These conditions were selected based on anecdotal evidence to improve PFAS treatment removal efficiency beyond the existing equipment. One RTO manufacturer estimated the footprint of each RTO to be 60 ft by 20 ft and 44 ft tall.

Prior to making an investment of this magnitude that replaces relatively new equipment, it is recommended that air emissions are sampled for PFAS using USEPA methods Other Test Method (OTM) 45 and OTM-50 to determine if the existing equipment is sufficiently reducing PFAS emissions to desired levels without the retrofit. The USEPA may also have OTM-55 published prior to sampling and should be incorporated into the program if a comprehensive evaluation is desired.

Lynn Regional Water Pollution Control Facility

This facility uses a fluidized bed furnace followed by a wet scrubber, WESP, and carbon bed for air emissions control. The inclusion of the carbon bed likely reduces PFAS emissions from Lynn's facility. However, as previously noted, the facility sampled by Winchell et al. (2024) did not have this equipment and typical removal efficiencies are presently unknown. Operating conditions and parameters were assumed to be the same as UBCW and footprint requirements for a single RTO of 43 feet by 14 feet by 41 feet high. Veolia has indicated rather than switching treatment process at the Lynn facility, they plan to rebuild the incineration system to extend the service life.

It is recommended that existing emissions be evaluated prior to making the capital investment to confirm if existing equipment is already meeting PFAS emissions desired levels. Emissions are expected to be low, given that the current operating carbon bed likely removes PFAS that escapes the furnace. Winchell et al. (2021) also noted that a fluidized bed furnace is a more efficient combustion technology and, therefore, has higher pollutant destruction efficiency than the multiple hearth furnace. As such, PFAS emissions are likely less than that measured for the multiple hearth by Winchell et al. (2024), assuming the sludge contamination is comparable. Also, the same study observed the fluidized bed sludge feed contained five times more PFAS than the multiple hearth sludge feed, and none of those compounds were observed in the stack samples. However, stack sample contamination limits this observation to 13 of the 16 compounds reported in the sludge.

3.2 Sludge Volume Reduction Technologies Overview

Northeast POTWs are facing major challenges due to capacity and hauling concerns. Typically, the most effective way to alleviate these challenges is to reduce the volume of sludge that needs to be treated, hauled, and managed. In addition to minimizing the amount of sludge or solids to be handled, volume reduction technologies produce a drier product, which has more options for end-use. Additionally, PFAS treatment technologies tend to be much more efficient and cost-effective

when applied to smaller, more concentrated waste streams, so it can be helpful to reduce the sludge volume ahead of PFAS treatment.

Sludge volume reduction can be achieved through various methods: thickening, which typically results in 2-8% solids concentration (the balance being water); dewatering, which typically produces 15-40% solids concentration; and drying, which can yield >90% solids concentration (USEPA, 2006 & WEF, 2019). Anaerobic digestion stabilizes sludge and reduces volume by converting some of the organic matter to biogas, which can be beneficially used for heating, electricity production and other uses. The following sections detail these technologies, with the exception of thickening which is not included in the discussion since most facilities currently have thickening. All of the technologies discussed are proven in many full-scale installations around the country.

As more of the water is removed from sludge or as it becomes more stable through digestion, more outlets are available for management—leading to greater resiliency for the plant. POTWs that only thicken sludge (increasing the solids content from less than 1% as it is separated from the wastewater liquid stream to typically 2-8% total solids (%TS)) are left with very few outlets. In 2023, 76 POTWs did not have further processing and produced thickened sludge. Landfills will not accept materials, like thickened (or "liquid") sludge, that do not pass a paint filter test (USEPA test method 9095B), which tests for the presence of free liquids. Many incineration or compost facilities are not equipped to accept liquid sludge. In decades past, private outlets became available for liquid sludge, notably incinerators in Connecticut and Rhode Island, and many POTWs found the simplified materials handling and cost savings from not dewatering (polymer, electricity, replacement parts, and operations and maintenance (O&M) labor) outweighed the additional cost for hauling a larger volume of material and so decommissioned dewatering units. The balance of those costs has shifted and POTWs with historical experience with dewatering and others may benefit from (re-)installing dewatering equipment. See Section 3.4.4 for capital and O&M cost curves that can give POTWs an estimate for the upfront and ongoing costs associated with dewatering.

Adding dewatering after thickening (and digestion, where applicable) reduces the volume of material to be managed by approximately three-quarters. This equates to fewer truckloads, reduced traffic and noise, and fewer greenhouse gas emissions. It should be noted that, conversely, some outlets (such as GLSD, UBCW, Lowell and some smaller POTWs accepting solids from surrounding communities) are not able to accept dewatered cake currently and can only accept liquid sludge. POTWs that add dewatering could retain the ability to load out thickened sludge in the event of temporary disruptions to facilities accepting dewatered cake. In addition, it is prudent for individual POTWs to verify availability and cost of sludge cake management with regional biosolids contractors prior to proceeding with dewatering upgrade projects.

Anaerobic digestion, which typically follows solids thickening, further reduces the quantity of solids to manage by converting some of the organic matter in sludge to biogas. Compared with undigested thickened sludge, solids that are digested and dewatered have around 85% lower mass. Barring no further regulatory restrictions, anaerobic digestion also allows sludge to meet Class B biosolids standards (when volatile solids reduction is greater than 38% to meet Vector Attraction Reduction requirements (503.33(b)(1)) and the residence time is greater than 15 days to meet Pathogen Reduction requirements (503.32(b)(3)), which can open up additional management outlets (e.g., land application in Massachusetts or neighboring states). Food waste and other organics can be co-digested with sludge at POTWs, providing a helpful outlet for compliance with landfill organics diversion regulations. See Section 3.4.4 for capital and O&M cost curves that can give POTWs an estimate for the upfront and on-going costs associated with anaerobic digestion.

At least twelve POTWs in Massachusetts have digesters that have either been repurposed or decommissioned (see Section 3.2.2 of the Part 1 report). The tank construction cost is typically the

most expensive portion of implementing digestion, so utilizing existing tanks (once suitability is confirmed) can significantly reduce the project cost. To give an idea of the potential scale of the impact from investing in digestion; if three large POTWs (producing 18,000 wtpy of dewatered cake) put in anaerobic digestion upstream of dewatering, due to the conversion of some of the organic matter in the sludge to biogas those POTWs would together produce 24,300 wtpy less dewatered cake, reducing the demand at outlets for dewatered cake.

Thermal drying removes nearly all the water from sludge, resulting in a 95% reduction in the amount of material to manage versus thickened sludge. Dried biosolids have a wider range of uses than liquid sludge or dewatered cake. Dryers typically produce Class A biosolids (usually via 503.32(a)(7) and 503.33(b)(8)), with a wide variety of potential uses (e.g., soil blending, landscaping, etc.). As was discussed in the Part 1 final report (Section 4.8), landfills increasingly have restrictions on wet or "high moisture content" materials, including dewatered cake, due largely to concerns about landfill stability. Dried biosolids would not fall into this category and so may be more widely accepted at landfills. See Section 3.4.4 for capital and O&M cost curves that can give POTWs an estimate for the upfront and ongoing costs associated with drying. To give an idea of the potential scale of the impact from investing in drying; if five medium POTWs (producing 4,500 wtpy of dewatered cake) put in dryers downstream of dewatering, those POTWs would together produce 19,500 wtpy less dewatered cake, reducing the demand at outlets for dewatered cake. In addition to freeing up capacity for dewatered cake in the region, dried solids are considered Class A biosolids and therefore have the additional outlet of land application available to use, barring no further regulatory restrictions.

Digestion upstream of drying has several advantages (e.g., homogenizing and stabilizing feed to the dryer, more stable and less odorous final product, reduced dryer size, potential for using digester gas and/or combined heat and power (CHP) heat recovery in the drying process to reduce the use and purchase of fossil fuels, etc.) and achieves mass reduction of around 97% in comparison to thickened sludge. Thermal drying of undigested sludge from primary treatment is typically not advised.

3.2.1 Dewatering

There are many proven mechanical dewatering technologies in the municipal market. Each of these technologies utilize different principles to separate liquid and solid phases in combined streams. The advantages and disadvantages of these technologies vary in their performance, power consumption, operating simplicity, maintenance requirements, utility demands, footprint and more. This section focuses on four dewatering technologies with proven experience in the North American municipal wastewater treatment market: centrifuge, screw press, belt filter press (BFP), and rotary press. An overview of the pros and cons of these four dewatering technologies is provided in Table 3-7. Appendix D – Sludge Volume Reduction Technologies provides additional detail on these technologies.

Table 3-7. Dewatering Technology Comparison

Centrifuge	Screw Press	Belt Filter Press	Rotary press
Advantages			
• High solids capture (>95%) • Highest cake solids (%TS) • Lowest equipment footprint to capacity ratio • Low operator attention requirements due to automation • Fully enclosed, mitigating odor control considerations and housekeeping • Low wash water usage • Typical solids concentration range can be 16 – 30%, depending on the several factors such as influent concentration and sludge type	• Low rotational speed reduces parts wear and maintenance • Low noise, low vibration • Low wash water usage • Low power consumption • Fully enclosed, mitigating odor control considerations and housekeeping • Mechanical simplicity • Low operator attention requirements due to automation • Typical solids concentration range can be 15 – 30%, depending on the several factors such as influent concentration and sludge type	• Low power consumption • Lower polymer demand • Relatively simple operation • Open design enables easier access for operation and maintenance activities • Low noise, low vibration • Typical solids concentration range can be 15 – 30%, depending on the several factors such as influent concentration and sludge type	• Fully enclosed, mitigating odor control considerations and housekeeping • Low power consumption • Can be expanded modularly • Low wash water usage • Typical solids concentration range can be 12 – 30%, depending on the several factors such as influent concentration and sludge type
Disadvantages			
• High power consumption and polymer demand • High noise level • High rotational speed leads to more long-term maintenance • Maintenance typically requires disassembly and shipping to 3rd party • High speed creates large dynamic loads effecting building structural considerations • Subject to accelerated wear from high grit loads due to high-speed operation • Centrifuge start-up and shut-down results in wet "sloppy" sludge which should be conveyed away from cake handling (usually routed to centrate).	• Large footprint to capacity ratio • Higher polymer demand • Dry equipment weight is high leading to structural considerations • Fewer municipal installations compared to centrifuge and BFP • Has not consistently demonstrated 95% solids capture • May be subject to accelerated wear due to high grit loads due to tight tolerances • May produce a relatively lower dewatered sludge solids concentration	• Open belt design requires greater odor control design considerations • Open belt design increases housekeeping requirements • Large amount of wash water required due to continuous belt washing • Greater risk of operator exposure to machine parts • Operator has more exposure to sludge and odor • Requires greater operator attention • Large footprint to capacity ratio	• High maintenance requirements • Complex polymer flocculation system • Fewer municipal installations compared to centrifuge and BFP • May produce a relatively lower dewatered sludge solids concentration

Dewatering - Selected Technologies for Further Analysis

In the life-cycle cost analysis detailed in Section 3.4, centrifuges and screw presses were chosen due to their prevalent use in facilities in Massachusetts, as opposed to belt filter presses and rotary presses. Centrifuges are recognized for achieving the highest solids content among dewatering technologies. Screw presses also outperform belt filter presses and rotary presses in terms of solids content. Additionally, both centrifuges and screw presses are enclosed systems, offering more odor control. Finally, rotary presses are less commonly used at facilities and with belt filter presses being open, these two technologies were not included in the analysis further unless otherwise specified.

Facilities can make an individual decision on any of these dewatering technologies during a preliminary design phase of a project.

3.2.2 Anaerobic Digestion

Anaerobic digestion is a sludge stabilization process that reduces solids, pathogens and vector attraction while improving the final product's aesthetic characteristics, such as odor. In this process, microorganisms decompose organic matter in a heated reactor and the absence of oxygen to reduce volatile solids and produce biogas. This method is commonly used to meet regulatory requirements for biosolids land application and can also generate onsite renewable energy through biogas utilization. Digested sludge contains stabilized organic material and nutrients (i.e., nitrogen and phosphorus) and can provide additional benefits via land application. Digesters can also co-digest food waste and other organics, which can reduce tonnages sent to landfill.

Anaerobic digestion is a conventional process operating at temperatures between 95 and 102°F with a minimum hydraulic retention time of 15 days, ensuring Class B pathogen status for beneficial use. While digestion is known for its operational simplicity and long history, it has disadvantages compared to advanced digestion processes, such as lower volatile solids destruction, lower gas production, and greater mass of solids remaining. This results in greater required tank volume. Typically, anaerobic digestion results in 40 to 60% volatile solids reduction (when operating in the most typical "mesophilic" temperature range), which translates into 25 to 45% total solids reduction. Performance will vary depending on the type of feed sludge into the digester as well as the volatile solids content on the feed.

Facilities can pair digestion with other technologies to increase the volatile solids reduction, reduce digester capacity needs, and increase dewaterability. For instance, one technology used for pretreatment is thermal hydrolysis. Thermal hydrolysis will break open the cells of the sludge, allowing more of the "food" needed for digestion to be available. Thermal hydrolysis can be advantageous, particularly in regional facilities, due to its ability to accept dewatered cake (sludge is typically fed to the thermal hydrolysis reactor at 15 to 18% total solids). However, it does come at a significant initial capital investment. The smallest unit available, capable of processing up to 28 dtpd, is estimated to cost $36M dollars of total project costs, inclusive of ancillary equipment. Without a core driver to include thermal hydrolysis, it was excluded from further analysis. As mesophilic anaerobic digestion is much more widely used than other digestion technologies, with representative facilities in Massachusetts, it was selected as the representative digestion technology in the analysis below.

3.2.3 Thermal Drying

There are three main types of thermal dryers used for biosolids applications in the U.S.: belt, indirect, and rotary drum. Each type has unique operational characteristics and applications, with belt dryers being suitable for small to medium facilities, indirect dryers offering compact footprints, and rotary drum dryers providing high throughput for large facilities. The dryers at MWRA's Quincy facility and GLSD are both drum dryers. This section also covers service and maintenance requirements for these dryers, emphasizing the importance of regular inspection and preventive maintenance to ensure efficient operation and longevity. Additional information on thermal drying can be found in Appendix D.

Belt Dryers

Belt dryers shape and distribute dewatered solids into noodle or granule-shaped particles on a slow-moving porous belt. Warm process air circulates through the belt chamber to evaporate the water content. The material's shape provides a large surface for exposure to the warm process air, and the

slow-moving belt ensures sufficient contact time, generating minimal dust and fines. Belt dryer exhaust is commonly dehumidified with a condenser, reheated, and mixed with incoming air to minimize exhaust volume and reuse waste heat

Belt dryers can be classified into direct-fired and indirect-fired belt dryers. Direct-fired systems burn a fuel source directly into the dryer inlet chamber, achieving higher process temperatures without needing to manage steam or thermal oil. Indirect-fired systems use a separate process heater to generate hot water, steam, or thermal oil circulated through heat exchangers to warm the process gas fed to the dryer. Each system has its advantages, with direct-fired systems offering higher throughput and indirect-fired systems being more flexible in heating methodologies.

Indirect Dryers

Indirect dryers use a thermal fluid to heat a metal wall that separates the dewatered biosolids from the thermal fluid, allowing heat transfer by conduction. A common type is the paddle dryer, which uses hollow paddles, discs, or augers to agitate and transfer heat to the biosolids within a heated vessel. This method reduces heat loss and fluid requirements, but the product quality can be finer and dustier compared to other dryers.

The thermal oil system in indirect dryers requires specialized piping and stress analysis due to high temperatures. Indirect dryers inherently produce significantly less offgas compared to other dryer types which reduces odor control needs. Safety measures like deflagration venting, dried product cooling and fire protection systems are essential to prevent overheating and potential explosions. Additionally, condensate heat recovery and regular maintenance are important to ensure efficient operation.

Thin film dryers, a type of indirect dryer, are gaining some interest in the U.S., in particular for a reported ability to handle the drying of undigested primary sludge, which other dryer types have historically had issues with.

Rotary Drum Dryers

Rotary drum dryers use a fuel-burning furnace to heat a rotating steel drum, which propels the material through a hot gas air stream. The process involves lifting and cascading the material to facilitate drying. The dried product is then separated from the exhaust air, screened, and processed for recycling or storage. Rotary drum dryers are known for their high throughput and thermal efficiency, making them suitable for large facilities. However, they require significant space and are operationally complex, with extensive maintenance needs due to constant contact with the material.

It is important to monitor operational variables such as inlet and outlet temperatures, wet feed ratio, and furnace inlet pressure to ensure optimal performance of a rotary drum dryer. Safety measures include nitrogen purging, water deluge sprays, and explosion panels to manage temperature excursions and prevent thermal events. Despite their complexity, rotary drum dryers are effective for large-scale operations, offering high efficiency and the ability to produce a marketable product.

In Massachusetts, there are drum dryers located at GLSD and MWRA, which were built in the 1990s, and have a long and successful operating history.

Drying – Selected Technologies for Further Analysis

Belt dryers were selected as a representative technology for all sizes of POTWS. Belt dryers and indirect dryers are both common choices for small to medium POTWs and have similar capital and operational costs; however, more projects in recent years have proceeded with belt dryers. Belt dryers typically have more operational flexibility, which allows for the dryer to be started and stopped more easily than a drum dryer.

Rotary drum dryers were only evaluated for medium, medium-large and large POTW sizes. Drum dryers have higher throughput capabilities which makes them better suited for larger drying facilities, including sizes larger than those evaluated here that could be pursued for a regional facility. Rotary drum dryers produce a high-quality material, which has been successfully marketed throughout the U.S.

3.3 Leachate PFAS Treatment Technologies Overview

3.3.1 Leachate Collection in Massachusetts

Landfills are potential repositories for PFAS-contaminated materials from domestic and industrial waste. Some of the PFAS end up in the landfill leachate which are often recovered and managed to avoid risks for subsurface contamination. One common leachate disposal option is to discharge the leachate to a POTW either through sewer connections or by transporting the waste to the treatment plant. In either case, leachate, if left untreated, can be a potential source of PFAS to the POTWs. In Part 1 of this project, a survey was conducted of landfills in the state. Information provided on leachate management is shown in Table 3-8, representing feedback from twelve of the sixteen landfill operators in Massachusetts to whom the survey was sent. All but one of the facilities reports collecting leachate, with the leachate typically sent to a POTW for treatment.

Table 3-8. Leachate Management Approach for Massachusetts Respondents to Landfill Operator Survey

Facility Name	Is there leachate collection at the landfill? If yes, please describe how it is managed.
Bondi's Island Landfill	Yes. Pumped to a local POTW.
Bourne Landfill	Yes. Pumped to two onsite storage tanks then transported off site for treatment.
Crapo Hill Landfill	Yes. Pumped into the sewer system.
Gardner WPCF Sludge Monofill	Yes. Underdrain to a pump station back to a POTW
Hull Sanitary Landfill	Yes. Stored in storage tanks then pumped to a nearby sanitary sewer.
Middleborough Sanitary Landfill	Yes. Stored in tanks and trucked off site.
Peabody Ash Monofill	Yes. Leachate undergoes pre-treatment before draining via gravity to a local POTW.
Peabody South Mound Swale	Yes. Managed through the sewer system.
Resource Control, Inc. - RCI Fitchburg Landfill	Yes. Sewer connection.
Templeton WWTF Sludge Monofill	No.
Upper Blackstone Clean Water (Ash Monofill)	Yes. Pumped to the facility headworks.
Wheelabrator Millbury Inc. (Shrewsbury Monofill)	Yes. Managed through a municipal sewer system.

3.3.2 Leachate - Selected Technologies for Further Analysis

Treatment of leachate for PFAS removal poses specific challenges due to leachate's high organic and salt content. Applying commonly used technologies for water and waste streams, such as media sorption via GAC or IX, may be less efficient for leachate treatment as significant levels of co-contaminants (e.g. organics and ions) reduces adsorption capacity and media fouling may occur resulting in contaminant breakthrough. This incurs high operation and maintenance costs as media requires more frequent replacement. Other emerging technologies, such as advanced oxidation

process (AOP), advanced reduction process (ARP), or electrochemical oxidation (EO), supercritical water oxidation (SCWO), and plasma may be potentially viable options, demonstrating effective treatment of PFAS in bench-scale and pilot testing. However, most of these chemical destructive techniques have limited scalability to full scale application and require further field verification. SWCO (see Section 3.1.2), for example, could be potentially viable for management of residuals (i.e., foamate), but may not be suitable for raw leachate due to the waste stream's complex matrix. Of the remaining well-established and mature technologies, reverse osmosis and foam fractionation were selected for consideration as potential leachate treatment options in this analysis. Both alternatives are the furthest-developed, most commercially available, and widely implemented technologies for leachate PFAS treatment and can be implemented with limited leachate pretreatment.

Reverse Osmosis

Reverse Osmosis (RO) is a separation process that uses a membrane to separate and concentrate constituents at the molecular level from water via high pressure. RO is effective at removing PFAS and most other leachate constituents by concentrating contaminants into a side-stream that must be subsequently managed (e.g., via destruction or sequestration of contaminants). RO has reduced efficacy with lower molecular weight compounds such as VOCs and short chain PFAS. In most cases, RO requires a very clean influent to prevent membrane fouling. In a leachate application, conventional RO membranes (e.g., spiral wound desalination type) require prefiltration by ultrafiltration (UF), and perhaps nanofiltration (NF), as well as removal of most organic materials to reduce/prevent fouling. As such, conventional membranes are suitable as a final polishing step only when coupled with other technologies for pretreatment such as Membrane Bioreactor (MBR) biological treatment. Conventional RO has been used successfully with pretreated leachate (e.g., after MBR) with a typical leachate concentrate volume of 30% of the feed volume. Thus, the leachate concentrate has about three times the concentration of constituents of the RO influent and must be disposed. Conventional RO has been shown to remove PFAS to below about 5 ng/L and in some cases below detection limits (less than 2 ng/L), but effluent (permeate) concentrations vary depending on the specific compound and overall liquid matrix characteristics. Permeate concentrations are dependent, in part, on influent concentrations since compound rejection percentage is relatively constant. Hence, increased influent concentrations result in increased effluent concentrations although the percent removal is similar. Accordingly, it is important that constituents in the RO leachate concentrate be effectively sequestered prior to disposal to avoid re-entrainment into the leachate and subsequent increases in raw leachate concentrations if the leachate concentrate is to be placed back in the landfill for disposal.

A variant of RO is NF, which is often termed a "loose" RO membrane (i.e., with slightly larger pores). NF has been shown to partially (approximately 90-99%) remove long-chain compounds. The removal efficiency of NF on PFOA/PFOS is also less than RO which may make this technology applicable for pretreatment options although it may not address future regulatory requirements satisfactorily. NF is more effective at removing PFOS than PFOA since PFOS has a higher molecular weight.

A different RO configuration is offered by Rochem Americas (Rochem) that has been demonstrated to operate effectively on raw leachate (with preliminary filtration at 10 microns [µm]). The Rochem system uses an alternative membrane construction with spacers and a high crossflow velocity to reduce fouling coupled with higher operating pressures than conventional membranes (up to about 1,800 pounds per square inch). Rochem reports achieving PFAS concentrations for a broad list of PFAS compounds to below detections limits (>2 ng/L) in raw leachate applications using a two-stage system (>99.9% removal). Removals to about 5 ng/L can be achieved with a single stage system. Rochem also offers a three-stage system that improves permeate recovery, thus potentially reducing leachate concentrate to approximately 12-15% of RO feed volume.

Foam Fractionation

Foam Fractionation (FF), as discussed in Section 3.1.1 for wastewater liquid fraction treatment, is a separation (bubble separation) process that removes surfactants such as PFAS dissolved in an aqueous solution. Gas (typically air) is bubbled through an aqueous solution of surfactants which partition to the surface of the rising bubbles. This reaction forms a foam layer above the liquid pool, and this can be removed to form a "foamate" liquid that is enriched in PFAS. The residual liquid at the bottom of the column is PFAS depleted. Additives such as surfactants and polymer have been used to enhance removal of select compounds (particularly shorter chain PFAS).

Foam fractionation has been shown to effectively remove ≥99.5% of long chain PFAS such as PFOS, PFHxS, and PFOA in leachate. There are several configurations available, but the system may be comprised of up to three foam fractionation stages in series to achieve a highly enriched concentrate. The first stage, known as the primary fractionator, strips PFAS from the contaminated feed and produces a PFAS-depleted effluent, which may be routed to an adsorptive polishing unit, The primary foamate containing the PFAS waste stream forms the feed to the second stage (secondary fractionation). Thereafter, the secondary foamate forms the feed to the third stage (tertiary fractionation). The effluent from both the secondary and tertiary fractionation stages are recycled back into the feed of the primary fractionation stage. The tertiary foamate, highly enriched in PFAS (at very low volumes) is stored for disposal such as via destruction or solidification/sequestration, Foamate volume is typically on the order of 1% of the overall treated volume.

Foam fractionation is a relatively simple technology with variable PFAS removal efficiency depending on operating conditions and liquid matrix. It is best suited for low to medium flow criteria but may be challenging for high flow capacities (>0.5 MGD or 350 gpm). This is primarily because high flows are typically associated with municipal wastewater applications where PFAS concentrations are relatively dilute compared to landfill leachate or other industrial applications. FF vendors may have pre-engineered systems with a defined maximum capacity based on pump and piping capacity, minimum contact times, etc. Although system capacity could be increased by adding additional units, practical considerations such as space, pump and piping networks and controls could limit the ultimate flow capacity for a given installation particularly for very high flows. Further, leachate foaming characteristics and treatment targets are site specific and therefore may impact system capacity.

Implementation of Leachate Treatment Technologies

Installation of RO and FF technologies for treatment of leachate may be employed at the landfill site where the leachate is generated, at a POTW where the leachate can be treated separately or combined with outer PFAS-contaminated waste streams. Table 3-9 provides an evaluation of some of the advantages and disadvantages of implementing these treatment options at either location to determine cost and technical feasibility.

Table 3-9. Pros and Cos of Leachate Treatment Technologies by Location		
Treatment Location	Advantages	Disadvantages
POTW	• Existing infrastructure may be available to support treatment system • Current POTW staff already familiar with overall wastewater treatment process may be utilized for system operation of treatment • Mixing leachate to head of treatment plant as influent is feasible • Ability to efficiently treat leachate from multiple landfills is possible • Handling of PFAS treatment residuals may be incorporated into existing residual management program	• Will need to haul leachate from landfill site to POTW for treatment which could be costly • May involve considerable permitting efforts that could delay implementation • New PFAS treatment system could require land area that may not be available at POTW
Landfill	• Implementation of treatment option at landfill may be faster due to less procurement and/or permitting hurdles • Leachate will be treated onsite minimizing the need to haul off untreated waste stream • Landfill site may have more flexibility in accommodating required treatment system footprint • Management of residuals may be facilitated by existing infrastructure (i.e., use of excess landfill gas or onsite disposal after solidification/sequestration) • If residuals are sequestered, no off-site hauling would be required	• Greater financial burden and management risk as responsibility solely falls to the landfill owner • Landfill site may require significant new infrastructure to support treatment system • New personnel may need to be hired/trained to operate new system

3.4 Life Cycle Cost Evaluation of Representative Technologies

In the previous sections, several technologies have been identified and summarized for PFAS mitigation and solids reduction. This section will summarize the 20-year life cycle cost evaluations for the most advantageous technologies identified including O&M and conceptual capital costs curves for these technologies. In addition, the 20-year life cycle costs will be evaluated for the incineration retrofits at UBCW and Lynn Regional Water Pollution Control Facility.

These curves were designed to be in a similar format to an analogous analysis done for the Minnesota market by Barr Engineering and Hazen and Sawyer to allow for easy comparison (Ling et al., 2023).

3.4.1 Facility Size Ranges

Based on survey information collected from the POTWs in MA in Part 1 of this project, representative facility sizes and types for small, medium, medium-large and large facilities were determined. The "medium-large" size was added for biosolids technologies only (except dewatering) since most of the biosolids technologies are known to not be economically viable at the "small" size, and three sizes were needed to make a meaningful cost curve. Table 3-10 summarizes the four facility flows assumed for the cost evaluation as well as the three leachate flows assumed, which have significantly smaller volumes. The MWRA Deer Island WWTP is significantly larger than any other POTW in the state and will have unique considerations. (Note: MassDEP defines "small" facilities as those with design or permitted flow less than 1 mgd, "medium" as those less than 5 mgd, and "large" as greater than 5 mgd. Slightly different sizes were used in this analysis to provide a more useful range for cost curves.)

Table 3-10. Representative Facility Flows Evaluated		
POTW Facility Flows		
	Influent Flow (mgd)	Biosolids Production (dtpy)
Small	0.5	90
Medium	5	900
Medium-Large[1]	10	1,800
Large	20	3,600
Leachate Flows		
	Leachate Influent Flow (gpd)	
Small	25,000	
Medium	100,000	
Large	250,000	

1. Facility size for sludge technologies only, except dewatering

3.4.2 Net Present Cost Methodology

The net present cost (NPC) calculations are structured as follows:

- Facility flows and loads are static over the 20-year period.
- Capital costs are incurred in the first year of the period.
- Where alternatives require new equipment, they are sized based on the facility size identified in Table 3-10.

NPC is calculated over 20 years with escalation and discount rates based on the last update of the White House Office of Management and Budget Circular A-94 Appendix C. The general NPC assumptions are shown in Table 3-11.

Table 3-11. NPC Assumptions	
Component	NPC assumption
NPC term, years	20
Nominal discount rate, annual percentage	2.2%
Escalation rate, annual percentage	4.7%

Conceptual Capital Costs Approach

Capital cost estimates developed for the technologies are based on Class 5 conceptual cost estimates per the Association for the Advancement of Cost Engineering International (AACEI), which carry a level of accuracy of -50 to +100%. Major equipment costs are based on vendor budgetary estimates and comparable recent project costs. Where a vendor budgetary quote was obtained, the equipment cost was multiplied by a sequence of standard cost estimate planning factors to develop an overall estimated project cost. The capital costs reflect equipment that is sized based on an assumed 1.5 peaking factor for the facility size represented. Table 3-12 summarizes the markups

used for each of the technologies to develop the total capital costs, unless otherwise noted. The following sections will detail the various components (equipment, tanks, new buildings, etc.) included as part of the capital costs for individual scenarios.

Capital cost curves are developed for the various technologies in the following sections. Note that the cost equations listed should not be used at facility sizes significantly outside of the ranges shown.

Table 3-12. A Summary of Capital Costs Markups

Miscellaneous Demolition	5%
Installation (on process equipment only)	20%
Electrical, Instrumentation, & Controls	50%
Site Work[1]	10%
Miscellaneous Piping[2]	15%
Excavation and Soil Disposal	9%
Startup and Construction Sequencing	2%
General Conditions	15%
Contractor Overhead and Profit	20%
Sales Tax	6%
Bonds and Insurance	3%
Engineering	10%
Construction Management	10%
Estimating Contingency[1]	30%

1. *For SWCO systems, the markup for site work was 20% and the estimating contingency was 50%*
2. *For centrifuges, the markup for miscellaneous piping is 20%*

Operational and Maintenance Costs Approach

Unit costs representative of current costs for facilities in Massachusetts were used and assumed to be consistent throughout the state. These unit costs were applied to the estimated electricity, natural gas, and chemical demand for each technology to obtain annual cost estimates. The associated demands were estimated based on the facility size as provided either by a vendor or calculated. Additional O&M costs evaluated were operational and maintenance staff as well as any spare parts or additional maintenance required. The additional maintenance is a percentage of mechanical equipment costs or known values provided by vendors. Table 3-13 describes the unit costs used for the annual O&M cost evaluations. Note that biochar management is assumed to be $0 per wt. This assumption was made based on conversations with pyrolysis vendors such as Bioforcetech. Bioforcetech can enter into an offtake agreement with the POTW wherein the product is managed by Bioforcetech. Contracts can be structured so that any revenue generated from sales is shared with the POTW; however, revenue potential was not included as part of this analysis. The actual value or management cost for the solids residual needs to be carefully evaluated on a case-by-case basis at the time of project development.

O&M cost curves were developed for the various technologies in the following sections. Note that the cost equations listed should not be used at facility sizes significantly outside of the ranges shown. Unit costs can vary significantly over time, in different locations and at different plant sizes, so calculated O&M costs have significant uncertainty.

Table 3-13. Assumptions for Operations and Maintenance Cost Analyses

Cost element	Facility Size	Units	Value in model	Basis
Solids handling and disposition				
Wastewater sludge management (hauling and tip fee)	All	$/wt	$156.00	Part 1 report
Biochar management	All	$/wt	$0.00	Based on conservative assumption around typical contractual arrangement with vendor
Foam fractionation and reverse osmosis residuals management	All	$/gal	$0.45	Based on similar projects, assumes that the residuals would be mixed with cement and sequestered in landfills
Electricity				
Electricity costs – blended rate	Small	$/kWh	$0.20	Based on EIA MA Industrial data
	Medium	$/kWh	$0.18	Based on EIA MA Industrial data
	Medium-Large	$/kWh	$0.17	Based on EIA MA Industrial data and recent MA plant electric data
	Large	$/kWh	$0.16	Based on EIA MA Industrial data and recent MA plant electric data
Natural gas costs				
Natural gas – blended rates	Small	$/therm	$1.40	Based on EIA MA commercial/industrial data
	Medium	$/therm	$1.00	Estimated based on MA DPU data; significant variation based on heating load/usage profile
	Medium-Large	$/therm	$0.80	Estimated based on MA DPU data; significant variation based on heating load/usage profile
	Large	$/therm	$0.80	Estimated based on MA DPU data; significant variation based on heating load/usage profile
Chemical costs				
Polymer cost – screw press	All	$/lb- neat polymer	$1.30	Based on recent projects
Polymer cost – centrifuge	All	$/lb- neat polymer	$1.50	Based on recent projects
Maintenance costs				
Major equipment – percent of equipment cost		percent	2% per year	Typical assumption
Labor				
Operator/maintenance labor cost	Small	$/hr-FTE	$55.00	Based upon state average salary estimates
	Medium	$/hr-FTE	$60.00	Based upon state average salary estimates
	Medium-Large	$/hr-FTE	$65.00	Based upon state average salary estimates
	Large	$/hr-FTE	$70.00	Based upon state average salary estimates
Media Exchange Cost				
GAC	Small	$195,000/yr	$55.00	Assumes two media exchanges per year; costs based on vendor quotes
	Medium	$1,950,000/yr	$60.00	Assumes two media exchanges per year; costs based on vendor quotes
	Large	$7,800,000/yr	$65.00	Assumes two media exchanges per year; costs based on vendor quotes
IX	Small	$170,000/yr	$55.00	Assumes two media exchanges per year; costs based on vendor quotes

Table 3-13. Assumptions for Operations and Maintenance Cost Analyses				
Cost element	Facility Size	Units	Value in model	Basis
	Medium	$1,700,000/yr	$60.00	Assumes two media exchanges per year; costs based on vendor quotes
	Large	$6,800,000/yr	$65.00	Assumes two media exchanges per year; costs based on vendor quotes
GAC & IX	Small	$215,000/yr	$55.00	Assumes two media exchanges per year; costs based on vendor quotes
	Medium	$2,150,000/yr	$60.00	Assumes two media exchanges per year; costs based on vendor quotes
	Large	$8,600,000/yr	$65.00	Assumes two media exchanges per year; costs based on vendor quotes

3.4.3 Wastewater Liquid Fraction PFAS Treatment Technologies

For the wastewater liquid fraction, the most advantageous technologies evaluated are GAC, IX, and GAC and IX in series. See Section 3.6.1 for discussion of non-cost criteria. The following sections outline the cost curves including capital and O&M costs for three facility sizes with capacities of 0.5, 5, and 20 mgd. The section concludes with the NPC results.

Granular Activated Carbon

Capital Costs

The capital costs include the following components:

- Pressure vessels
- Media
- Pumps
- Pump station
- Yard piping
- Building

The equipment costs for both the main GAC equipment and ancillary equipment were developed using quotes for similar installations and escalated to today's dollars and the correct geographic area as needed. The treatment building cost is developed using a unit cost of $564 per square foot. The building was sized to fit the main and ancillary equipment treatment equipment. The estimated footprints for the facilities are 1,200, 6,000, and 18,000 square feet for small, medium, and large flow rates, respectively. Markups for the above-listed capital cost components are listed in Table 3-12. A capital cost breakdown for GAC at low, medium, and large flow rates can be found in Appendix I.

Figure 3-1. summarizes the capital costs associated with GAC for the three facility sizes. As shown in the figure, the trend between the facility size and capital cost is mostly linear since the amount of media required, size/quantity of pumps, and building size are dictated by and proportional to the system design flow. The orange, center line shows three points for the small, medium, and large facility sizes used to create the trend line. The figure also shows a +100% and -50% estimating range in blue above and below the estimated capital cost line.

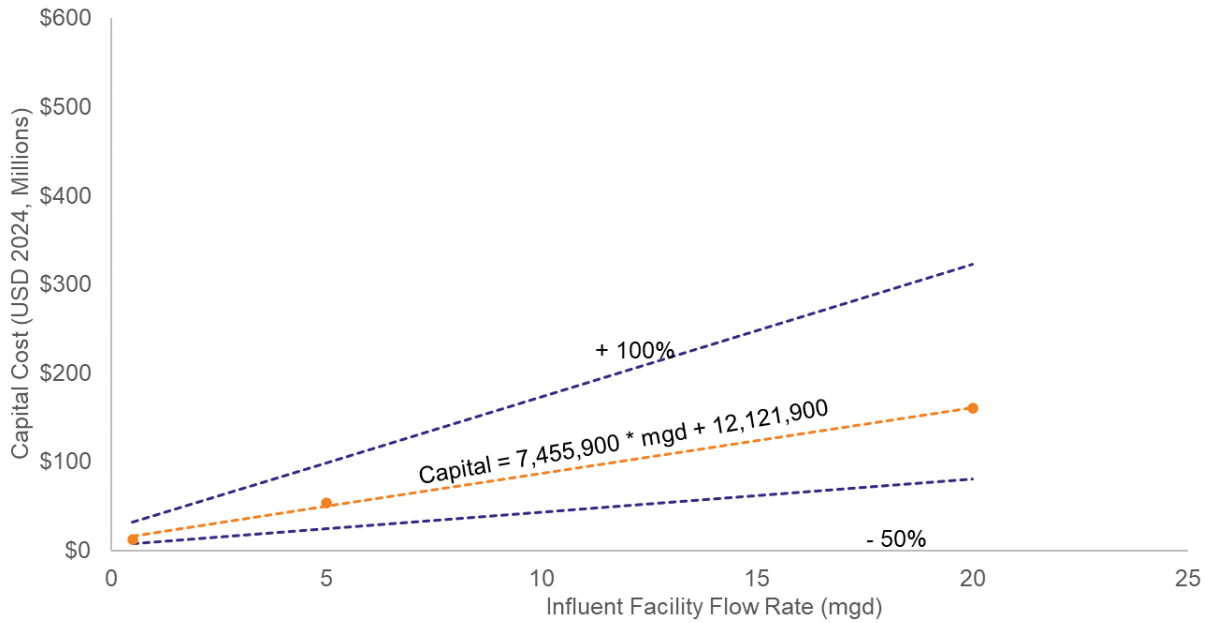


Figure 3-1. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of GAC

Operations and Maintenance Costs

The major assumed O&M costs associated with this technology are the following:

- Electricity (assumed facility operating 12 hours per day)
- Media replacement
- Spare parts
- Operational and maintenance labor
- Each of these items contribute to the overall O&M cost on an annual basis. Media exchange costs make up the bulk of O&M costs. It should be noted that required media exchange frequency is difficult to estimate without bench testing. Depending on treatment goals, the actual O&M costs attributed to media exchanges can vary significantly.

As shown in Table 3-14, media replacement/exchange and spare parts have an associated annual cost. Electrical costs are on a MWh/yr basis which can then be multiplied by the assumed unit prices for electricity shown in Table 3-13. Labor, including operations and maintenance, is calculated using full-time equivalents (FTE) and then multiplied by the assumed wages listed in Table 3-13.

Table 3-14. O&M Totals Per Component - GAC						
Facility Size	O&M Cost Item	Unit	Total	Unit Cost Assumptions (from Table 3-13)	Total O&M Cost ($/yr)	Total O&M Cost by Facility Size
Small (0.5 mgd)	Media Exchange	$/yr	$195,000	N/A	$195,000	$420,000
	Electricity	MWh/yr	500	$0.20 /kWh	$100,000	
	Spare Parts	$/yr	$10,000	N/A	$10,000	
	Labor	FTE	1.0	$55 /hr	$114,400	
Medium (5 mgd)	Media Exchange	$/yr	$1,950,000	N/A	$1,950,000	$2,591,000
	Electricity	MWh/yr	2700	$0.18 /kWh	$486,000	
	Spare Parts	$/yr	$30,000	N/A	$30,000	
	Labor	FTE	1.0	$60 /hr	$124,800	
Large (20 mgd)	Media Exchange	$/yr	$7,800,000	N/A	$7,800,000	$9,263,000
	Electricity	MWh/yr	7400	$0.16 /kWh	$1,184,000	
	Spare Parts	$/yr	$60,000	N/A	$60,000	
	Labor	FTE	1.5	$70 /hr	$218,400	

Figure 3-2 summarizes the O&M costs in Table 3-14 associated with GAC for the three facility sizes on a yearly basis. Again, the trend is mostly linear since the amount of media requiring replacement and power demand is proportional to the system design flow.

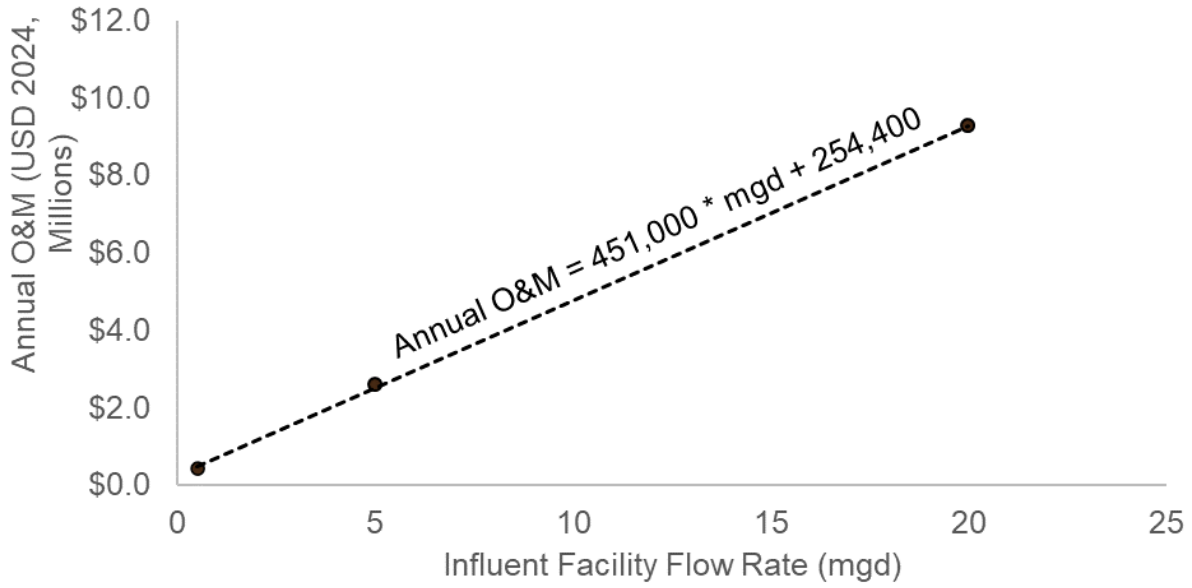


Figure 3-2. Annual Estimated O&M Cost Curve for GAC

Ion Exchange

Capital Costs

The capital costs include the following components:

- Pressure vessels
- Media

- Pumps
- Pump station
- Yard piping
- Building

The equipment costs for both the main IX equipment and ancillary equipment were developed using quotes for similar installations and escalated to today's dollars and the correct geographic area as needed. The treatment building cost is developed using a unit cost of $564 per square foot. The building was sized to fit the main and ancillary equipment treatment equipment. The estimated footprints for the facilities are 1,200, 6,000, and 20,000 square feet for small, medium, and large flow rates, respectively. Markups for the above-listed capital cost components are listed in Table 3-12. A capital cost breakdown for IX at low, medium, and large flow rates can be found in Appendix I.

Figure 3-3 capital summarizes the capital costs associated with IX for the 3 facility sizes. Similar to GAC, the trend between the facility size and capital cost is mostly linear since the amount of resin required, size/quantity of pumps, and building size are dictated and proportional to the system design flow. The orange, center line shows three points for the small, medium, and large facility sizes used to create the trend line. The figure also shows a +100% and -50% estimating range in blue above and below the estimated capital cost line

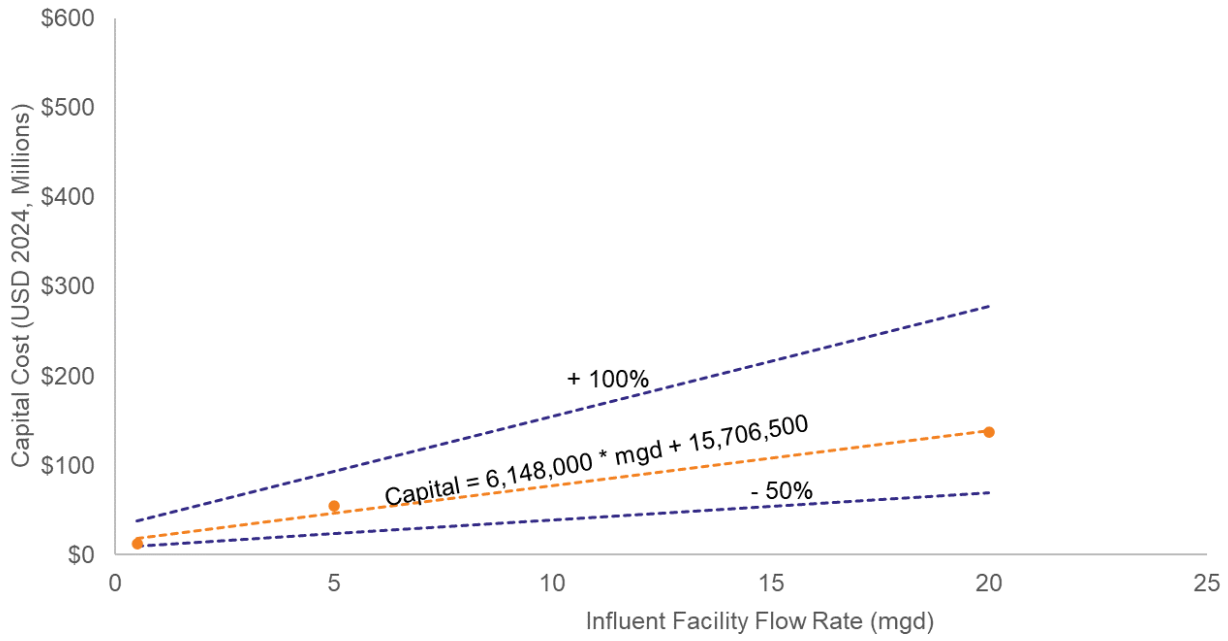


Figure 3-3. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of IX

Operations and Maintenance Costs

The assumed O&M costs associated with this technology are the following:

- Electricity (assumed facility operating 12 hours per day)
- Media replacement
- Spare parts
- Operational and maintenance labor

Each of these items contribute to the overall O&M cost on an annual basis. Media exchange costs make up the bulk of O&M costs. It should be noted that required media exchange frequency is difficult to estimate without bench testing. Depending on treatment goals, the actual O&M costs attributed to media exchanges can vary significantly.

As shown in Table 3-15, media replacement/exchange and spare parts have an associated annual cost. Electrical costs are on a MWh/yr basis which can then be multiplied by the assumed unit prices for electricity shown in Table 3-13. Labor, including operations and maintenance, is calculated using full-time equivalents (FTE) and then multiplied by the assumed wages listed in Table 3-13.

Table 3-15. O&M Totals Per Component - IX

Facility Size	O&M Cost Item	Unit	Total	Unit Cost Assumptions (from Table 3-13)		Total O&M Cost (in $/yr)	Total O&M Cost by Facility Size
Small (0.5 mgd)	Media Exchange	$/yr	$170,000	N/A		$170,000	$555,000
	Electricity	MWh/yr	1240	$0.20	/kWh	$248,000	
	Spare Parts	$/yr	$22,000	N/A		$22,000	
	Labor	FTE	1.0	$55	/hr	$114,400	
Medium (5 mgd)	Media Exchange	$/yr	$1,700,000	N/A		$1,700,000	$3,767,000
	Electricity	MWh/yr	10400	$0.18	/kWh	$1,872,000	
	Spare Parts	$/yr	$70,000	N/A		$70,000	
	Labor	FTE	1.0	$60	/hr	$124,800	
Large (20 mgd)	Media Exchange	$/yr	$6,800,000	N/A		$6,800,000	$10,573,000
	Electricity	MWh/yr	20900	$ 0.16	/kWh	$3,344,000	
	Spare Parts	$/yr	$210,000	N/A		$210,000	
	Labor	FTE	1.5	$70	/hr	$218,400	

Figure 3-2 summarizes the O&M costs in Table 3-14 associated with GAC for the three facility sizes on a yearly basis. Again, the trend is mostly linear since the amount of media requiring replacement and power demand is proportional to the system design flow.

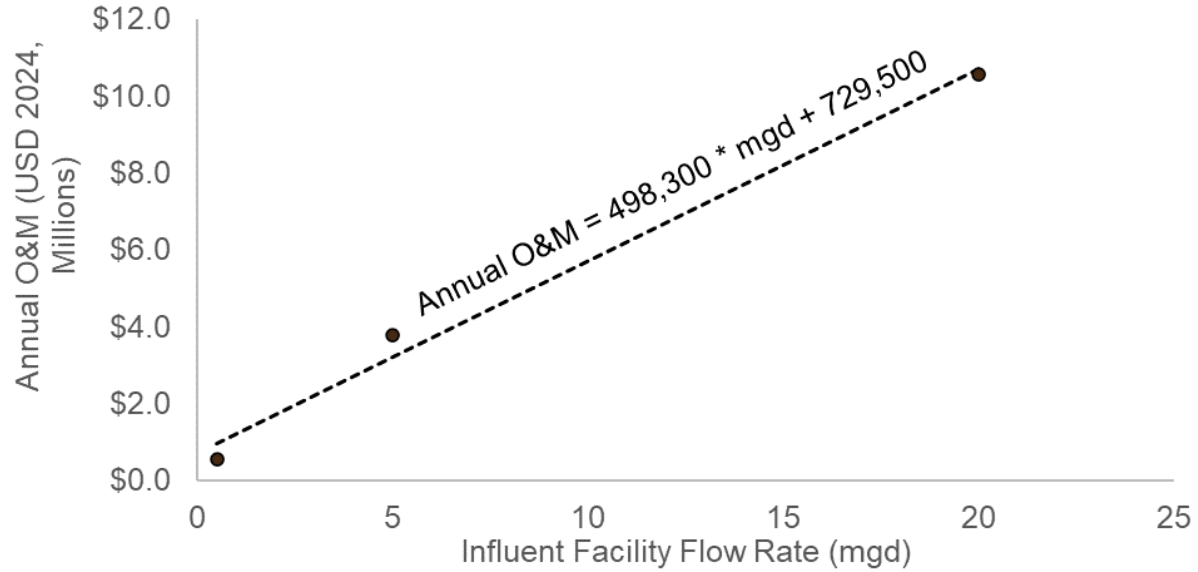


Figure 3-4. Annual Estimated O&M Cost Curve For IX

Granular Activated Carbon with Ion Exchange

Capital Costs

The capital costs include the following components:

- Pressure vessels
- Media
- Pumps
- Pump station
- Yard piping
- Building

The equipment costs for both the main GAC with IX equipment and ancillary equipment were developed using quotes for similar installations and escalated to today's dollars and the correct geographic area as needed. The treatment building cost is developed using a unit cost of $564 per square foot. The building was sized to fit the main and ancillary equipment treatment equipment. The estimated footprints for the facilities are 1,200, 6,000, and 18,000 square feet for small, medium, and large flow rates, respectively. Markups for the above-listed capital cost components are listed in Table 3-12. A capital cost breakdown for GAC with IX at low, medium, and large flow rates can be found in Appendix I.

Figure 3-5 summarizes the capital costs associated with GAC with IX for the three facility sizes. As with the other alternatives, the trend between the facility size and capital cost is mostly linear since the amount of media required, size/quantity of pumps, and building size are dictated and proportional to the system design flow. The orange, center line shows three points for the small, medium, and large facility sizes used to create the trend line. The figure also shows a +100% and -50% estimating range in blue above and below the estimated capital cost line.

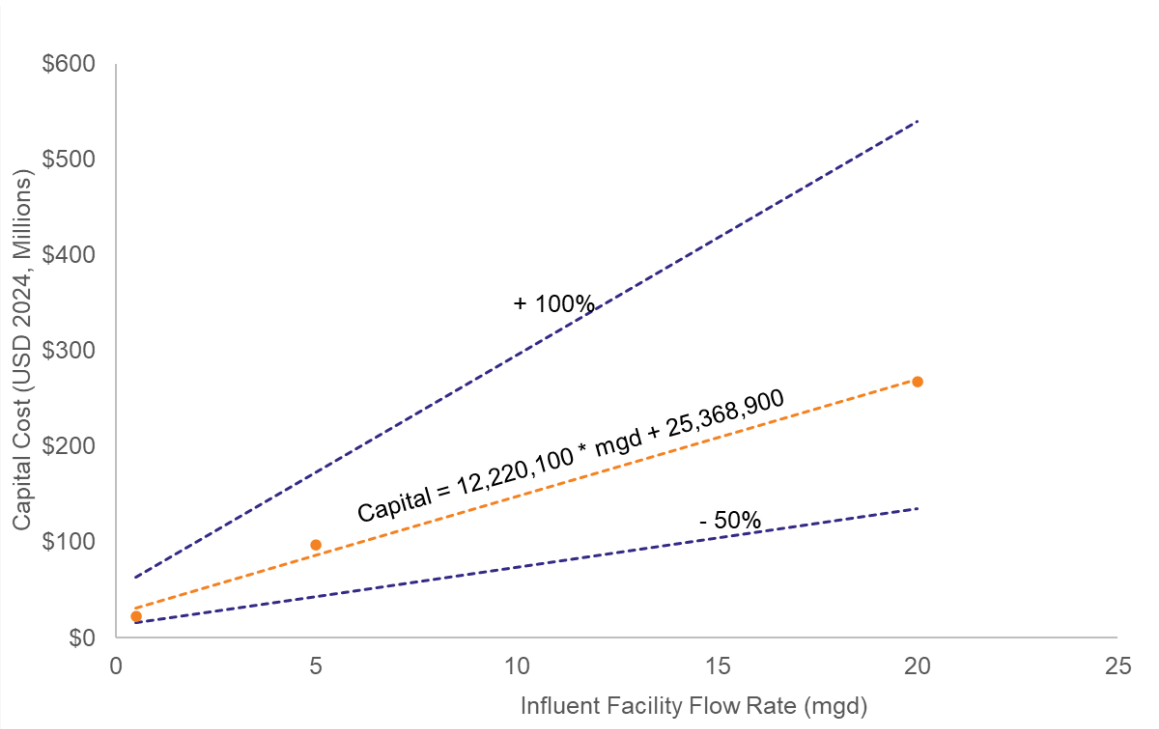


Figure 3-5. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of GAC+IX

Operations and Maintenance Costs

The major O&M cost associated with this technology are the following:

- Electricity (assumed facility operating 12 hours per day)
- Media replacement
- Spare parts
- Operational and maintenance labor

Each of these items contribute to the overall O&M cost on an annual basis. Media exchange costs make up the bulk of O&M costs. It should be noted that required media exchange frequency is difficult to estimate without bench testing. Depending on treatment goals, the actual O&M costs attributed to media exchanges can vary significantly.

As shown in Table 3-16, media replacement/exchange and spare parts have an associated annual cost. Electrical costs are on a MWh/yr basis which can then be multiplied by the assumed unit prices for electricity shown in Table 3-13 . Labor, including operations and maintenance, is calculated using full-time equivalents (FTE) and then multiplied by the assumed wages listed in Table 3-13.

Table 3-16. O&M Totals Per Component – GAC with IX

Facility Size	O&M Cost Item	Unit	Total	Unit Cost Assumptions (from Table 3-13)	Total O&M Cost ($/yr)	Total O&M Cost by Facility Size
Small (0.5 mgd)	Media Exchange	$/yr	$215,000	N/A	$215,000	$511,000
	Electricity	MWh/yr	800	$0.20 /kWh	$160,000	
	Spare Parts	$/yr	$21,000	N/A	$21,000	
	Labor	FTE	1.0	$55 /hr	$114,400	
Medium (5 mgd)	Media Exchange	$/yr	$2,150,000	N/A	$2,150,000	$3,582,000
	Electricity	MWh/yr	6900	$0.18 /kWh	$1,242,000	
	Spare Parts	$/yr	$65,000	N/A	$65,000	
	Labor	FTE	1.0	$60 /hr	$124,800	
Large (20 mgd)	Media Exchange	$/yr	$8,600,000	N/A	$8,600,000	$11,173,000
	Electricity	MWh/yr	13900	$0.16 /kWh	$2,224,000	
	Spare Parts	$/yr	$130,000	N/A	$130,000	
	Labor	FTE	1.5	$70 /hr	$218,400	

Figure 3-6 summarizes the O&M costs associated with GAG+IX for the three facility sizes on a yearly basis. Again, the trend is mostly linear since the amount of media requiring replacement and power demand is proportional to the system design flow.

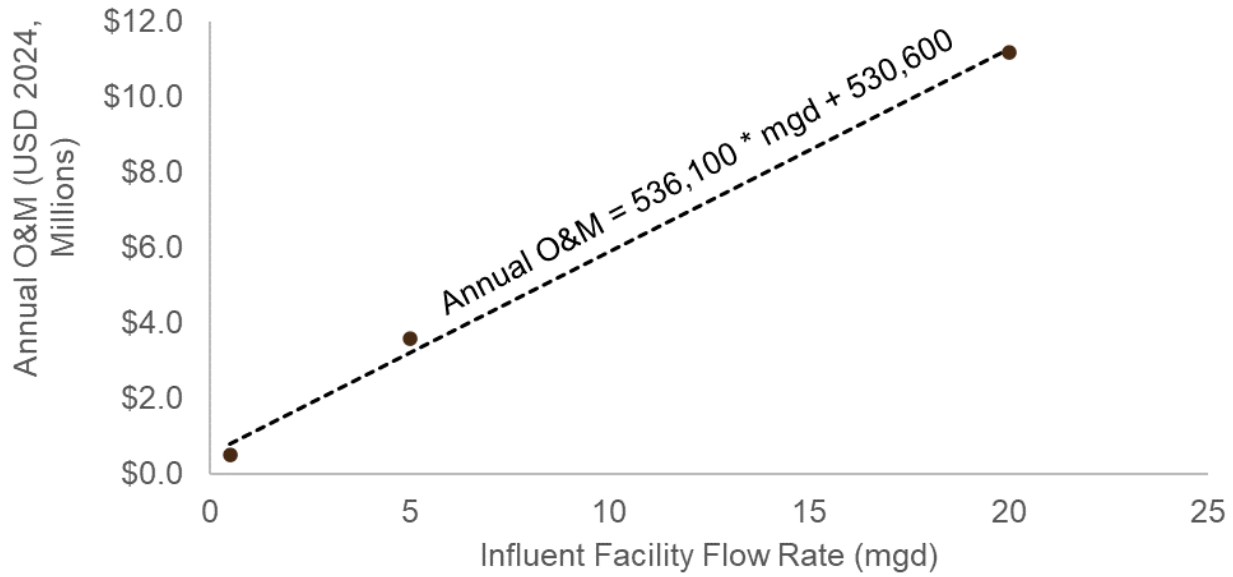


Figure 3-6. Annual Estimated O&M Cost Curve of GAC+IX

Net Present Cost Results

Based on the Class 5 capital cost estimates and estimated annual O&M costs, the 20-year NPC for PFAS mitigation of the liquid fraction wastewater is displayed in Figure 3-7. The basis for the "Small," "Medium," and "Large" Facilities was a design flowrate of 0.5, 5.0, and 20 mgd, respectively. The NPC of the Medium Facility is approximately five times greater than for the Small Facility, compared to ten times the treated flow. The NPC of the Large Facility is approximately three times greater than for the Medium Facility, compared to four times the treated flow. In terms of the treatment alternatives evaluated, GAC and IX have comparable NPCs for each facility size. The GAC + IX alternative has an NPC approximately 20-25% more expensive for each facility size. This is largely due to the higher media exchange costs associated with this alternative.

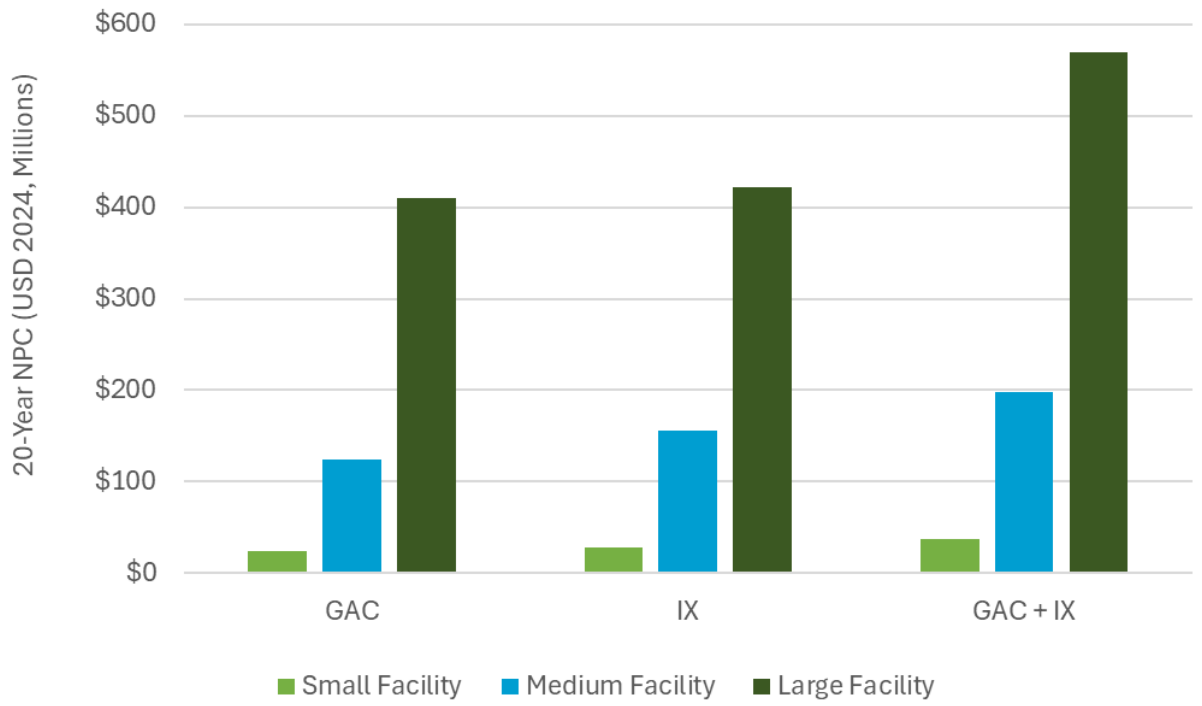


Figure 3-7. A Summary of the 20-Year NPC for Liquid Fraction of Wastewater PFAS Mitigation Technologies

Small = 0.5 MGD, Medium = 5 MGD, Large = 20 MGD

Economies of scale are realized for all three approaches. Cost savings is largely due to ancillary items that can be consolidated with larger projects such as project management, design services, and pipe trenching. Due to this effect, construction of larger treatment facilities that may be a combination of smaller treatment units is likely economically advantageous to just constructing smaller individual treatment facilities.

3.4.4 Sludge Volume Reduction and PFAS Treatment Technologies

For the solids fraction of wastewater, the technologies evaluated for volume reduction are dewatering (centrifuges and screw presses), mesophilic anaerobic digestion, and thermal drying (belt and rotary drum). To assess potential PFAS treatment technologies, pyrolysis, gasification, and SCWO were evaluated, along with retrofitting existing incinerators for PFAS treatment. Sludge volume reduction technologies are proven, well established technologies; however, they do not treat for PFAS. They would be installed upstream of the PFAS treatment technologies discussed in this section. For instance, dewatering and drying are required prior to gasification and pyrolysis. Dewatering would be ahead of SCWO. Digestion can be ahead of any of these treatment technologies, but it is not required. As previously mentioned, anaerobic digestion stabilizes sludge prior to dryer and other advanced technologies. It can reduce volatile organic fraction up to 65 percent, thereby producing an energy-rich biogas. This biogas can be recovered and utilized for heating, electricity production, or renewable natural gas. The following sections outline the cost curves and the NPCs.

Screw Press Dewatering

Capital Costs

The capital cost includes the following components:

- Thickened sludge storage at 4 days at 5% total solids

- Small facility assumes 12 days of storage as the system runs less often
- These storage systems are not for raw primary sludge, but waste activated sludge only
  - Polymer system including dilution and aging tanks and feed pumps
  - Conveyors
  - Feed pumps
  - Screw Press equipment (assume duty+1 standby)
  - Odor control
  - Building

The equipment costs for both the main equipment and ancillary equipment were developed using quotes for similar installations and escalated to today's dollars and the correct geographic area as needed. The treatment building cost is developed using a unit cost of $564 per square foot. The building was sized to fit the main and ancillary equipment treatment equipment. Markups for the above listed capital cost components are listed in Table 3-12. A capital cost breakdown for screw press dewatering at low, medium, and large flow rates can be found in Appendix I.

Figure 3-8 summarizes the capital costs associated with screw presses for different facility sizes. The orange, center line shows three points for the small, medium, and medium-large facility sizes used to create the trend line. The figure also shows a +100% and -50% estimating range in blue above and below the estimated capital cost line.

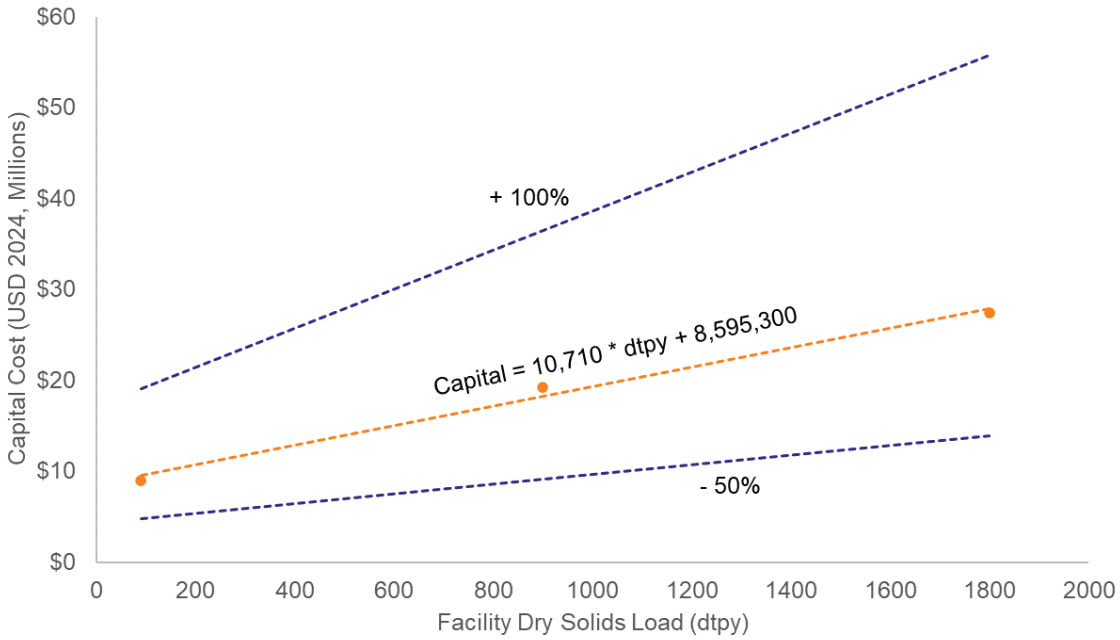


Figure 3-8. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of Screw Presses

Operations and Maintenance Costs

The major O&M cost associated with this technology is solids management. The additional assumed O&M costs associated with this technology are the following:

- Electricity (assumes 8 hours a day)
- Polymer

- Spare Parts
- Labor

Each of these items contribute to the overall O&M cost on an annual basis. Biosolids management costs are based on the dry tonnage and the total solids percentage of these biosolids. This is then multiplied by the hauling fee per wet ton in Table 3-13 to determine an overall associated cost. Electricity costs are on a kWh/yr basis which can then be multiplied by the assumed unit prices for electricity shown in Table 3-13. Polymer costs are similarly on a lbs-neat/yr basis that is then multiplied by a unit cost for polymer from Table 3-13. Labor, including operations and maintenance, is calculated using FTE and then multiplied by the assumed wages listed in Table 3-13.

Table 3-17. O&M Totals – Screw Press

Facility Size	O&M Cost Item	Unit	Total	Unit Cost Assumptions (from Table 3-13)		Total O&M Cost ($/yr)	Total O&M Cost by Facility Size
Small (0.5 mgd)	Biosolids	dt/yr	90	20%	TS	$70,200	$214,000
				$156	/wt		
	Electricity	kWh/yr	4990	$0.20	/kWh	$1,000	
	Polymer	lb-neat/yr	4737	$1.30	/lb-neat	$6,200	
	Spare Parts	$/yr	$21,900	N/A		$21,900	
	Labor	FTE	1	$55	/hr	$114,400	
Medium (5 mgd)	Biosolids	dt/yr	900	20%	TS	$702,000	$947,000
				$156	/wt		
	Electricity	kWh/yr	15390	$0.18	/kWh	$2,800	
	Polymer	lb-neat/yr	47368	$1.30	/lb-neat	$61,600	
	Spare Parts	$/yr	$55,500	N/A		$55,500	
	Labor	FTE	1	$60	/hr	$124,800	
Medium-Large (10 mgd)	Biosolids	dt/yr	1800	20%	TS	$1,404,000	$1,750,000
				$156	/wt		
	Electricity	kWh/yr	30780	$0.17	/kWh	$5,200	
	Polymer	lb-neat/yr	94737	$1.30	/lb-neat	$123,200	
	Spare Parts	$/yr	$82,300	N/A		$82,300	
	Labor	FTE	1	$65	/hr	$135,200	

Figure 3-9. summarizes the O&M costs associated with screw presses for the three facility sizes.

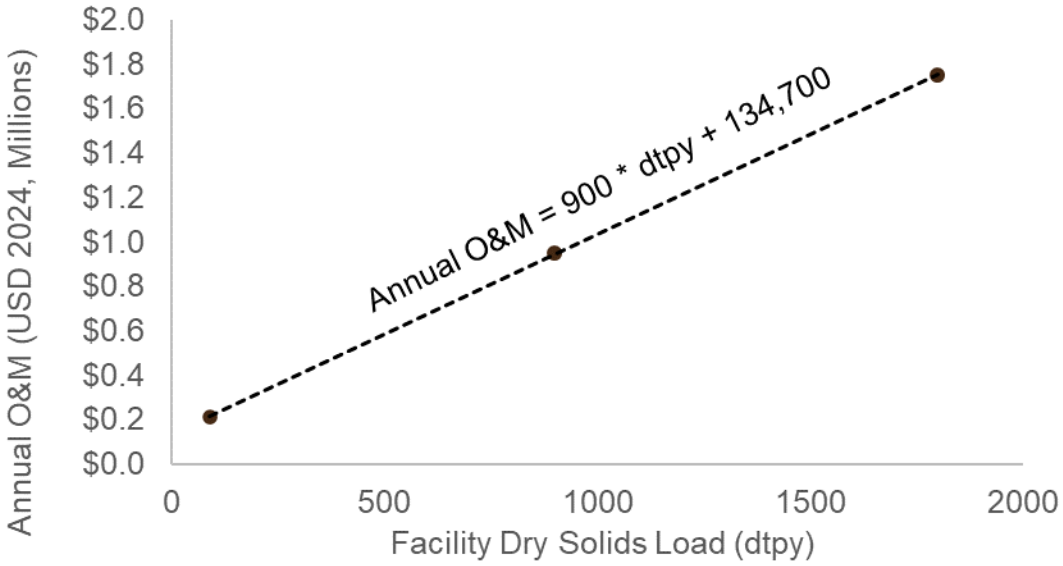


Figure 3-9. Annual Estimated O&M Cost Curve of Screw Presses

As shown in both figures the trends for project costs and O&M are linear. Project costs are linear as they increase with increase solids loading. Additionally, the O&M is also linear as the major O&M cost is associated with solids management. This will increase linearly with increasing solids loading to the system.

Centrifuge Dewatering

Capital Costs

The capital costs include the following components:

- Thickened sludge storage at 4 days at 5% total solids
  - Small facility assumes 12 days of storage as the system run less often
  - These storage systems are not for raw primary sludge, but waste activated sludge only
  - Includes course bubble aeration
- Polymer system including dilution and aging tanks and feed pumps
- Conveyors
- Feed pumps
- Centrifuge equipment (assume duty+1 standby)
- Odor control
- Building

The equipment costs for both the main equipment and ancillary equipment were developed using quotes for similar installations and escalated to today's dollars and the correct geographic area as needed. The treatment building cost is developed using a unit cost of $564 per square foot. The building was sized to fit the main and ancillary equipment treatment equipment. Markups for the above listed capital cost components are listed in Table 3-12. A capital cost breakdown for centrifuge dewatering at low, medium, and large flow rates can be found in Appendix I.

Figure 3-10 summarizes the capital costs associated with centrifuges for facilities at various sizes. The orange, center line shows three points for the small, medium, and medium-large facility sizes used to create the trend line. The figure also shows a +100% and -50% estimating range in blue above and below the estimated capital cost line.

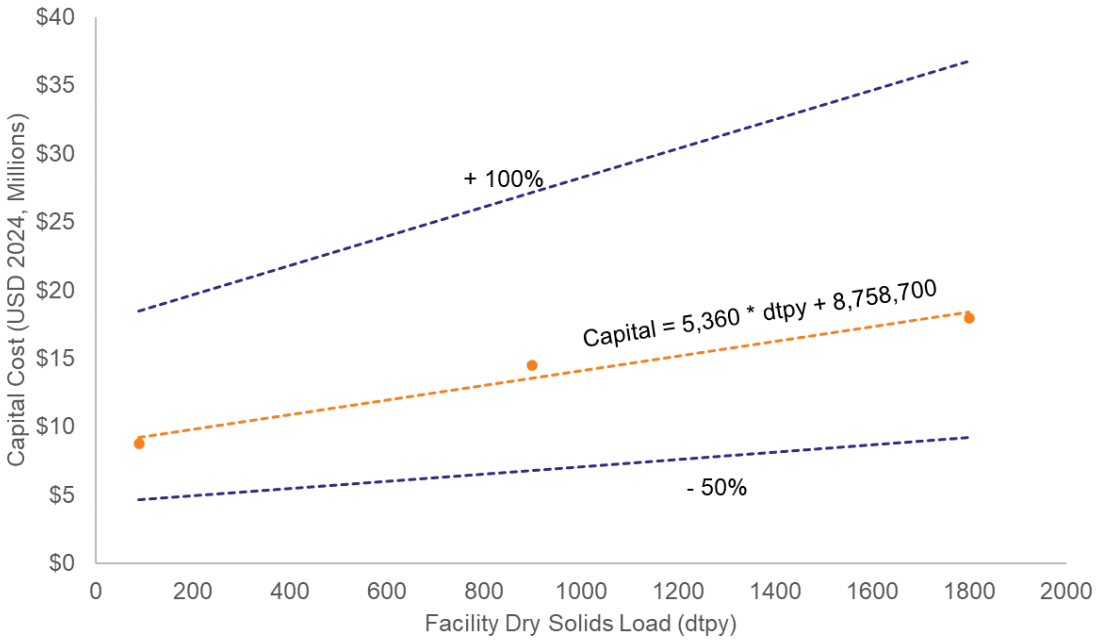


Figure 3-10. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of Centrifuges

Operations and Maintenance Costs

The major O&M cost associated with this technology is solids management. The additional assumed O&M cost associated with this technology are the following:

- Electricity (assumes 8 hours a day)
- Polymer
- Spare parts
- Labor

Each of these items contribute to the overall O&M cost on an annual basis. Biosolids management costs are based on the dry tonnage and the total solids percentage of these biosolids. This is then multiplied by the hauling fee per wet ton in Table 3-13 to determine an overall associated cost. Electricity costs are on a kWh/yr basis which can then be multiplied by the assumed unit prices for electricity shown in Table 3-13. Polymer costs are similarly on a lbs-neat/yr basis that is then multiplied by a unit cost for polymer from Table 3-13. Labor, including operations and maintenance, is calculated using FTE and then multiplied by the assumed wages listed in Table 3-13.

Table 3-18. O&M Totals - Centrifuge							
Facility Size	O&M Cost Item	Unit	Total	Unit Cost Assumptions (from Table 3-13)		Total O&M Cost ($/yr)	Total O&M Cost by Facility Size
Small (90 dtpy)	Biosolids	dt/yr	90	22%	TS	$63,800	$270,000
				$156	/wt		
	Electricity	kWh/yr	7490	$0.20	/kWh	$1,500	
	Polymer	lb-neat/yr	5684	$1.50	/lb-neat	$8,500	
	Spare Parts	$/yr	$23,800	N/A		$23,800	
	Labor	FTE	1.5	$55	/hr	$171,600	
Medium (900 dtpy)	Biosolids	dt/yr	900	22%	TS	$638,200	$965,000
				$156	/wt		
	Electricity	kWh/yr	79040	$0.18	/kWh	$14,200	
	Polymer	lb-neat/yr	56842	$1.50	/lb-neat	$85,300	
	Spare Parts	$/yr	$39,700	N/A		$39,700	
	Labor	FTE	1.5	$60	/hr	$187,200	
Medium-Large (1,800 dtpy)	Biosolids	dt/yr	1800	22%	TS	$1,276,400	$2,480,000
				$156	/wt		
	Electricity	kWh/yr	4578750	$0.17	/kWh	$778,400	
	Polymer	lb-neat/yr	113684	$1.50	/lb-neat	$170,500	
	Spare Parts	$/yr	$51,700	N/A		$51,700	
	Labor	FTE	1.5	$65	/hr	$202,800	

Figure 3-11 summarizes the O&M costs associated with centrifuges for the three facility sizes. As shown in both figures the trends for project costs and O&M are linear. Project costs are linear as they increase with increased solids loading. Additionally, the O&M is also linear as the major O&M cost is associated with solids management. This will increase linearly with increasing solids loading to the system.

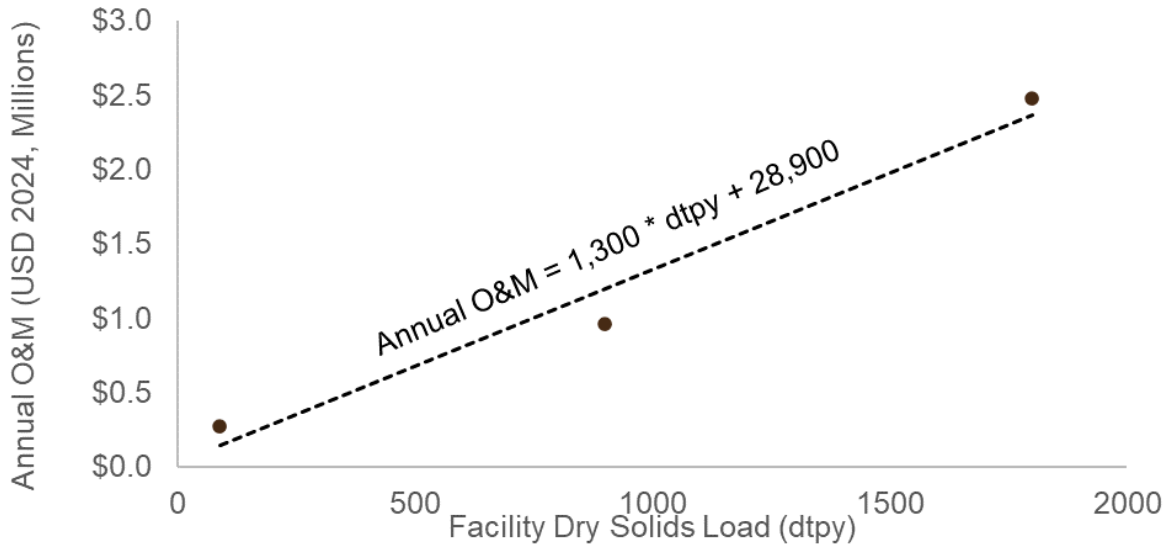


Figure 3-11. Annual Estimated O&M Cost Curve of Centrifuges

When you compare project costs and O&M costs for screw presses and centrifuges, they are similar at the small and medium sized facilities. However as shown in the figures at the larger sized facility there is more deviation. At the medium-large sized facility, centrifuge dewatering has a lower project cost, but higher O&M costs compared to screw press. The higher O&M costs are primarily due to the higher energy requirements for centrifuges as well as the increased maintenance and polymer costs.

Mesophilic Anaerobic Digestion

Capital Costs

The capital costs include the following components:

- Digesters sized based on 15-day hydraulic retention time and 0.18 pounds volatile solids per cubic foot
- Digester sludge storage for 3 days
- Centrifuge equipment (assume duty+1 standby)
- Polymer system including dilution and aging tanks and feed pumps
- Conveyors
- Feed pumps
- Heating
- Waste gas burners
- Heat exchangers
- Odor control
- Control and pumping building

The equipment costs for both the main equipment and ancillary equipment were developed using quotes for similar installations and escalated to today's dollars and the correct geographic area as needed. The treatment building cost is developed using a unit cost of $564 per square foot. The building was sized to fit the main and ancillary equipment treatment equipment. Markups for the above listed capital cost components are listed in Table 3-12. A capital cost breakdown for mesophilic anaerobic digestion at low, medium, and large flow rates can be found in Appendix I.

Figure 3-12 summarizes the capital costs associated with mesophilic anaerobic digestion for facilities at various sizes. The orange, center line shows three points for the medium, medium-large, and large facility sizes used to create the trend line. The figure also shows a +100% and -50% estimating range in blue above and below the estimated capital cost line.

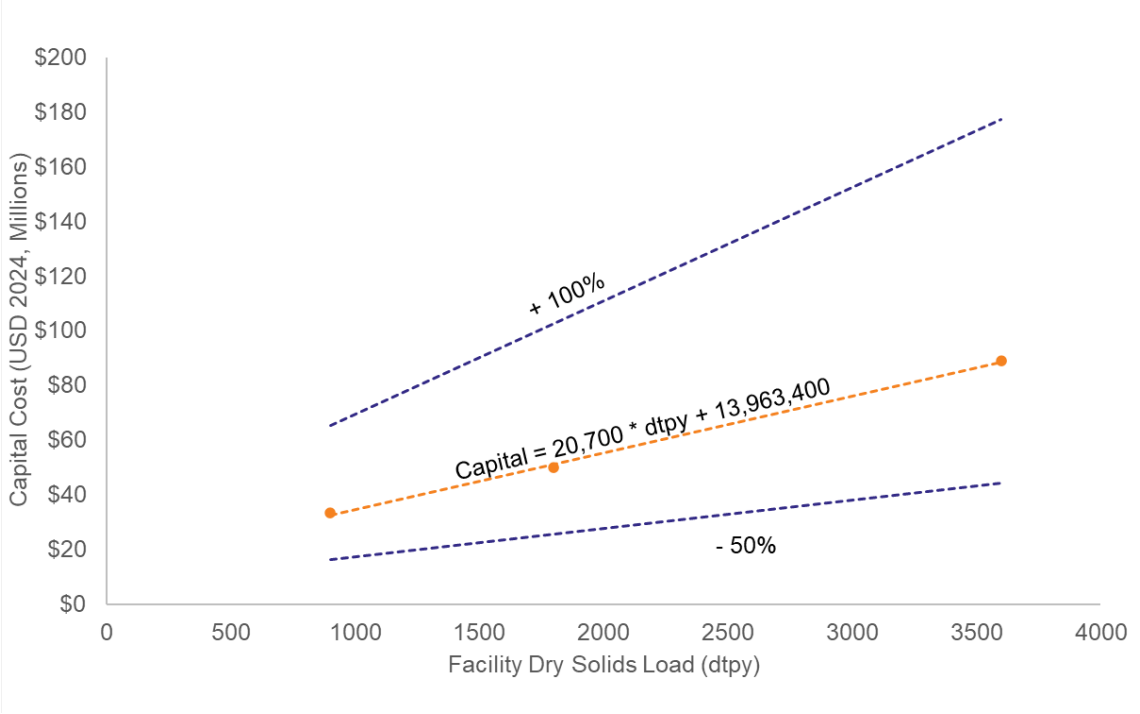


Figure 3-12. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of Mesophilic Anaerobic Digestion

Operations and Maintenance Costs

The major O&M costs associated with this technology are:

- Solids management
- Electricity

The additional O&M costs associated with this technology are:

- Centrifuge maintenance
- Polymer
- Labor

It is assumed that the biogas produced is used in boilers for digester heating; therefore, no additional natural gas is required. This biogas can be used to produce electricity or be upgraded to renewable natural gas; however, that was not considered as part of this analysis. Dewatering was included as dewatering would have to be resized based on the solids reduction achieved by digestion. As the 20-year life cycle costs were similar for screw presses and centrifuges, centrifuges were selected as the representative technology, as it typically can achieve a higher solids content from digested sludge than screw presses.

Each of these items contribute to the overall O&M cost on an annual basis. Solids management costs are based on the dry tonnage and the total solids percentage of these biosolids. This is then multiplied by the hauling fee per wet ton in Table 3-13 to determine an overall associated cost. Note that this assumes 55% VSR in the digesters and a 95% capture rate in the centrifuges. Electricity costs are on a kWh/yr basis which can then be multiplied by the assumed unit prices for electricity shown in Table 3-13. Polymer costs are similarly on a lbs-neat/yr basis that is then multiplied by a

unit cost for polymer from Table 3-13. Labor, including operations and maintenance, is calculated using FTE and then multiplied by the assumed wages listed in Table 3-13.

Table 3-19. O&M Totals - Mesophilic Anaerobic Digestion

Facility Size	O&M Cost Item	Unit	Total	Unit Cost Assumptions (from Table 3-13)		Total O&M Cost ($/yr)	Total O&M Cost by Facility Size
Medium (900 dtpy)	Biosolids	WT/yr	2629	20%	TS	$410,100	$819,000
				$156	/wt		
	Electricity	kWh/yr	399390	$0.18	/kWh	$71,900	
	Polymer	lb-neat/yr	45651	$1.50	/lb-neat	$68,500	
	Spare Parts	$/yr	$81,200	N/A		$81,200	
	Labor	FTE	1.5	$60	/hr	$187,200	
Medium-Large (1,800 dtpy)	Biosolids	WT/yr	5258	20%	TS	$820,300	$1,412,000
				$156	/wt		
	Electricity	kWh/yr	753030	$0.17	/kWh	$128,000	
	Polymer	lb-neat/yr	91303	$1.50	/lb-neat	$137,000	
	Spare Parts	$/yr	$123,600	N/A		$123,600	
	Labor	FTE	1.5	$65	/hr	$202,800	
Large (3,600 dtpy)	Biosolids	WT/yr	10517	20%	TS	$1,640,600	$2,745,000
				$156	/wt		
	Electricity	kWh/yr	1566370	$0.16	/kWh	$250,600	
	Polymer	lb-neat/yr	182605	$1.50	/lb-neat	$273,900	
	Spare Parts	$/yr	$215,000	N/A		$215,000	
	Labor	FTE	2.5	$70	/hr	$364,000	

Figure 3-13 summarizes the O&M costs associated with mesophilic anaerobic digestion and centrifuge dewatering for the three facility sizes.

The project capital costs shown here are based on high-level cost estimate. They do not take into account the number of digesters but rather a cost per gallon approach. Ultimately the project costs for a digester capital project will depend on the number of digesters, size of the digesters, material of the tanks, etc. It is typically more cost-effective to build several larger digesters than many smaller digesters. However, the facility needs to balance costs with operational needs and maintenance. Ideally, a facility would want to be able to take a digester out of service periodically to clean or service. These maintenance periods typically happen once every 5-8 years. But it can take 1-3 months to take a digester offline, clean, and start it back up. The other digesters need to have enough capacity to manage peak conditions.

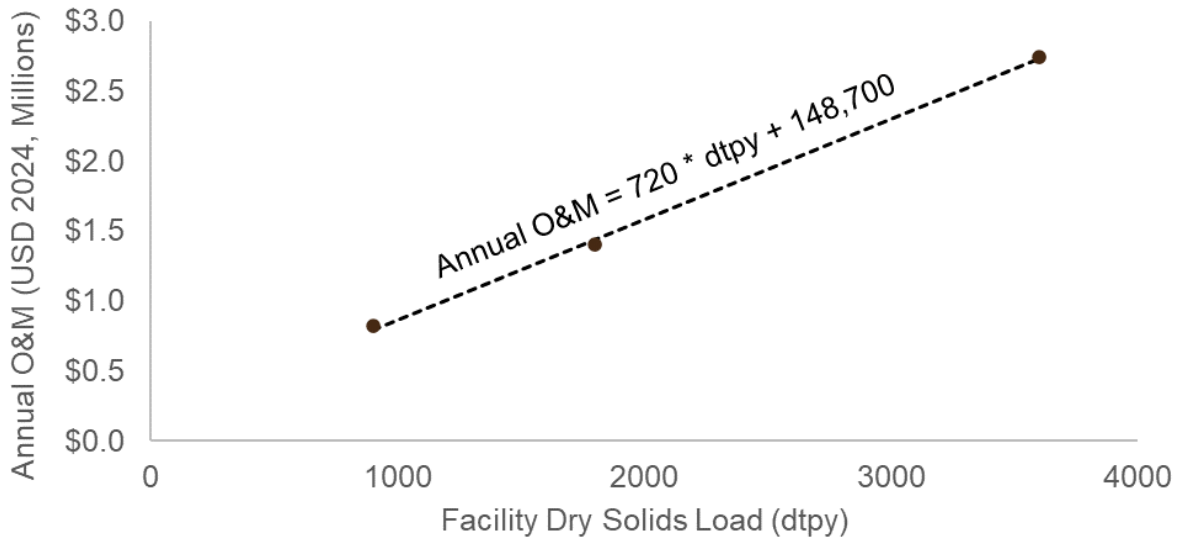


Figure 3-13. Annual Estimated O&M Cost Curve of Mesophilic Anaerobic Digestion

Belt Dryers

Capital Costs

The capital costs include the following components:

- Belt dryers
- Heating
- Dried product conveyance and storage
- Odor control
- Building

It is assumed that the facility has dewatering already onsite. While anaerobic digestion upstream of thermal drying will improve process function and final product quality, it was not considered a requirement for dryer implementation and is not included in these cost curves. The equipment costs for both the main equipment and ancillary equipment were developed using quotes for similar installations and escalated to today's dollars and the correct geographic area as needed. The treatment building cost is developed using a unit cost of $564 per square foot. The building was sized to fit the main and ancillary equipment treatment equipment. Markups for the above-listed capital cost components are listed in Table 3-12. A capital cost breakdown for centrifuge dewatering at low, medium, and large flow rates can be found in Appendix I.

Figure 3-14 summarizes the capital costs associated with belt dryers for facilities at various sizes. The orange, center line shows three points for the small, medium, medium-large, and large facility sizes used to create the trend line. The figure also shows a +100% and -50% estimating range in blue above and below the estimated capital cost line. As noted above in the thermal dryer technology selection, belt dryers were evaluated for all four facility sizes as belt dryers are suitable for small facilities, while drum dryers are not. The figure also shows a +100% and -50% level of accuracy.

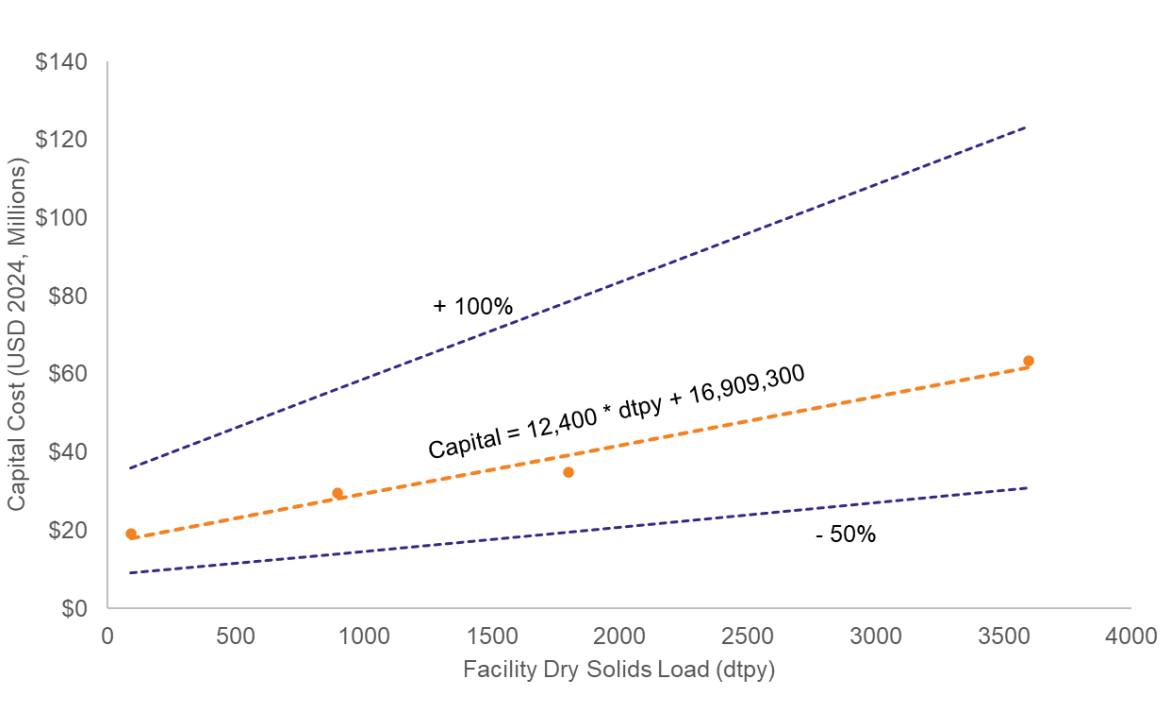


Figure 3-14. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of Belt Dryers

Operations and Maintenance Costs

The major O&M costs associated with this technology are:

- Solids management, including sending dewatered cake to an alternative management site during downtime.
  - The small, medium, and medium-large facilities assumed to have an uptime of 91% with single dryer trains.
  - The large facility assumed uptime was 95% with dual dryer trains.
- Natural gas
- Electricity

The additional O&M costs associated with this technology are the following:

- Caustic for odor control
- Spare parts
- Labor

Each of these items contribute to the overall O&M cost on an annual basis. Solids management costs are based on the dry tonnage and the total solids percentage of these biosolids at the assumed uptime and downtime. This is then multiplied by the hauling fee per wet ton in Table 3-13 to determine an overall associated cost. Electricity costs are on a kWh/yr basis which can then be multiplied by the assumed unit prices for electricity shown in Table 3-13. Natural costs are similarly on a mmBTU/yr basis that is then multiplied by a unit cost for polymer from Table 3-13. Labor, including operations and maintenance, is calculated using FTE and then multiplied by the assumed wages listed in Table 3-13.

Table 3-20. O&M Totals - Belt Dryer							
Facility Size	O&M Cost Item	Unit	Total	Unit Cost Assumptions (from Table 3-13)		Total O&M Cost ($/yr)	Total O&M Cost by Facility Size
Small (90 dtpy)	Biosolids cake (downtime)	dt/yr	8	22%	TS	$5,700	$174,000
				$156	/wt		
	Biosolids dry	dt/yr	82	92%	TS	$13,900	
				$156	/wt		
	Electricity	kWh/yr	39,900	$0.20	/kWh	$8,000	
	Natural Gas	mmBTU/yr	791	$14	/mmbtu	$11,100	
	Spare Parts	$/yr	$20,000	N/A		$20,000	
	Labor	FTE	1.0	$55	/hr	$114,400	
Medium (900 dtpy)	Biosolids cake (downtime)	dt/yr	81	22%	TS	$57,400	$480,000
				$156	/wt		
	Biosolids dry	dt/yr	819	92%	TS	$138,900	
				$156	/wt		
	Electricity	kWh/yr	272,500	$0.18	/kWh	$49,100	
	Natural Gas	mmBTU/yr	7,910	$10	/mmbtu	$79,100	
	Spare Parts	$/yr	$30,000	N/A		$30,000	
	Labor	FTE	1.0	$60	/hr	$124,800	
Medium-Large (1,800 dtpy)	Biosolids cake (downtime)	dt/yr	162	22%	TS	$114,900	$868,000
				$156	/wt		
	Biosolids dry	dt/yr	1,638	92%	TS	$277,700	
				$156	/wt		
	Electricity	kWh/yr	406,500	$0.17	/kWh	$69,100	
	Natural Gas	mmBTU/yr	19,775	$8	/mmbtu	$158,200	
	Spare Parts	$/yr	$45,000	N/A		$45,000	
	Labor	FTE	1.5	$65	/hr	$202,800	
Large (3,600 dtpy)	Biosolids cake (downtime)	dt/yr	180	22%	TS	$127,600	$1,370,000
				$156	/wt		
	Biosolids dry	dt/yr	3,420	92%	TS	$579,900	
				$156	/wt		
	Electricity	kWh/yr	813,000	$0.16	/kWh	$130,100	
	Natural Gas	mmBTU/yr	31,640	$8	/mmbtu	$253,100	
	Spare Parts	$/yr	$60,000	N/A		$60,000	
	Labor	FTE	1.5	$70	/hr	$218,400	

Figure 3-15. summarizes the O&M associated with belt dryers for the four facility sizes. As noted above, in the total project costs, belt dryers have a linear capital trend as there are many different sizes available to adjust with change in solids loading by extension water evaporation capacity. Additionally, a similar trend is noted in O&M costs as these costs increase relative to increase in solids loading, assuming consistent solids content. This results in a consistent increase in water evaporation requirements and heat demand as the solids load increases.

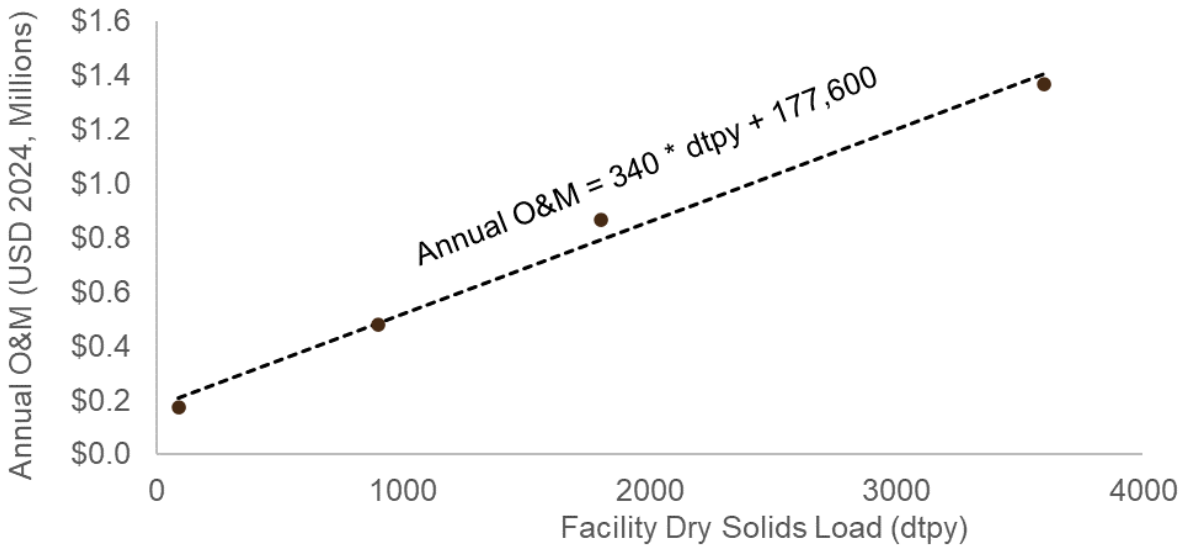


Figure 3-15. Annual Estimated O&M Cost Curve of Belt Dryers

Rotary Drum Dryers

Capital Costs

The capital costs include the following components:

- Rotary drum dryers and ancillary equipment
- Heating
- Dried product conveyance and storage
- Odor control
- Regenerative thermal oxidizer
- Building

It is assumed that the facility already has dewatering onsite. The equipment costs for both the main equipment and ancillary equipment were developed using quotes for similar installations and escalated to today's dollars and the correct geographic area as needed. The treatment building cost is developed using a unit cost of $564 per square foot. The building was sized to fit the main and ancillary equipment treatment equipment. Markups for the above listed capital cost components are listed in Table 3-12. A capital cost breakdown for rotary drum drying at medium, medium-large, and large flow rates can be found in Appendix I.

Figure 3-16 summarizes the capital costs associated with rotary drum dryers for the medium, medium-large, and large facility sizes. The difference in capacity between the various models offered by a rotary drum dryer vendor are typically larger than for belt dryers, meaning individual models cover a broader range of water evaporating capacity (and hence solids throughput). Sizing rotary drum dryers for the medium-large and large facility sizes resulted in the same size model, hence the capital cost for these two facility sizes is the same in Figure 3-16. The dryers are assumed to have different levels of redundancy (the medium-large facility has partial redundancy, while the large facility does not have redundancy) and different operating schedules, so the cost difference between the facility sizes shows up in the O&M costs and the 20-year net-present cost. As noted below, the

medium-large and large facility sizes have two trains. Larger dryers could be installed for single train operation instead of dual train. Having dual trains, does allow for partial redundancy, while single train operation requires a facility to have alternative solids management for the dewatered cake for the period time when the dryer is down either for routine maintenance or emergency. The orange, center line shows three points for the medium, medium-large and large facility sizes used to create the trend line. The figure also shows a +100% and -50% estimating range in blue above and below the estimated capital cost line.

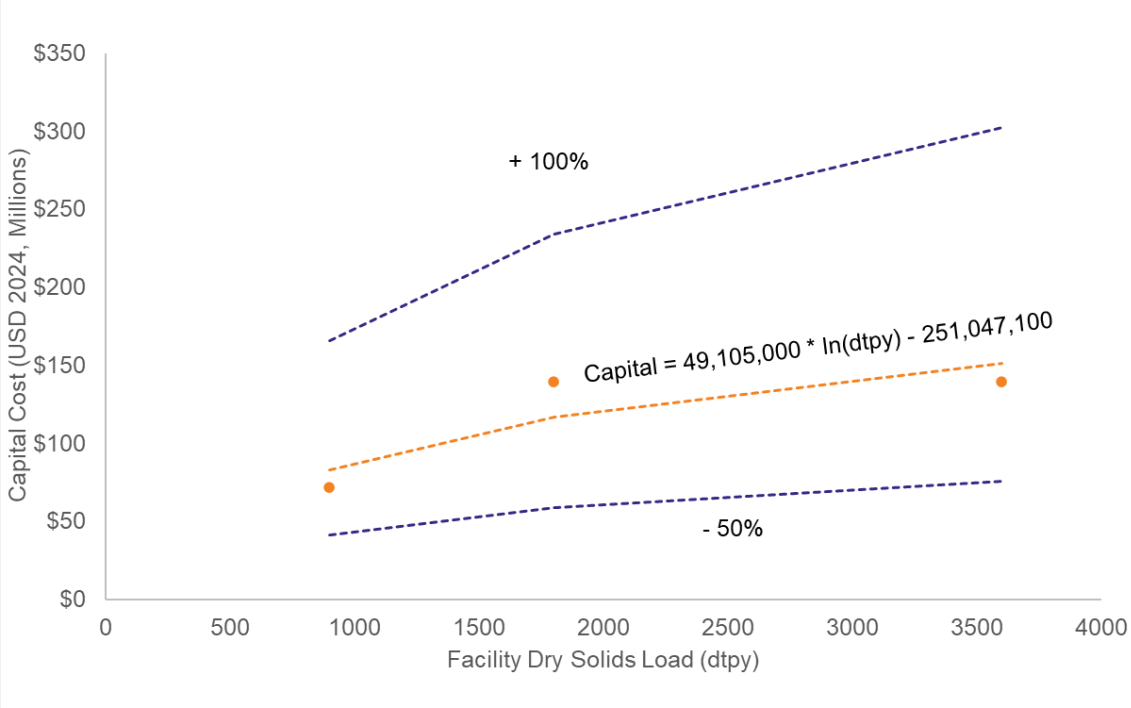


Figure 3-16. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of Rotary Drum Dryers

Note: There are limited unit sizes available for rotary drum dryers. The solids production from medium-large and large facilities fall in a range that can be handled by a unit of the same size, with different assumptions about operating schedules and redundancy. The capital costs are, therefore, the same in this figure.

Operations and Maintenance Costs

The major O&M costs associated with this technology are:

- Solids management, including sending dewatered cake to an alternative management site(s) during downtime.
- The medium facility assumed to have an uptime of 85% with a single dryer train, providing partial redundancy.
- The medium-large facility assumed uptime was 95% as the two trains provide near full redundancy.
- The large facility assumed to have an uptime of 85% with two dryer trains, providing partial redundancy.
- Natural gas
- Electricity
- Labor

The additional O&M cost associated with this technology are the following:

- Oil for pellets
- Spare parts

Each of these items contribute to the overall O&M cost on an annual basis. Biosolids management costs are based on the dry tonnage and the total solids percentage of these biosolids at the assumed uptime and downtimes. This is then multiplied by the hauling fee per wet ton in Table 3-13 to determine an overall associated cost. Electricity costs are on a kWh/yr basis which can then be multiplied by the assumed unit prices for electricity shown in Table 3-13. Natural gas costs are similarly on a mmBTU/yr basis that is then multiplied by a unit cost for natural gas from Table 3-13. Labor, including operations and maintenance, is calculated using FTE and then multiplied by the assumed wages listed in Table 3-13.

As discussed previously in the thermal dryer technology section, rotary drum dryers are not suitable for small facility sizes. The smallest unit would be too big for the small facility size. They are more suitable for medium to large facilities; therefore, the small size facility was not included as part of the cost analysis.

Table 3-21. O&M Totals - Rotary Drum

Facility Size	O&M Cost Item	Unit	Total	Unit Cost Assumptions (from Table 3-13)		Total O&M Cost ($/yr)	Total O&M Cost by Facility Size
Medium (900 dtpy)	Biosolids cake (downtime)	dt/yr	135	22%	TS	$95,700	$1,470,000
				$156	/wt		
	Biosolids dry	dt/yr	765	93%	TS	$128,300	
				$156	/wt		
	Electricity	kWh/yr	328,500	$0.18	/kWh	$59,100	
	Natural Gas	mmBTU/yr	7,300	$10	/mmbtu	$73,000	
	Spare Parts	$/yr	$240,000	N/A		$240,000	
	Labor	FTE	7	$60	/hr	$873,600	
Medium-Large (1,800 dtpy)	Biosolids cake (downtime)	dt/yr	90	22%	TS	$63,800	$1,964,000
				$156	/wt		
	Biosolids dry	dt/yr	1,710	93%	TS	$286,800	
				$156	/wt		
	Electricity	kWh/yr	498,230	$0.17	/kWh	$84,700	
	Natural Gas	mmBTU/yr	15,820	$8	/mmbtu	$126,600	
	Spare Parts	$/yr	$320,000	N/A		$320,000	
	Labor	FTE	8	$65	/hr	$1,081,600	
Large (3,600 dtpy)	Biosolids cake (downtime)	dt/yr	540	22%	TS	$382,900	$3,536,000
				$156	/wt		
	Biosolids dry	dt/yr	3,060	93%	TS	$513,300	
				$156	/wt		
	Electricity	kWh/yr	996,450	$0.16	/kWh	$159,400	
	Natural Gas	mmBTU/yr	31,640	$8	/mmbtu	$253,100	
	Spare Parts	$/yr	$480,000	N/A		$480,000	
	Labor	FTE	12	$70	/hr	$1,747,200	

Figure 3-17 summarizes the O&M associated with rotary drum dryers for the medium, medium-large, and large facility sizes.

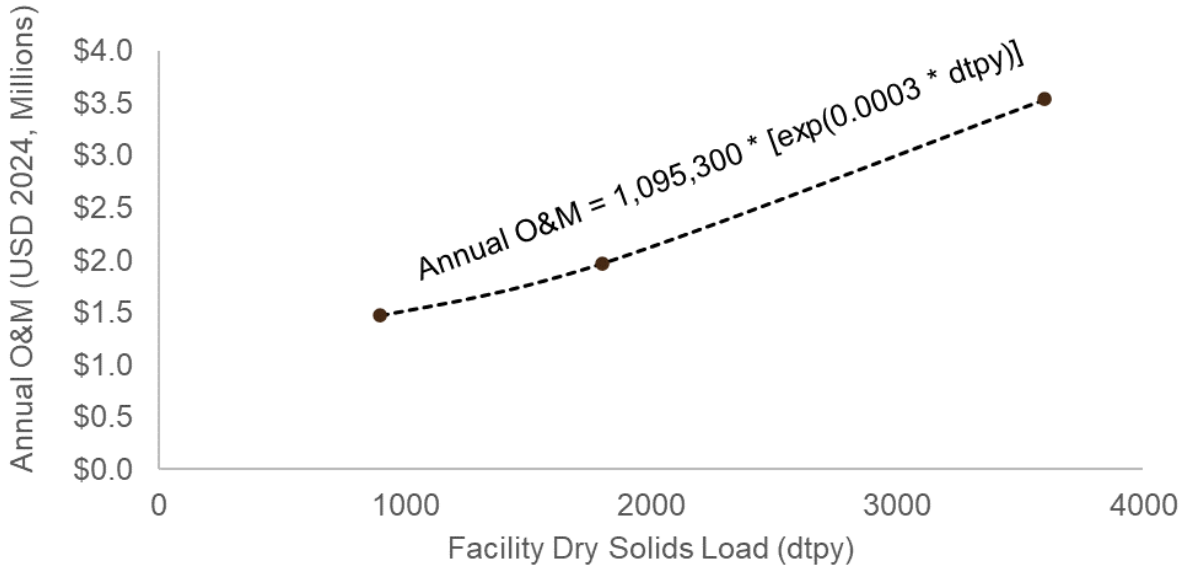


Figure 3-17. Annual Estimated O&M Cost Curve of Rotary Drum Dryers

Gasification

Capital Costs

The capital costs include the following components:

- Rotary drum dryers and ancillary equipment
- Gasifier
- Ash management
- Heating
- Dried product conveyance and storage
- Odor control
- Building

It is assumed that the facility has dewatering already onsite. The equipment costs for both the main equipment and ancillary equipment were developed using quotes for similar installations and escalated to today's dollars and the correct geographic area as needed. The treatment building cost is developed using a unit cost of $564 per square foot. The building was sized to fit the main and ancillary equipment treatment equipment. Markups for the above listed capital cost components are listed in Table 3-12. A capital cost breakdown for gasification at the medium, medium-large, and large flow rates can be found in Appendix I.

Figure 3-18 summarizes the capital costs associated with gasification systems for facilities at various sizes. The orange, center line shows three points for the medium, medium-large and large facility sizes used to create the trend line. The figure also shows a +100% and -50% estimating range in blue above and below the estimated capital cost line.

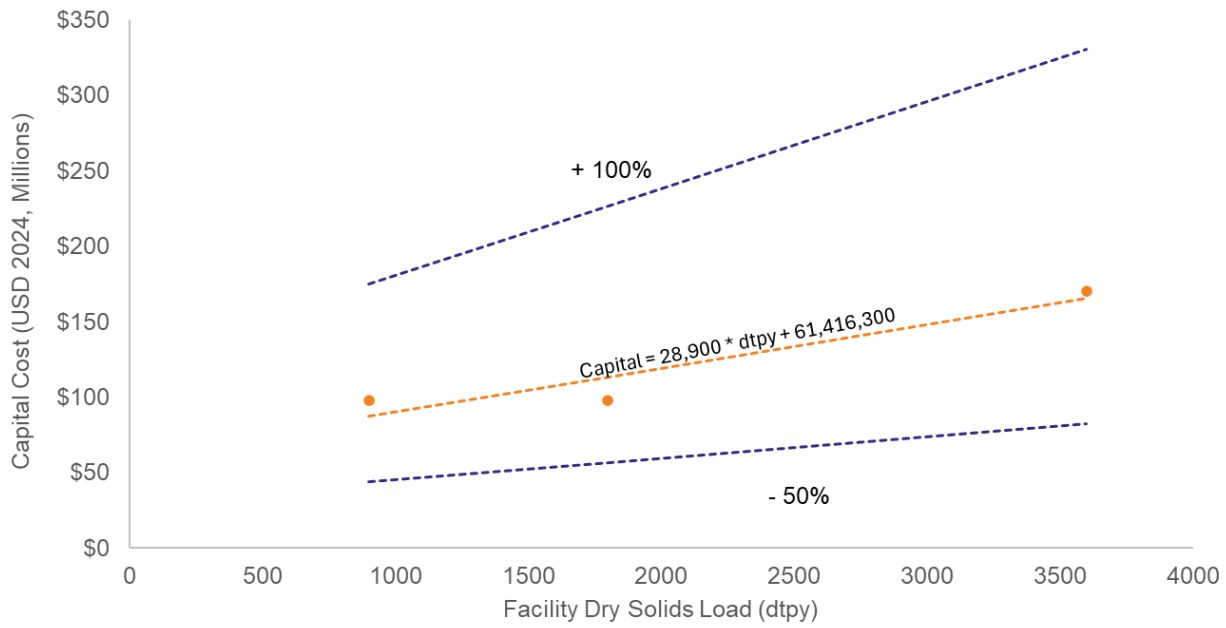


Figure 3-18. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of Gasification Systems

Operations and Maintenance Costs

The major O&M costs associated with this technology are

- Electricity
- Labor

The additional O&M cost associated with this technology are the following:

- Caustic for odor control
- Natural gas
- Solids management (biochar and/or ash), including sending dewatered cake or dried biosolids to an alternative management site during downtime.

– The medium and medium-large facilities assumed to have an uptime of 85% as a single train.

– The large facility assumed uptime was 89% as the two trains provide partial redundancy.

- Spare parts

Each of these items contribute to the overall O&M cost on an annual basis. Biosolids management costs are based on the dry tonnage and the total solids percentage of these biosolids. This is then multiplied by the hauling fee per wet ton in Table 3-13 to determine an overall associated cost of the biosolids cake during downtime. During uptime, the end product is a dry biochar. Electricity costs are on a kWh/yr basis which can then be multiplied by the assumed unit prices for electricity shown in Table 3-13. Natural gas costs are similarly on an mmBTU/yr basis that is then multiplied by a unit cost for natural gas from Table 3-13. Labor, including operations and maintenance, is calculated using FTE and then multiplied by the assumed wages listed in Table 3-13.

Table 3-22. O&M Totals - Gasification							
Facility Size	O&M Cost Item	Unit	Total	Unit Cost Assumptions (from Table 3-13)		Total O&M Cost ($/yr)	Total O&M Cost by Facility Size
Medium (900 dtpy)	Biosolids cake (downtime)	dt/yr	135	22%	TS	$95,700	$1,174,000
				$156	/wt		
	Ash Dry	dt/yr	268	90%	TS	$46,400	
				$156	/wt		
	Electricity	kWh/yr	361,350	$0.18	/kWh	$65,000	
	Natural Gas	mmBTU/yr	500	$10	/mmbtu	$5,000	
	Spare Parts	$/yr	$150,000	N/A		$150,000	
	Labor	FTE	6.5	$60	/hr	$811,200	
Medium-Large (1,800 dtpy)	Biosolids cake (downtime)	dt/yr	270	22%	TS	$191,500	$1,658,000
				$156	/wt		
	Ash Dry	dt/yr	536	90%	TS	$92,800	
				$156	/wt		
	Electricity	kWh/yr	646,050	$0.17	/kWh	$109,800	
	Natural Gas	mmBTU/yr	875	$8	/mmbtu	$7,000	
	Spare Parts	$/yr	$175,000	N/A		$175,000	
	Labor	FTE	8	$65	/hr	$1,081,600	
Large (3,600 dtpy)	Biosolids cake (downtime)	dt/yr	396	22%	TS	$280,800	$2,145,000
				$156	/wt		
	Ash Dry	dt/yr	1,121	90%	TS	$194,400	
				$156	/wt		
	Electricity	kWh/yr	930,750	$0.16	/kWh	$148,900	
	Natural Gas	mmBTU/yr	1,250	$8	/mmbtu	$10,000	
	Spare Parts	$/yr	$200,000	N/A		$200,000	
	Labor	FTE	9	$70	/hr	$1,310,400	

Figure 3-19 summarizes the O&M associated with gasification systems for the three facility sizes. The total project costs for gasification systems at the three facility sizes are showing a linear trend; however, as noted above the total project capital costs for the medium and medium-large facilities are the same. This is because at this time the vendor (Ecoremedy) on which this analysis was based offers only one size for their gasification system. The single train can process the same amount for both facilities, however less operating time is needed for the medium facility relative to the medium-large facility. This is why the O&M costs are not linear but have logarithmic function. There is a noticeable increase (steeper slope) between the medium and the medium-large facility relative to the slope between the medium-large and large facility.

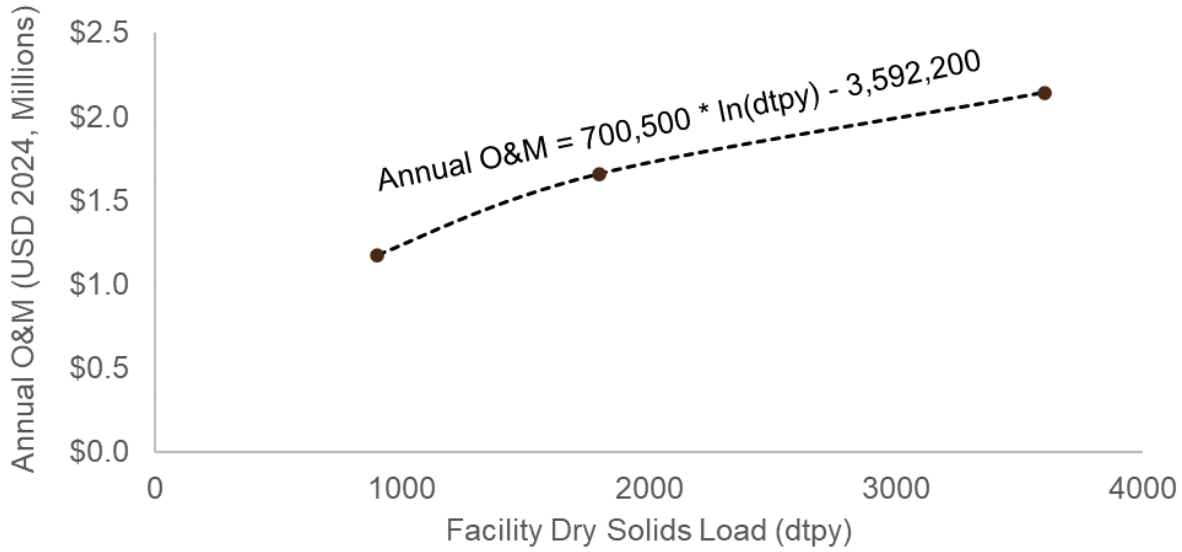


Figure 3-19. Annual Estimated O&M Cost Curve of Gasification Systems

Pyrolysis

Capital Costs

The capital costs include the following components:

- Belt dryers and ancillary equipment
- Pyrolysis units
- Heating
- Dried product conveyance and storage
- Biochar conveyance and storage
- Odor control
- Building

It is assumed that the facility has dewatering already onsite. The equipment costs for both the main equipment and ancillary equipment were developed using quotes for similar installations and escalated to today's dollars and the correct geographic area as needed. The treatment building cost is developed using a unit cost of $564 per square foot. The building was sized to fit the main and ancillary equipment treatment equipment. Markups for the above-listed capital cost components are listed in Table 3-12. A capital cost breakdown for pyrolysis at medium, medium-large, and large flow rates can be found in Appendix I.

Figure 3-20. summarizes the capital costs associated with pyrolysis systems for facilities at various sizes. The orange, center line shows three points for the medium, medium-large, and large facility sizes used to create the trend line. The figure also shows a +100% and -50% estimating range in blue above and below the estimated capital cost lines. The figure also shows a +100% and -50% level of accuracy.

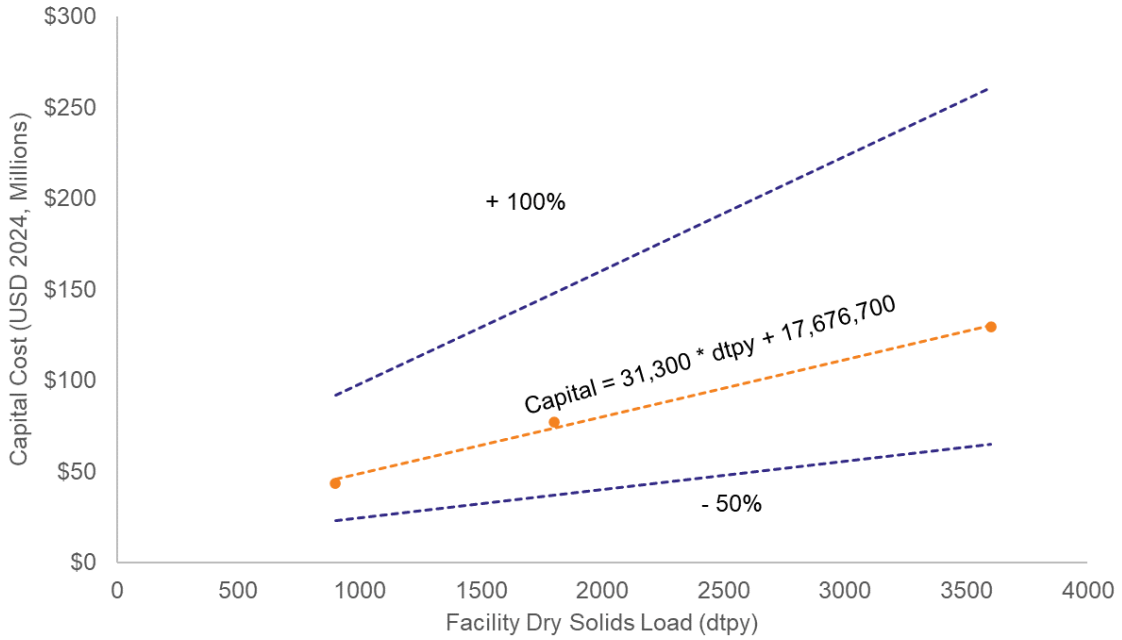


Figure 3-20. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of Pyrolysis Systems

Operations and Maintenance Costs

The major O&M cost associated with this technology is labor. The additional O&M costs associated with this technology are the following:

- Caustic for odor control
- Spare parts
- Electricity
- Natural gas
- Downtime solids management in which dewatered cake is sent to an alternative management site.

– The medium facility assumed uptime was 85% as a single train.

– The medium-large and large facilities assumed to have an uptime of 89% as the two trains provide partial redundancy.

Each of these items contribute to the overall O&M cost on an annual basis. Biosolids management costs are based on the dry tonnage and the total solids percentage of these biosolids. This is then multiplied by the hauling fee per wet ton in Table 3-13 to determine an overall associated cost for the biosolids cake produced during downtime. Electricity costs are on a kWh/yr basis which can then be multiplied by the assumed unit prices for electricity shown in Table 3-13. Polymer costs are similarly on a lbs-neat/yr basis that is then multiplied by a unit cost for polymer from Table 3-13. Labor, including operations and maintenance, is calculated using FTE and then multiplied by the assumed wages listed in Table 3-13.

Pyrolysis will have a savings in natural gas as heat can be recovered. Additionally, biochar can be a revenue source, depending on the market. Therefore, a $0/wt unit cost was used for the dry biochar to denote that there is no associated hauling cost.

Table 3-23. O&M Totals - Pyrolysis							
Facility Size	O&M Cost Item	Unit	Total	Unit Cost Assumptions (from Table 3-13)		Total O&M Cost ($/yr)	Total O&M Cost by Facility Size
Medium (900 dtpy)	Biosolids cake (downtime)	dt/yr	135	22%	TS	$95,700	$688,000
				$156	/wt		
	Biochar Dry	dt/yr	383	93%	TS	$0	
				$0	/wt		
	Electricity	kWh/yr	417,500	$0.18	/kWh	$75,200	
	Natural Gas	mmBTU/yr	5,260	$10	/mmbtu	$52,600	
	Spare Parts	$/yr	$90,000	N/A		$90,000	
	Labor	FTE	3	$60	/hr	$374,400	
Medium-Large (1,800 dtpy)	Biosolids cake (downtime)	dt/yr	198	22%	TS	$140,400	$911,000
				$156	/wt		
	Biochar Dry	dt/yr	801	93%	TS	$0	
				$0	/wt		
	Electricity	kWh/yr	722,960	$0.17	/kWh	$122,900	
	Natural Gas	mmBTU/yr	14,555	$8	/mmbtu	$116,400	
	Spare Parts	$/yr	$125,000	N/A		$125,000	
	Labor	FTE	3	$65	/hr	$405,600	
Large (3,600 dtpy)	Biosolids cake (downtime)	dt/yr	396	22%	TS	$280,800	$1,372,000
				$156	/wt		
	Biochar Dry	dt/yr	1,602	93%	TS	$0	
				$0	/wt		
	Electricity	kWh/yr	1,445,910	$0.16	/kWh	$231,300	
	Natural Gas	mmBTU/yr	21,200	$8	/mmbtu	$169,600	
	Spare Parts	$/yr	$180,000	N/A		$180,000	
	Labor	FTE	3.5	$70	/hr	$509,600	

Figure 3-21. summarizes the O&M associated with pyrolysis systems for the three facility sizes. The total project costs did scale linearly as noted above with increasing facility size. This was aided by pairing the pyrolysis units with belt dryers. As noted in the belt dryer section, above, their project costs also scaled linearly. Additionally, the O&M also increased linearly with increasing solids load. As the facility sized increased, there was an increase in labor requirements as well as natural gas and electricity for units.

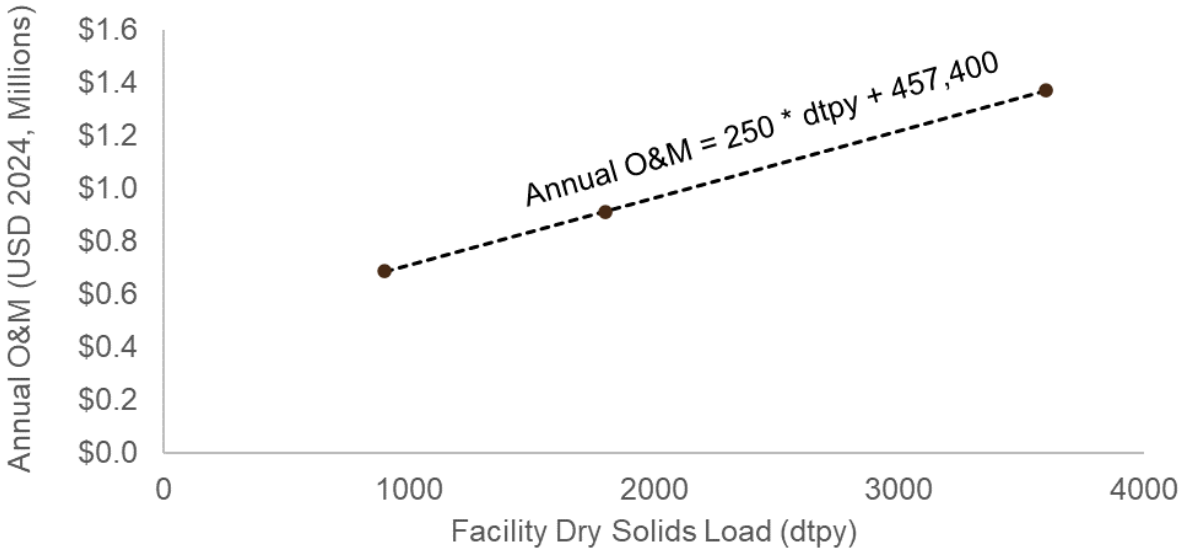


Figure 3-21. Annual Estimated O&M Cost Curve of Pyrolysis Systems

The Minnesota report (c) evaluated pyrolysis and gasification together as a single category of technology. Here they are evaluated separately. The O&M costs presented here are slightly higher than the Minnesota report as this analysis included downtime alternative solids management (i.e., managing dried biosolids or dewatered cake when the pyrolysis or gasification unit is down). If downtimes were not included, then the annual O&M cost would be comparable to those developed in the Minnesota report.

Supercritical Water Oxidation

Capital Costs

The capital costs include the SCWO system, which is installed in a shipping container. Provided as part of the capital costs is the equipment to manage the minerals produced from the SCWO process. It is assumed that these minerals are managed similar to ash from an incinerator. The following are additional items included as part of the capital costs for SCWO:

- 2 x gravity thickener for ash thickening
- 2 x belt press for ash dewatering
- Building for ash management systems and ancillary equipment
- ancillary equipment

It is assumed that the facility has sludge dewatering already onsite. Also, the SCWO system would not be located within a building but housed in the container that the manufacturer provides. The equipment costs for both the main equipment and ancillary equipment were developed using quotes for similar installations and escalated to today's dollars and the correct geographic area as needed. The treatment building cost is developed using a unit cost of $564 per square foot. The building was sized to fit the main and ancillary equipment treatment equipment. Markups for the above listed capital cost components are listed in Table 3-12. A capital cost breakdown for SCWO dewatering at low, medium, and large flow rates can be found in Appendix I.

Figure 3-22 summarizes the capital costs associated with SCWO systems for facilities at various sizes. The orange, center line shows three points for the medium, medium-large and large facility sizes used to create the trend line. The figure also shows a +100% and -50% estimating range in blue above and below the estimated capital cost line.

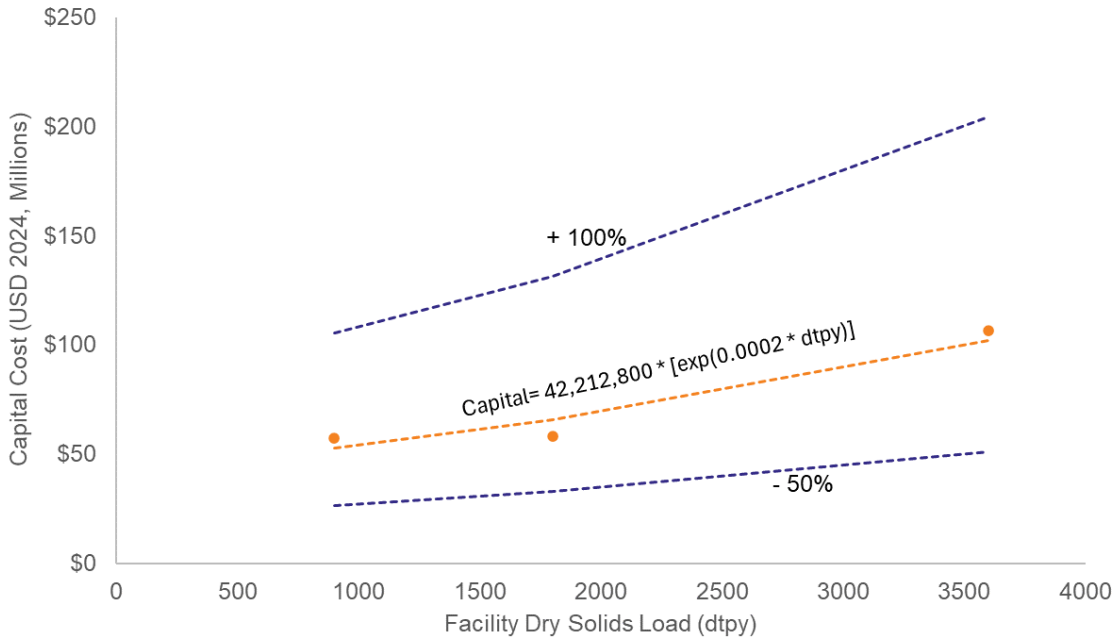


Figure 3-22. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of SCWO Systems

Operations and Maintenance Costs

The major O&M costs associated with this technology are:

- Labor
- Spare parts
- Solids management (mineral ash), including sending dewatered cake to an alternative management site during downtime.

– The medium and medium-large facilities assumed to have an uptime of 80%.

– The large facility assumed uptime was 90% as the two trains provide partial redundancy.

Each of these items contribute to the overall O&M cost on an annual basis. SCWO produces electricity and thermal heat, requiring additional electricity and heat during start-up. For larger systems, there can be an excess of electricity produced. This assumes that the system is paired with a generator. Additionally, it was assumed that the system would require 24 startups a year, requiring the addition of diesel fuel for each start up. Electricity costs are on a kWh/yr basis and diesel fuel costs are on a gallons per year basis which can then be multiplied by the assumed unit prices for electricity shown in Table 3-13. This analysis did not assume any benefits from electricity production. Additionally, it was assumed that the system would require 24 startups a year, requiring the addition of diesel fuel for each start up. Finally, a mineral ash is produced, which needs to be managed. This potentially can be recovered and land applied; however, not enough information is known at this time about a beneficial market as this is an emerging process. For this analysis, the mineral ash was

thickened and dewatered. It was assumed it would be sent to the landfill for the same hauling and tip fee as biosolids management.

Table 3-24. O&M Totals - SCWO

Facility Size	O&M Cost Item	Unit	Total	Unit Cost Assumptions (from Table 3-13)		Total O&M Cost ($/yr)	Total O&M Cost by Facility Size
Medium (900 dtpy)	Biosolids cake (downtime)	dt/yr	135	22% TS		$95,700	$760,000
				$156	/wt		
	SCWO Minerals	wtpd	360	$156	/wt	$56,200	
	Electricity	kWh/yr	990,400	$0.18	/kWh	$178,300	
	Diesel Fuel	gpy	1,087	$3.91	/gal	$4,300	
	Polymer	lb-neat/yr	2,700	$2	/lb-neat	$4,100	
	Spare Parts	$/yr	$171,800	N/A		$171,800	
	Labor	FTE	2	$60	/hr	$249,600	
Medium-Large (1,800 dtpy)	Biosolids cake (downtime)	dt/yr	90	22% TS		$63,800	$1,410,400
				$156	/wt		
	SCWO Minerals	wtpd	720	$156	/wt	$112,300	
	Electricity	kWh/yr	4,578,800	$0.17	/kWh	$778,400	
	Diesel Fuel	gpy	1,087	$3.91	/gal	$4,300	
	Polymer	lb-neat/yr	5,400	$2	/lb-neat	$8,100	
	Spare Parts	$/yr	$173,100	N/A		$173,100	
	Labor	FTE	2	$65	/hr	$270,400	
Large (3,600 dtpy)	Biosolids cake (downtime)	dt/yr	540	22% TS		$382,900	$2,787,000
				$156	/wt		
	SCWO Minerals	wtpd	1,440	$156	/wt	$224,600	
	Electricity	kWh/yr	9,157,500	$0.16	/kWh	$1,465,200	
	Diesel Fuel	gpy	2,175	$3.91	/gal	$8,500	
	Polymer	lb-neat/yr	10,800	$2	/lb-neat	$16,200	
	Spare Parts	$/yr	$325,600	N/A		$325,600	
	Labor	FTE	2.5	$70	/hr	$364,000	

Figure 3-23. summarizes the O&M associated with SCWO systems for the three facility sizes.

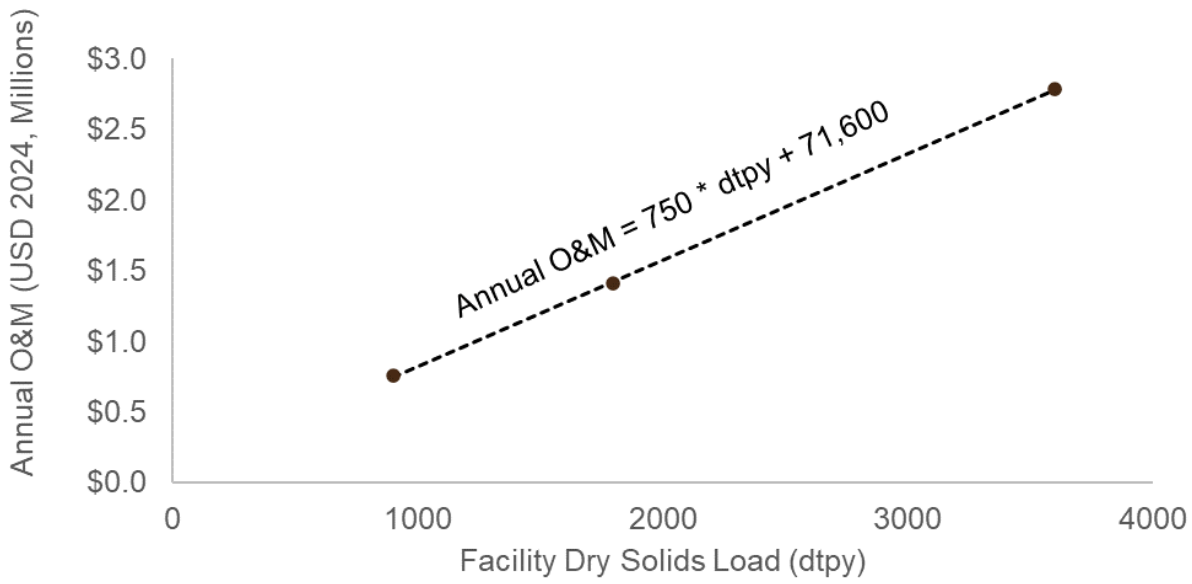


Figure 3-23. Annual Estimated O&M Cost Curve of SCWO Systems

The capital costs presented here relative to those presented in the report from a similar effort in Minnesota are comparable (Ling et al., 2023); however, these will increase after the additional equipment for mineral ash management has been included. Additionally, the O&M costs are slightly higher in this report as we have included management of the mineral ash, alterative solids management associated with down time, and diesel fuel for startups, which was not included in the Minnesota report.

Net Present Cost Results

Based on the Class 5 capital cost ranges developed (summarized in Table 3-25 and Table 3-26) as well as the annual O&M costs, the 20 year net present cost (NPC) for sludge volume reduction technologies are summarized in Figure 3-24 and for PFAS treatment technologies in Figure 3-25. Cost is not the only consideration when selecting a technology; see Section 3.5 for a discussion of non-cost advantages and disadvantages for these technologies.

Table 3-25. Project Capital Cost Estimates with Estimating Range (-50% to 100%) for Installation of Sludge Volume Reduction Technologies at Various POTW Sizes

Technology Type	Technology	Small (90 dtpy)	Medium (900 dtpy)	Medium-Large (1,800 dtpy)	Large (3,600 dtpy)
Dewatering	Screw Press	$9.0M ($4.8M - $19.1M)	$19.3M ($9.1M - $36.5M)	$27.4M ($13.9M - $55.8M)	*POTWs of this size assumed already to have dewatering*
	Centrifuge	$8.8M ($4.6M - $18.5M)	$14.5M ($6.8M - $27.2M)	$18.0M ($9.2M - $36.8M)	*POTWs of this size assumed already to have dewatering*
Digestion	Mesophilic Anaerobic Digestion	*Not typically installed at the scale of Small facilities*	$33.5M ($16.3M - $65.3M)	$50.0M ($25.6M - $102.6M)	$89.0M ($44.3M - $177.2M)
Thermal Drying	Belt Dryer	$19.1M ($9.0M - $36.1M)	$29.6M ($14.1M - $56.2M)	$35.0M ($19.7M - $78.6M)	$63.5M ($30.8M - $123.4M)
	Rotary Drum Dryer	*Not typically installed at the scale of Small facilities*	$71.6M ($41.5M - $166.0M)	$139.7M ($58.5M - $234.0M)	$139.7M ($75.5M - $302.1M)

Table 3-26. Project Capital Cost Estimates with Estimating Range (-50% to 100%) for Installation of Sludge PFAS Treatment Technologies at Various POTW Sizes

Technology	Small (90 dtpy)	Medium (900 dtpy)	Medium-Large (1,800 dtpy)	Large (3,600 dtpy)
Gasification	*Not typically produced at the scale of Small facilities*	$97.8M ($43.7M - $174.8M)	$97.8M ($56.7M - $226.8M)	$170.6M ($82.7M - $330.7M)
Pyrolysis	*Not typically produced at the scale of Small facilities*	$43.7M ($22.9M - $91.7M)	$77.3M ($37.0M - $148.1M)	$129.3M ($65.2M - $260.8M)
Supercritical Water Oxidation	*Not typically produced at the scale of Small facilities*	$57.1M ($26.3M - $105.3M)	$58.1M ($32.8M - $131.3M)	$106.4M ($51.1M - $204.3M)

When evaluating the volume reduction technologies (dewatering, digestion, and thermal drying), the NPC increases with level of complexity and increase in volume reduced. The NPC for dewatering is the lowest, as these are the least complex systems. When not paired with other technologies (e.g. digestion, thermal drying), however, the degree of volume reduction achieved by dewatering is less when compared to the other two technology categories.

For the dewatering technologies, the costs between centrifuges and screw presses are not significantly different at this level when comparing the NPCs between similar sized facilities. This is something that the team has experienced in recent planning projects. Both are well established technologies. The decision between the two tends to be site specific, based on utility preference or specific goals.

As mentioned previously, the true project costs of an anaerobic digestion capital project can be complex, requiring several factors to be determined. Depending on the nature of construction, digestion can be more expensive than belt drying; however, if additional energy generation systems are included or the inclusion of organic waste acceptance to increase biogas production is included, this can alter the overall costs of the system.

The final two technologies in the sludge volume reduction category are thermal dryers: belt and rotary drum. Belt dryers have lower capital and O&M costs than rotary drum dryers, so they have a favorable NPC. As mentioned previously, belt dryers tend to favor smaller utilities, while rotary drum

dryers are better suited for larger utilities. For the medium facility the NPC for the rotary drum dryers was four times higher than the belt dryer. This NPC gap decreased as the facility size increased. However, the NPC for the rotary drum dryers was still two times higher than belt dryers for the large facility.

For the PFAS treatment technologies, pyrolysis and SCWO have similar NPCs, with gasification having the highest NPCs for each of the three facility sizes: medium, medium-large, and large. Pyrolysis and gasification have had more commercial installations with sludge only facilities; however, their run time is still less than 5 years. The long-term O&M costs are not well known. For SCWO, there are no full-scale installations at the time of writing this report. The estimates provided for O&M as well as capital are not well known. They were provided with input from the SCWO manufacturer as well as additional input from senior engineers. These uncertainties are one of the reasons SCWO has lower run times as well as higher estimating contingency. As all three of these technologies gain full-scale installations as well as run time, these NPCs could change. For all of these systems the medium-large facility size seems to be the most economical when considering the mass of solids being treated. As mentioned previously, similar sizes used to treat medium and medium-large facilities impact the economics so that the overall NPC favors the medium-large facilities.

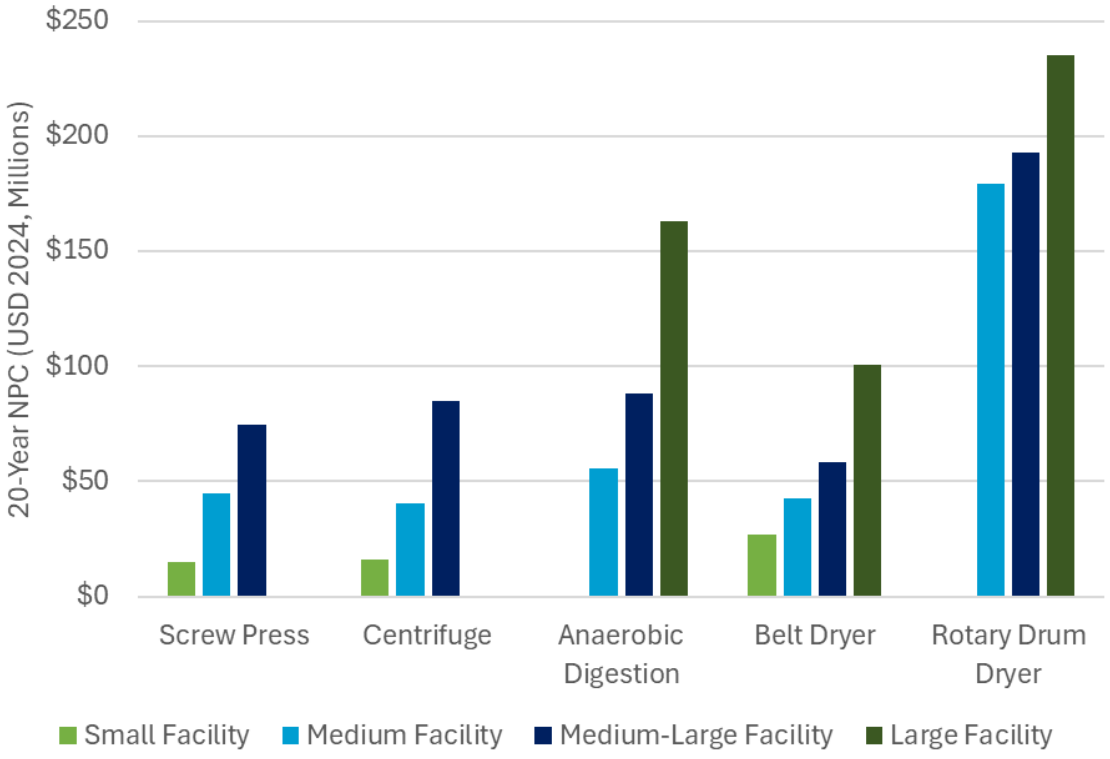


Figure 3-24. A Summary of the 20-Year NPC for Sludge Volume Reduction Technologies

Small = 90 DTPY, Medium = 900 DTPY, Medium-Large = 1,800 DTPY, Large = 3,600 DTPY

Large facilities not included for dewatering because facilities of this size typically have dewatering. Anaerobic digestion and rotary drum dryers are not typically installed at the scale of Small facilities.

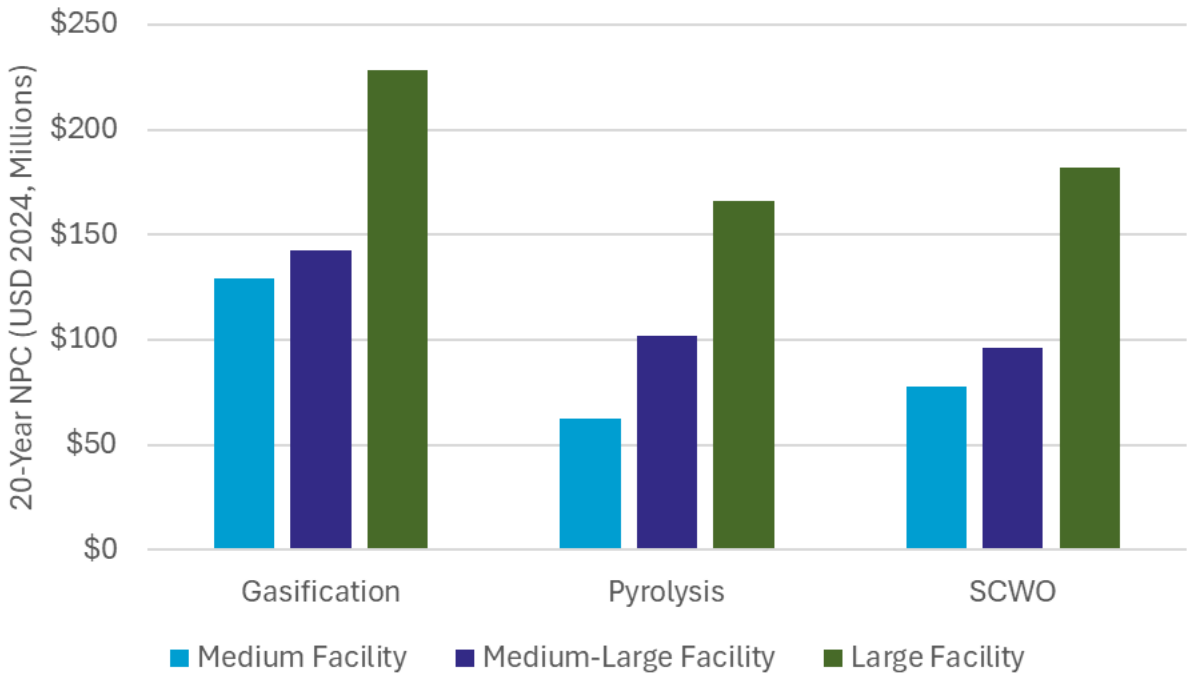


Figure 3-25. A summary of the 20-year NPC for Biosolids PFAS Mitigation Technologies

Medium = 900 DTPY, Medium-Large = 1,800 DTPY, Large = 3,600 DTPY

Small facilities not included as units for these technologies typically are not produced for facilities at that scale.

Incineration Retrofit for PFAS Mitigation

The retrofit of UBCW and LRWPF includes the addition of an RTO specifically for PFAS treatment to each of these facilities as well as ancillary equipment. In addition, operation of the RTO requires electricity and natural gas with some annual costs for labor and spare parts. Table 3-27 summarizes the conceptual level capital cost estimates as well as the additional annual O&M costs associated with these retrofits. Figure 3-26 illustrates the 20-year lifecycle costs these facilities would incur for the additional capital and O&M associated with the retrofit. For reference, the entire fiscal year 2025 plant operations budget for UBCW is $21M (excluding debt service and other costs not related to day-to-day operations and maintenance).

A life cycle cost analysis of activated carbon bed system was not included in this analysis in part because of the lack of published PFAS performance data. For reference, an equipment supplier provided a budgetary price of $1.75M per train for only the equipment, with two trains required at the scale of UBCW. Additional capital costs would be needed for design, ancillary equipment, and construction.

Table 3-27. Summary of Capital and O&M Costs for Incinerator Retrofits

	Upper Blackstone	Lynn
Approximate annual throughput	18,000 dry-tons/year	5,700 dry-tons/year
Capital cost Estimate (with Class 5 estimating range)	$28.8M ($14.4M - $57.6M)	$10.4M ($5.2M - $20.8M)
Annual O&M (2024)	$3,091,000	$1,544,000

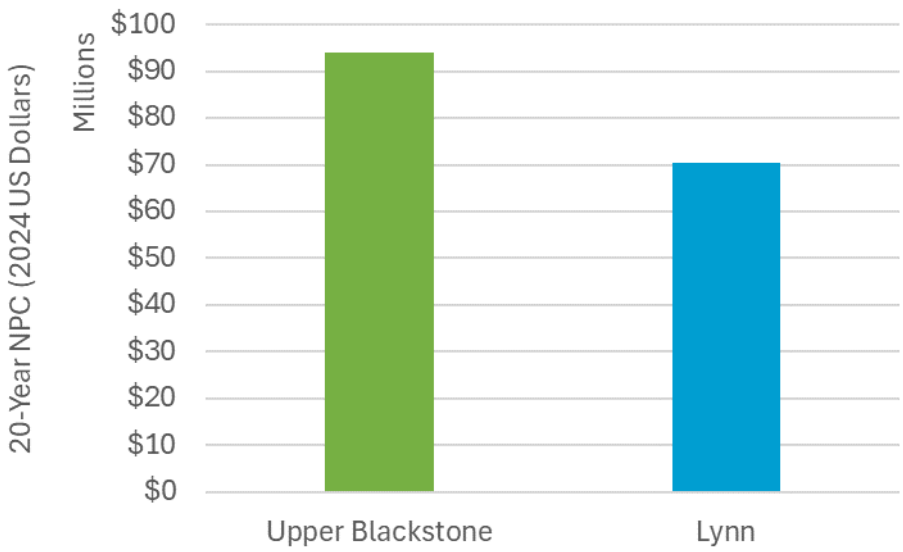


Figure 3-26. A summary of the 20-year NPC for Retrofits at UBCW and LRWPF

3.4.5 Leachate PFAS Treatment Technologies

For leachate treatment, the most advantageous technologies were determined to be FF and RO. The following sections outline the cost curves and the NPCs. Capital cost markups for leachate PFAS treatment technologies differ from the markup estimates used for other technologies evaluated. Implementation of both technologies often employ modular systems (full-package units) minimizing complexity in equipment procurement, construction, installation and integration. For FF and RO, Table 3-28 below lists markups for purchased equipment delivered for all three size facilities.

Table 3-28. A Summary of Capital Costs Markups Purchased Equipment Delivered

Purchased Equipment Installation	25%
Instrumentation and Controls (Installed)	40%
Piping (Installed)	35%
Electrical Systems (Installed)	40%
Buildings (including services)	5%
Yard Improvements	7%
Service Utilities (Installed)	30%
Freight	10%
General Conditions	20%
Contractor Overhead and Profit	15%
Bonds, Insurance, Permit fees	2%
Estimating contingency	35%

For lump sum packages, Table 3-29 below lists the markups, which are the same for each size facility, but differ for FF versus RO. Not listed in the table is the 120 dollar per square foot cost of a prefabricated steel treatment building and 25 dollar per square foot cost for the cast-in-place concrete pump area.

Table 3-29. A Summary of Capital Costs Markups for Lump Sum Packages

	Foam Fractionation Lump Sum Package	Reverse Osmosis Lump Sum Package
Instrumentation and Controls (Installed)	5%	5%
Piping	5%	5%
Electrical Systems	15%	15%
Installation	25%	25%
Freight	10%	10%
General Conditions	20%	20%
Contractor Overhead and Profit	15%	15%
Bonds, Insurance, Permit Fees	2%	2%
Estimating Contingency	35%	35%

An additional markup for both purchased equipment delivered and lump sum packages is engineering and services during construction. For the small and medium facilities using FF or RO, this markup is 13%. For the large facilities using either FF or RO, this markup is 9%.

Foam fractionation

Capital Costs

The capital costs include the following components:

- Storage tanks
- Mixers
- Pumps
- Foam fractionation unit (vendor package)
- Bag Filters
- Pre-fabricated stainless steel building

The equipment costs for both the main equipment and ancillary equipment were developed using quotes for similar installations and escalated to today's dollars and the correct geographic area as needed. The building was sized to fit the main and ancillary equipment treatment equipment. Markups for the above listed capital cost components are listed in Table 3-28. A capital cost breakdown for FF at low, medium, and large flow rates can be found in Appendix I.

Figure 3-27 summarizes the capital costs associated with FF for the three landfill leachate flow rates facility sizes shown in 3.4.1. The orange, center line shows three points for the small, medium, and large facility sizes used to create the trend line. The figure also shows a +100% and -50% estimating range in blue above and below the estimated capital cost line.

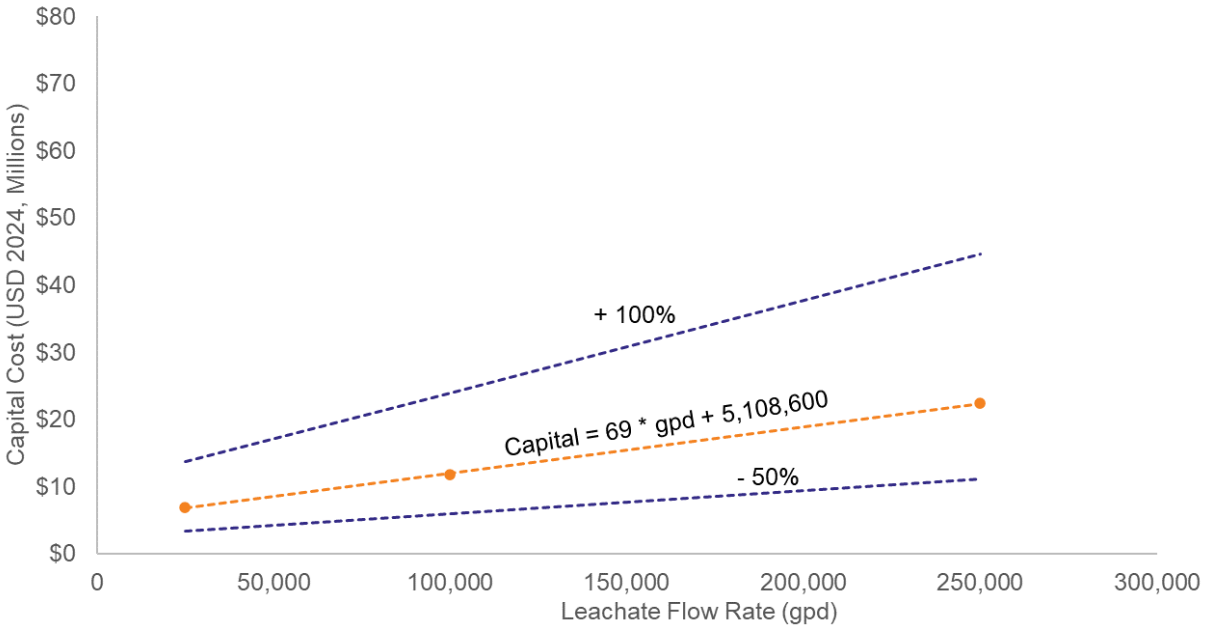


Figure 3-27. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of Foam Fractionation

Operations and Maintenance Costs

The major O&M costs associated with this technology are the following:

- Electricity
- Management of residuals

The additional assumed O&M cost associated with this technology are the following:

- Chemicals
- Spare parts
- Labor

Each of these items contribute to the overall O&M cost on an annual basis. Residuals management costs are based on gallons per year. This is then multiplied by the residuals management fee per gallon in Table 3-13 to determine an overall associated cost. Electricity costs are on a kWh/yr basis which can then be multiplied by the assumed unit prices for electricity shown in Table 3-13. Labor, including operations and maintenance, is calculated using FTE and then multiplied by the assumed wages listed in Table 3-13.

Table 3-30. O&M Totals - Foam Fractionation								
Facility Size	O&M Cost Item	Unit	Total	Unit Cost Assumptions (from Table 3-13)			Total O&M Cost ($/yr)	Total O&M Cost by Facility Size
Small (25,000 gpd)	Leachate Residuals	gpy	91,250	$	0.45	/gal	$41,063	$275,000
	Electricity	kWh/yr	131,890	$	0.20	/kWh	$26,400	
	Chemicals	$/yr	$3,750	N/A			$3,750	
	Other Costs	$/yr	$89,000	N/A			$89,000	
	Labor	FTE	1	$	55	/hr	$114,400	
Medium (100,000 gpd)	Leachate Residuals	gpy	365,000	$	0.45	/gal	$164,250	$504,000
	Electricity	kWh/yr	292,410	$	0.18	/kWh	$52,600	
	Chemicals	$/yr	$15,000	N/A			$15,000	
	Other Costs	$/yr	$147,006	N/A			$147,006	
	Labor	FTE	1	$	60	/hr	$124,800	
Large (250,000 gpd)	Leachate Residuals	gpy	912,500	$	0.45	/gal	$410,625	$1,075,000
	Electricity	kWh/yr	626,500	$	0.16	/kWh	$100,200	
	Chemicals	$/yr	$37,500	N/A			$37,500	
	Other Costs	$/yr	$235,258	N/A			$235,258	
	Labor	FTE	2	$	70	/hr	$291,200	

Figure 3-28 summarizes the O&M costs associated with FF for the three facility sizes. As shown in the figure, the trend between the facility size and O&M cost is mostly linear since the main O&M cost components for this technology, such as power demand and residuals management, are dictated and proportional to the system design flow (facility size).

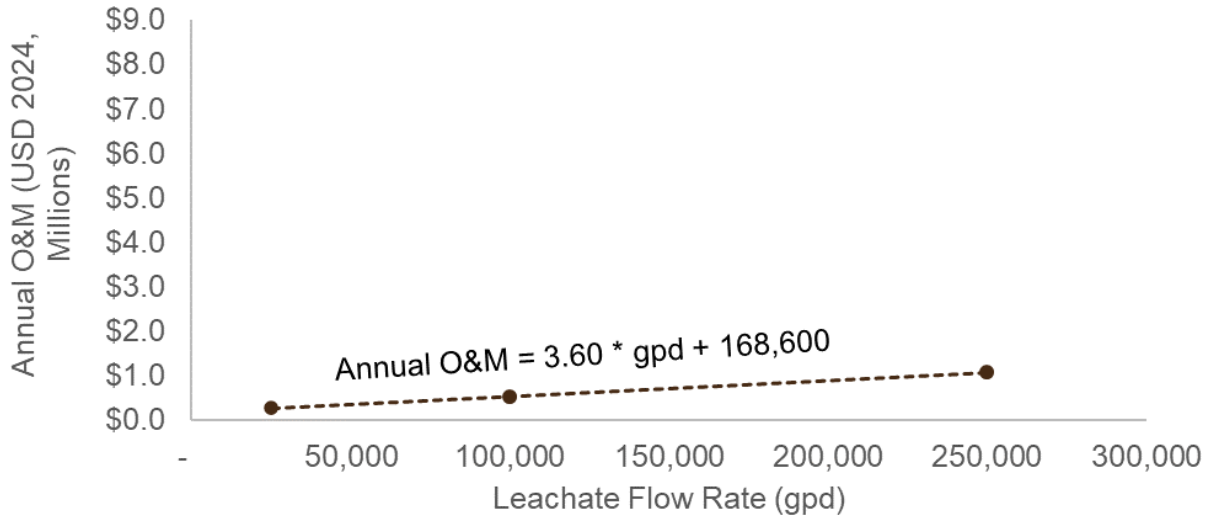


Figure 3-28. Project Capital Cost Curve for Installation of Foam Fractionation

Reverse Osmosis

Capital Costs

The capital costs include the following components:

- Storage tanks
- Mixers
- Pumps
- RO system (vendor package)
- Pre-fabricated steel building

The equipment costs for both the main equipment and ancillary equipment were developed using quotes for similar installations and escalated to today's dollars and the correct geographic area as needed. The building was sized to fit the main and ancillary equipment treatment equipment. Markups for the above listed capital cost components are listed in Table 3-28. A capital cost breakdown for RO at low, medium, and large flow rates can be found in Appendix I.

Figure 3-29 summarizes the capital costs associated with RO for facilities at various sizes. The orange, center line shows three points for the small, medium, and large facility sizes used to create the trend line. The figure also shows a +100% and -50% estimating range in blue above and below the estimated capital cost line.

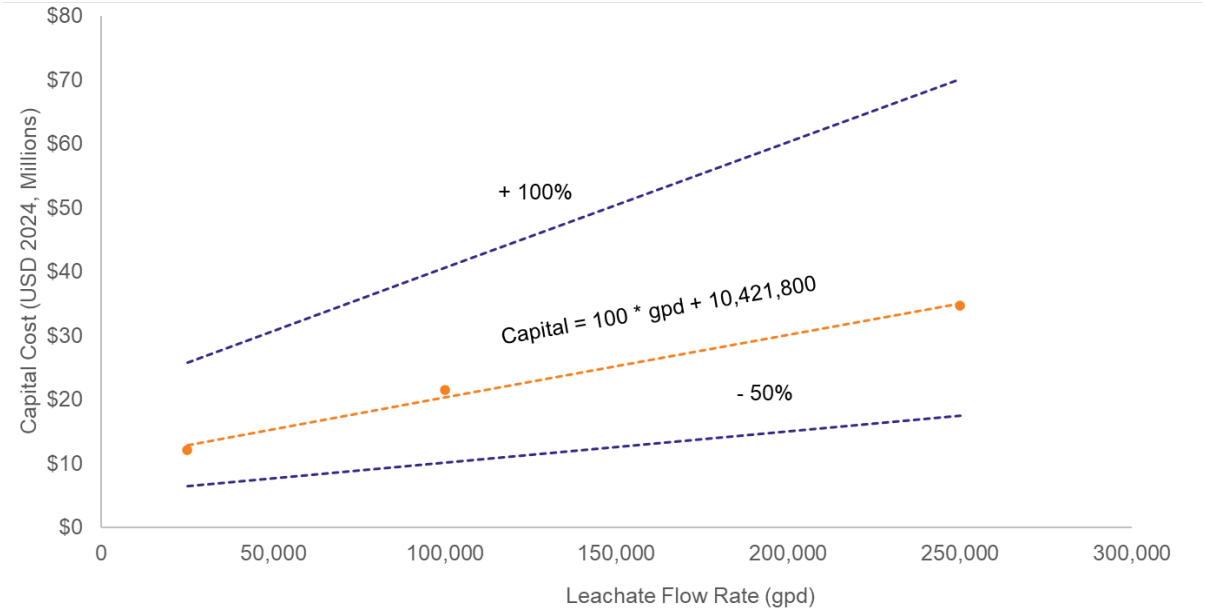


Figure 3-29. Project Capital Cost Curve with Estimating Range (-50% to +100%) for Installation of Reverse Osmosis

Operations and Maintenance Costs

The major O&M costs associated with this technology are the following:

- Electricity
- Management of residuals

The additional O&M costs associated with this technology are the following:

- Chemicals
- Spare parts

- Labor

Each of these items contribute to the overall O&M cost on an annual basis. Residuals management costs are based on gallons per year. This is then multiplied by the residuals management fee per gallon in Table 3-13 to determine an overall associated cost. Electricity costs are on a kWh/yr basis which can then be multiplied by the assumed unit prices for electricity shown in Table 3-13. Labor, including operations and maintenance, is calculated using FTE and then multiplied by the assumed wages listed in Table 3-13.

Table 3-31 O&M Totals - Reverse Osmosis

Facility Size	O&M Cost Item	Unit	Total	Unit Cost Assumptions (from Table 3-13)		Total O&M Cost ($/yr)	Total O&M Cost by Facility Size
Small (25,000 gpd)	Residuals	gpy	1,368,750	$0.45	/gal	$615,938	$1,025,000
	Electricity	kWh/yr	114,320	$0.20	/kWh	$22,900	
	Chemicals	$/yr	$117,317	N/A		$117,317	
	Other Costs	$/yr	$153,800	N/A		$153,800	
	Labor	FTE	1	$55	/hr	$114,400	
Medium (100,000 gpd)	Residuals	gpy	5,475,000	$ 0.45	/gal	$2,463,750	$3,634,000
	Electricity	kWh/yr	238,430	$ 0.18	/kWh	$42,900	
	Chemicals	$/yr	$469,268	N/A		$469,268	
	Other Costs	$/yr	$407,987	N/A		$407,987	
	Labor	FTE	2	$ 60	/hr	$249,600	
Large (250,000 gpd)	Residuals	gpy	13,687,500	$ 0.45	/gal	$6,159,375	$8,460,000
	Electricity	kWh/yr	496,460	$ 0.16	/kWh	$79,400	
	Chemicals	$/yr	$1,173,170	N/A		$1,173,170	
	Other Costs	$/yr	$756,572	N/A		$756,572	
	Labor	FTE	2	$ 70	/hr	$291,200	

Figure 3-30 summarizes the O&M costs associated with RO for the three facility sizes. Similar to FF, the trend between the facility size and O&M cost is mostly linear since the main O&M components affecting the cost are proportional to the system design flow. Note that the O&M costs for RO are considerably higher than FF.

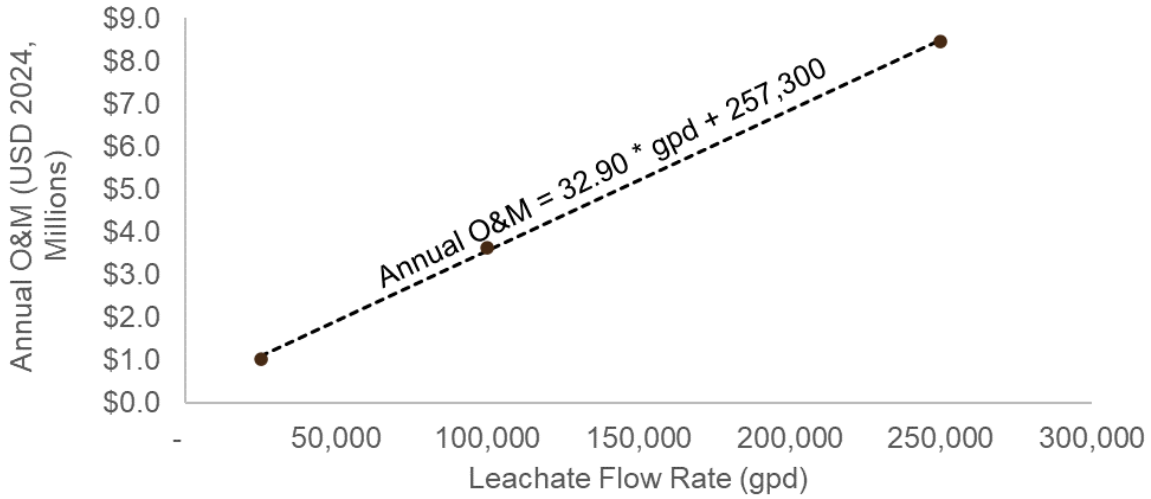


Figure 3-30. Project Capital Cost Curve for Installation of Reverse Osmosis

Net Present Costs

Based on the Class 5 capital cost estimates developed as well as the annual O&M costs, the 20-year NPC for PFAS mitigation of leachate at a landfill are displayed in Figure 3-31.

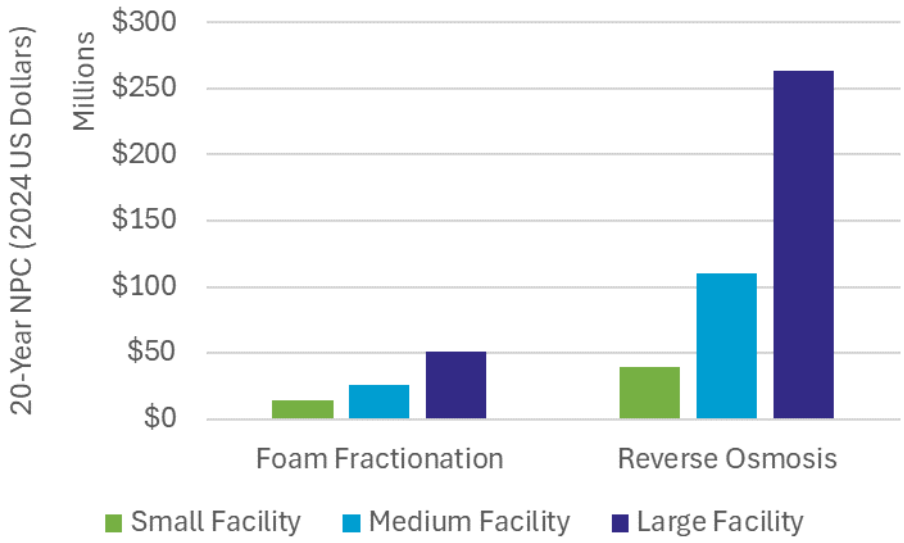


Figure 3-31. A Summary of the 20-year NPC for Leachate PFAS Mitigation Technologies

Overall, the NPC is higher for implementation of an RO system as compared to an FF system. Although NPC does not fluctuate significantly for FF treatment as facility size increases, facility size significantly impacts the NPC of RO treatment. This is largely due to greater capital expenditures associated with purchased equipment costs, both from major treatment equipment (i.e. RO membranes) and ancillary parts needed to support the system. In terms of O&M expenditures, an RO system also accrues substantial costs for residual management, chemical and power usage, and periodic membrane replacement. Though FF NPC increases incrementally, the footprint required for this technology does not vary as much and less residuals are produced, resulting in lower net capital and O&M costs.

3.5 Sewer Rate Impact Estimates

Three approaches are taken below to put the estimated costs for implementing these technologies in perspective. An annualized cost for the required capital is estimated based on typical debt service terms and added to the O&M costs to obtain an approximation for the total annual cost. These total annual costs for different technologies at the modeled POTW sizes (Small, Medium, Medium-Large and Large) are:

1) Compared to the operating budgets of POTWs of approximately the same size,
2) Divided by an estimate of the number of household ratepayers in the service area to determine an approximate cost per household, and compared to median incomes in Massachusetts, and
3) Same as #2 above but compared to current median water and sewer bills.

Actual costs will vary significantly on a project-by-project basis and would be refined during the planning and design process, but this analysis is intended to provide a high-level approximation of the relative cost of installing the technologies discussed.

Note that in this section the "Incinerator Upgrade" for PFAS treatment of air emissions (as discussed in 3.1.3) is represented by the Lynn Regional WPCF since its plant flows are most nearly the "Large" facility size (20 mgd). The other technologies represent new full-scale construction projects, whereas the incineration upgrade is adding air treatment equipment (a regenerative thermal oxidizer) to an existing installation, so costs are relatively lower.

3.5.1 Assumptions

The assumptions in Figure 3-17 were used in this analysis.

Table 3-32. Input Assumptions for Sewer Rate Impact Calculations

Variable	Value	Units	Notes
Bond duration	20	yrs	Typical for municipal projects
Bond rate	5	%	Typical non-SRF rate
Typical inflow and infiltration (I&I)	20%	% of total plant influent	Typical assumption for non-billable flow
Residential Gallons per Capita Day	65	gallons/person/day	DEP-Approved Performance Standards for Massachusetts Public Water Suppliers (2024)
People/equivalent residential unit	2.2	People/ERU	Typical assumption
Wastewater generation per household	143	Gallons/ERU	Calculated
Households per mgd of non-I&I flow	5,594	ERU/mgd	Calculated
Median household income - statewide	99,900	$/yr	U.S. Census Bureau QuickFacts
Median household income – Boston area	105,900	$/yr	U.S. Census Bureau QuickFacts
Median household income – western MA	66,600	$/yr	U.S. Census Bureau QuickFacts

3.5.2 Calculation Approach

Annualized Costs

Annual debt service payments for each technology are calculated from the capital costs from Sections 3.4.3 and 3.4.4 according to the following equation:

$$Annual\ bond\ service\ payment = 12 * \frac{Capital\ cost * \frac{-Bond\ rate}{12}}{1 - (1 + \frac{Bond\ rate}{12})^{-12 * Bond\ duration}}$$

Bond service payments and O&M costs are summed according to the following equation to determine a total estimated annual cost of implementing each technology:

$$Total\ annual\ cost = Annual\ bond\ service\ payment + Annual\ O\&M$$

Cost per Residential User

The equivalent residential unit (ERU) was calculated according to the following equation:

$$ERU = Billable\ plant\ flow\ \div Wastewater\ generation\ per\ household$$

The total cost per year per ERU was calculated according to the following equation:

$$Annual\ cost\ per\ ERU = Total\ annual\ cost\ \div ERU$$

The annual cost per ERU as a percent of median household income was calculated according to the following equation:

$$Annual\ cost\ per\ ERU\ as\ \%\ of\ median\ household\ income$$
$$= Annual\ cost\ per\ ERU\ \div Median\ household\ income$$

The annual cost per ERU as a percent of median water and sewer rates was calculated according to the following equation:

$$Annual\ cost\ per\ ERU\ as\ \%\ of\ water\ and\ sewer\ rates$$
$$= Annual\ cost\ per\ ERU\ \div Median\ water\ and\ sewer\ rates$$

3.5.3 Comparison to Select POTW Operating Budgets

Operating and maintenance budgets from several POTWs in Massachusetts were collected to provide a reference to the annualized cost of implementing the technologies discussed. These values are summarized in Table 3-33 below.

Operating budgets are sourced from official administrative sources such as city budgets, public financial audits, or capital improvement plans. A selection of facilities in Massachusetts were chosen so that there are at least two data points for each typical size facility analyzed (e.g. Small, Medium, Medium-Large, and Large). Note that the representative POTW sizes differ slightly from the sizes assumed for the capital and O&M costs (Small: 0.5 mgd; Medium: 5 mgd; Medium-Large: 10 mgd; Large: 20 mgd) but are close enough to allow for a high level comparison.

Table 3-33. Annual O&M Budgets for Various Wastewater Treatment Plants in Massachusetts

Facility Name	Facility Size	Average Daily Flow (mgd)	Operating Budget ($, in source year)	Source Budget Year	Operating Budget (escalated to 2024 $ if needed)	Data Source
Athol WWTP	Small	0.91	$1,558,839	2024	$1,558,839	Town of Athol FY24 Budget Summary
Ipswich WWTP		0.8	$2,880,916	2024	$2,880,916	Town of Ipswich 2024 Annual Budget
Attleboro WWTP	Medium	4.68	$6,378,680	2022	$6,863,460	City of Attleboro Proposed Budget
Charles River PCD		5.1	$5,557,648	2023	$5,741,050	PCD Examination of Basic Financial Statements
Holyoke WWTP	Medium-Large	8	$7,878,573	2024	$7,878,573	City of Holyoke City FY Budget
Fitchburg East WWTP		7.7	$4,904,250	2024	$4,904,250	City of Fitchburg FY 2024 Operating Budget
Upper Blackstone WPAD	Large	34	$30,275,421	2024	$30,275,421	Upper Blackstone WPAD Basic Financial Statements
Greater Lawrence Sanitary District		32	$23,586,494	2024	$23,586,494	Greater Lawrence Sanitary District FY 2024 Operating Budget
Haverhill WWTP		18	$8,460,880	2024	$8,460,880	City of Haverhill Budget Plan

Figure 3-32 shows the total estimated annual operating costs for the technologies evaluated as a percent of the average annual operating budget for a POTW of that size from Table 3-18. Introducing these technologies would significantly add to the annual costs for POTWs, particularly for smaller POTWs. Costs of these technologies range from a tenth to over double the current annual operating budgets of representative POTWs in Massachusetts. In general, these technologies benefit from economies of scale. Some of the annual cost could be reduced if lower interest loans (e.g., SRF) or grants were obtained for the capital cost.

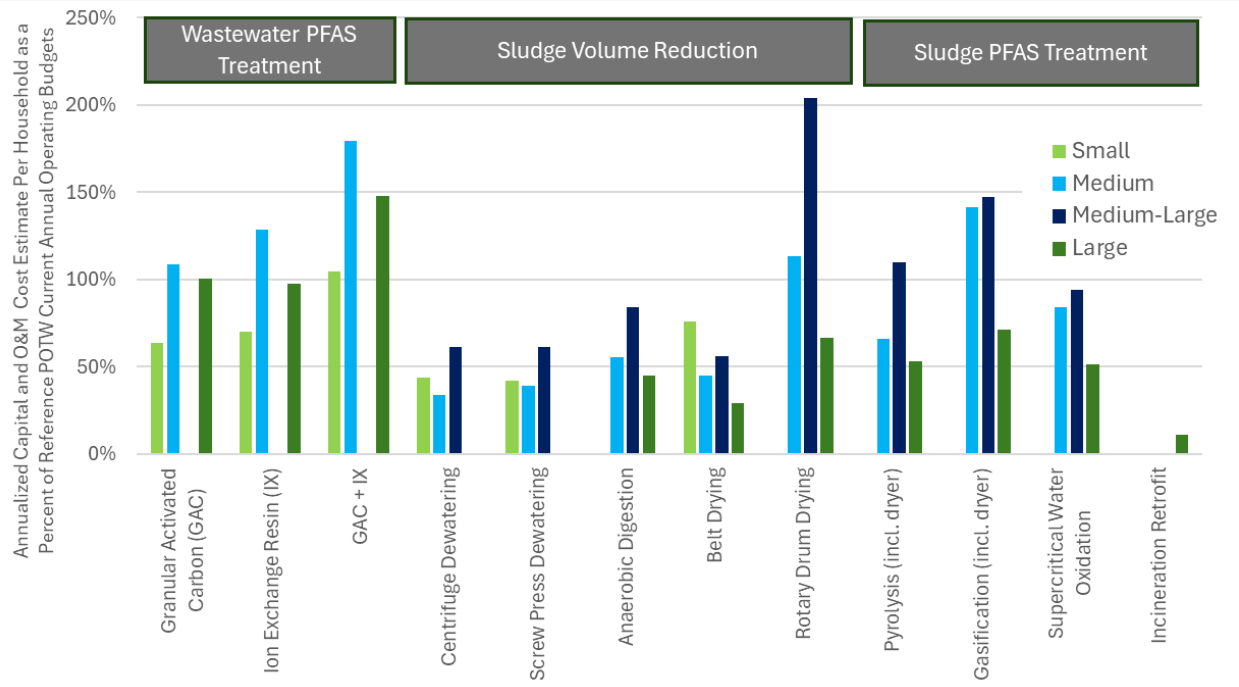


Figure 3-32 Annualized Capital and O&M Cost of Implementing Technologies as a Percent of Reference POTW Current Annual Operating Budgets

Note: Cost estimates were not developed at all POTW sizes for all technologies.

3.5.4 Comparison to Median Income

Estimated annual costs to cover capital (i.e. debt service) and O&M costs for these technologies at various POTW sizes were divided by estimates of the number of households in a service area of that size ("Equivalent Residential Units," or ERUs) to get an approximation of the cost per household. Figure 3-34, Figure 3-35, and Figure 3-36 compare these estimated annualized costs per household to median household income in Massachusetts as a whole, in the Boston area, and in Western Massachusetts, respectively (from Table 3-32). The costs of implementing these technologies are estimated to range from less than 0.1% of median household income to nearly or even above 1%. For reference, the EPA (2021) considers sewer bills of greater than 2% to be a "high burden" to lower and middle income households. The cost to implement these technologies would add to existing charges so the resulting overall bill as a percentage of household income would be higher.

In general, the levelized cost of these technologies decreases with larger facilities due to economies of scale. The potential economic impact of implementing these technologies is greater in communities like Western Massachusetts where the median income is lower. It should also be noted that income distribution in the Massachusetts, and particularly in the Boston area, is uneven with particularly high income households raising the median income level. Rising sewer rates would be particularly difficult to accommodate for those making significantly less than the median income.

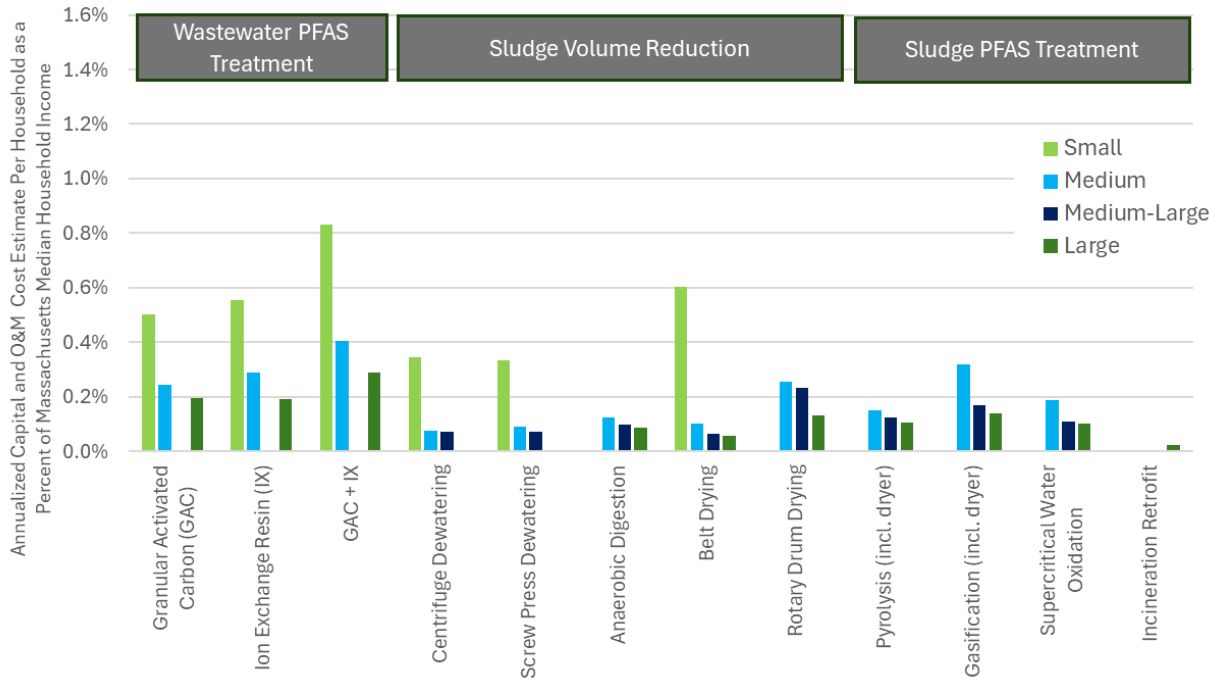


Figure 3-33 Estimated Annual Costs of Technology Implementation Per Household in the Service Area as a Percent of Massachusetts Median Household Income by Modeled POTW Size

- *Cost estimates were not developed at all POTW sizes for all technologies.*
- *Small = 0.5 mgd; Medium = 5 mgd; Medium-Large = 10 mgd; Large = 20 mgd*
- *% based on statewide median income in Massachusetts*

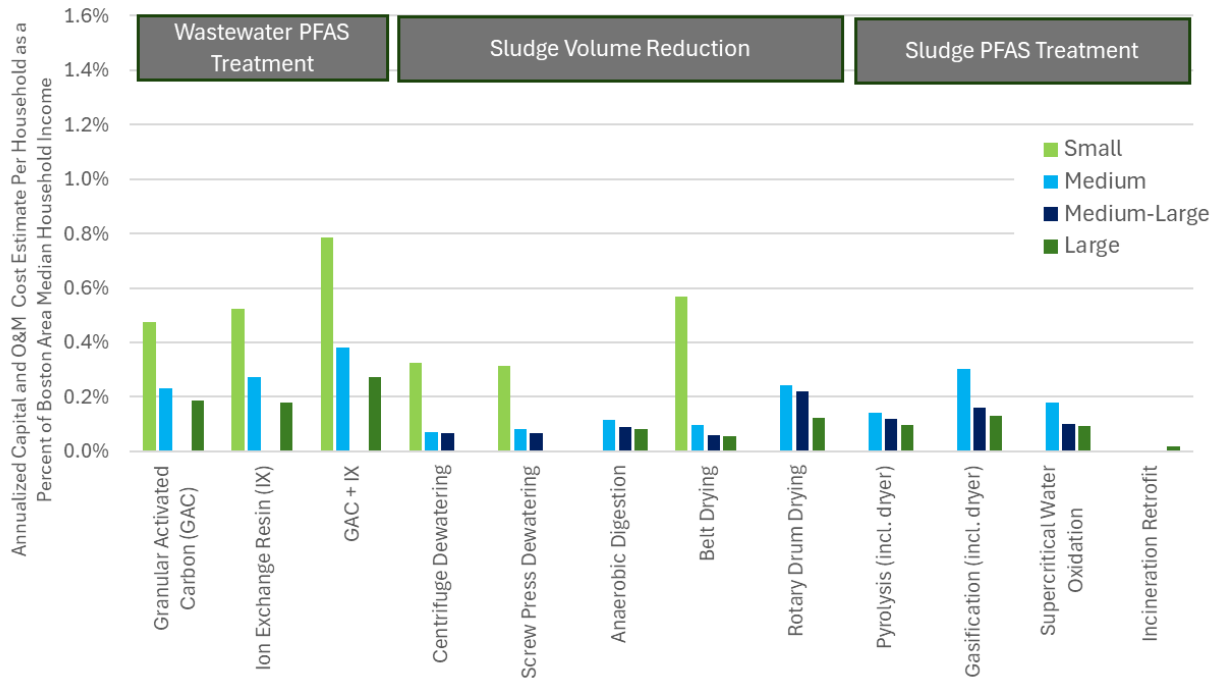


Figure 3-34 Estimated Annual Costs of Technology Implementation Per Household in the Service Area as Percent of Boston Area Median Household Income by Modeled POTW Size

- *Cost estimates were not developed at all POTW sizes for all technologies.*
- *Small = 0.5 mgd; Medium = 5 mgd; Medium-Large = 10 mgd; Large = 20 mgd*
- *% based on median income in Boston area*

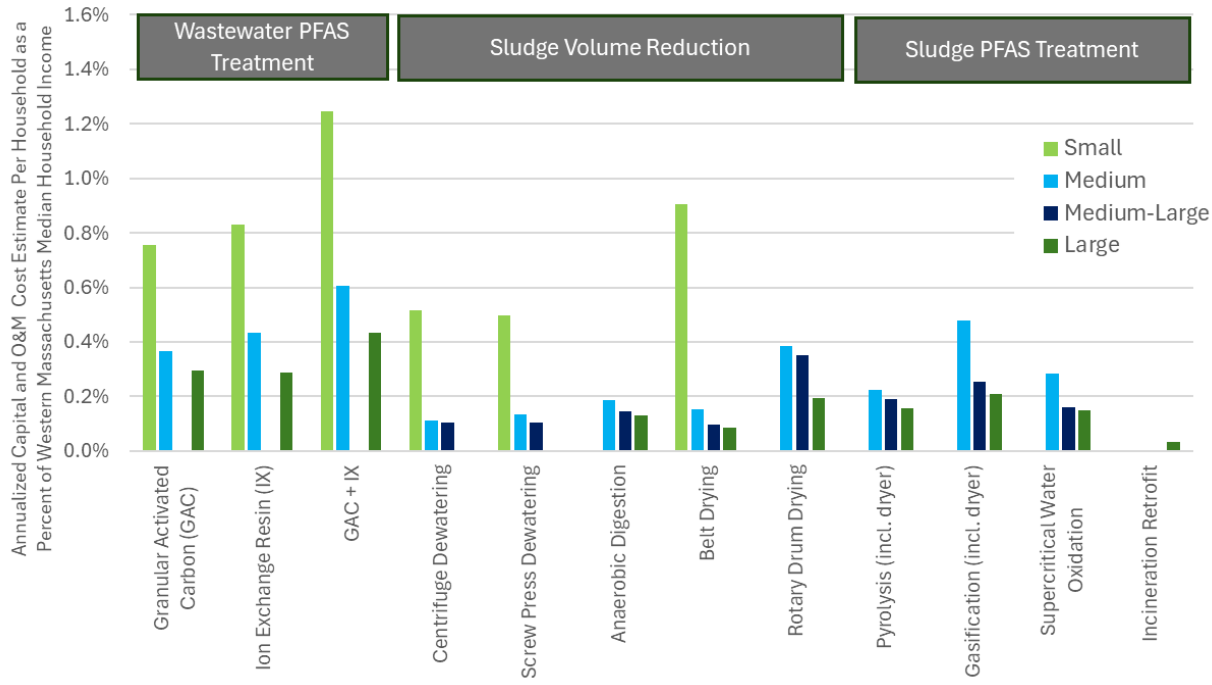


Figure 3-35 Estimated Annual Costs of Technology Implementation Per Household in the Service Area as a Percent of Western Massachusetts Median Household Income by Modeled POTW Size

- *Cost estimates were not developed at all POTW sizes for all technologies.*
- *Small = 0.5 mgd; Medium = 5 mgd; Medium-Large = 10 mgd; Large = 20 mgd*
- *% based on median income in Western Massachusetts*

3.5.5 Comparison to Existing Water and Sewer Bills

Another way to put these costs into context is to compare them to existing water and sewer rates. Typical Massachusetts water and sewer rates were obtained to provide a reference for the annualized cost of the technologies discussed. According to an ongoing survey of water and sewer rates across the commonwealth conducted by Tighe & Bond in collaboration with the University of North Carolina Environmental Finance Center (2024), the median monthly water and sewer bill for a household producing the assumed average of 65 gallons per person per day is $41.33 per month, or $496 per year. Note that this is for drinking water and sewer services. While most communities have separate rate structures for water and sewer charges, they are typically billed together. This combined water and sewer rate was used as a comparison in the following discussion since the total on the water and sewer bill is likely the value most people will be most familiar with.

As in the comparison to median income, estimated annual costs for these technologies were divided by estimated ERUs to get an approximation of the cost per household. These values are shown in Figure 3-36 as a percentage of the current median annual water and sewer bills paid by households in Massachusetts. The cost of implementing many of these technologies per ratepayer would be significant, particularly at smaller scale facilities. For instance, the annualized cost per ERU for the wastewater PFAS treatment technologies and for belt dryers at small POTWs would represent the equivalent of more than doubling existing water and sewer rates (>100% of existing rates) for those communities. But even at “Large” (20 mgd) POTWs, wastewater PFAS treatment technologies are estimated to be equivalent to a 40-60% increase in median water and sewer rates, sludge volume reduction technologies are a 10-25% increase, and sludge PFAS treatment technologies are a 20-30% increase.

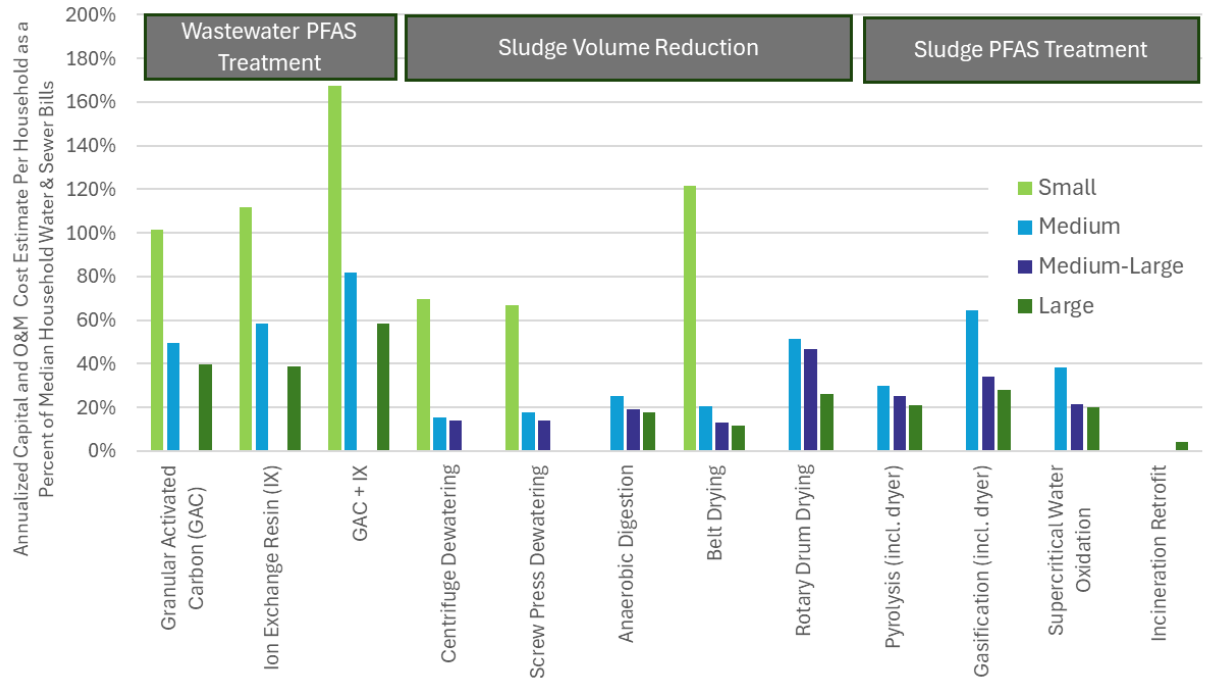


Figure 3-36. Estimated Annual Costs Per Household in the Service Area of Technology Implementation as a Percent of Current Median Annual Household Water and Sewer Bills by Modeled POTW Size

- *Cost estimates were not developed at all POTW sizes for all technologies.*
- *% based on median water and sewer rates per household assuming 4,400 gallons per month water use*
- *Small = 0.5 mgd; Medium = 5 mgd; Medium-Large = 10 mgd; Large = 20 mgd*

3.5.6 Sewer Rate Impact Estimate Summary

The annualized cost of implementing the technologies explored in this report can be expensive, estimated to represent a significant fraction of:

- Current POTW operating budgets,
- Household median income, and
- Current water and sewer bills.

While high level estimates, some of the costs appear to be cost prohibitive at certain scales without significant financial support from, for instance, low- or no-interest loans or grants. If installation of these technologies is cost prohibitive for smaller facilities, their sludge can be hauled to larger POTWs or regional facilities for processing. This option is not practical for wastewater liquid treatment. If smaller facilities are required to treat full-plant liquid flows for PFAS this analysis suggests that it would not be feasible without significant support for capital and likely O&M costs.

3.6 Non-Cost Criteria

In addition to cost, there are several other factors affecting the operation and suitability of these technologies that must be evaluated. There are a unique set of concerns in Massachusetts that were assessed for wastewater and sludge treatment technologies.

3.6.1 Wastewater Liquid Fraction PFAS Treatment Technologies

Below is a non-cost evaluation of the technologies selected for further analysis in Section 1.1.1.7.

Priority Criteria for Evaluation

MassDEP, in consultation with BC, chose seven highest priority non-cost criteria when considering technologies for PFAS treatment for wastewater or sludge.

- **Air Emissions** – Impacts on air quality.
- **Required Footprint** – The relative amount of space a given technology requires for installation and to operate and maintain.
- **Reliability/Treatment Efficacy** – Consistency of treatment performance.
- **Operational Flexibility and Complexity** – The ease with which operators can run the system, as well as adapt to changing conditions.
- **Technology Maturity** – The extent to which a technology has been proven for the application under consideration.
- **PFAS/Contaminant Reduction Efficiency** – How effective the technology is at reducing and/or destroying PFAS and other contaminants.
- **Climate Impact** – Relative energy consumption or production, and other greenhouse gas emissions.

Other Criteria for Evaluation

Six other criteria were also selected for evaluation.

- **Odor Potential** – Generation of odors during operation
- **Compatibility with Typical POTW Processes**– Consideration of whether certain technologies are better suited for certain types of wastewater treatment processes, such as activated sludge, pure oxygen, etc.
- **Potential for Financing** – Consideration of availability of financing to implement a given technology. This is discussed in detail in Section 3.8.
- **Statutory/Regulatory Requirements –** Consideration of impediments and challenges to implement a given technology
- **Resiliency to Regulatory Changes** – Consideration of the extent to which changes in regulations will affect the performance or relative benefit of a technology
- **Centralized vs Decentralized Installation** – Consideration of whether a technology is better suited to centralized or decentralized treatment

Major Criteria

A synopsis of the relative performance of each technology compared to the others according to the highest priority criteria is provided below. Green indicates a non-cost criterion that is relatively favorable for that technology; orange is relatively unfavorable; and yellow is neutral or mixed.

Table 3-34. Rating of PFAS Mitigation Technologies for Wastewater by Priority Criteria Identified by MassDEP

	Granular Activated Carbon	Anion Exchange Resin	GAC + IX
Air Emissions[1]	GAC may be landfilled or re-activated to dispose of PFAS. Re-activation may contribute to air emissions. PFAS may leach from GAC in LF.	PFAS-specific resin must be incinerated or landfilled after use (non-regenerable). Incineration may contribute to air emissions. PFAS may leach from resin in LF.	PFAS-specific resin must be incinerated or landfilled after use (non-regenerable). GAC may be landfilled or re-activated to dispose of PFAS. Incineration and re-activation may contribute to air emissions. PFAS may leach from media in LF.
Required Footprint	Slower kinetics require a lower loading rate, larger vessels, and larger footprint.	Kinetics of IX are faster than for GAC, permitting higher loading rates and a smaller footprint.	A combined treatment layout would require a footprint between the size of IX and GAC.
Reliability/Treatment Efficacy	Higher reliability when run in a lead-lag configuration. Lead vessel removes most contaminants and can be fully exhausted, allowing the lag vessel to serve as a polishing step before transitioning to the lead vessel. However, PFAS may be "bumped off" media if other, more favorable compounds are present in the influent.	Higher reliability when run in a lead-lag configuration. Lead vessel removes most contaminants and can be fully exhausted, allowing the lag vessel to serve as a polishing step before transitioning to the lead vessel.	Combination of GAC and IX would tend to have higher reliability than either process individually. However, the choice of locating GAC or IX first in the train may affect reliability and should be considered on a site-by-site basis.
Operational Flexibility and Complexity	Lower susceptibility to fouling but requires more frequent change-out. Backwashing is straightforward when needed. Disinfection with chlorine not advised due to tendency to be quenched by GAC.	Higher susceptibility to fouling, so may require extensive pretreatment. Requires less frequent change-out. Chlorine disinfection not possible due to resin material. Backwashing not advised due to risk of washing out beads.	Higher complexity due to combination of technologies. Also includes two different media and two different residuals requiring disposal.
Technology Maturity	Well-established technology for PFAS in drinking water, not established for use in wastewater.	Well-established technology for PFAS in drinking water, not established for use in wastewater.	Each component is well-established for PFAS in drinking water. However, combining the two technologies, and applying either for wastewater treatment, has not been established.
Degree of PFAS/Other Contaminant Reduction	Good removal of long-chain PFAS and other organics. High levels of organics may limit PFAS removal due to blinding and domination of adsorption sites	PFAS-specific resin may primarily remove PFAS and some anions. Provides better removal of short-chain PFAS than GAC.	GAC may allow for higher removal of organics. IX may increase removal of short-chain PFAS, as well as PFAS that may be out-competed by organics in the GAC treatment step.
Climate Impact	GAC can be reused via thermal re-activation. GAC also has the lowest energy requirements of the three options considered. GAC requires greater volumes of media to be transported for re-activation more frequently.	PFAS-specific resin is typically single use. IX has the highest energy requirements of the three options considered.	A combination of GAC and IX will have a moderate energy usage.

1. *New research suggests PFAS may be transported out of landfills via air emissions. Ongoing research in this area is needed to confirm these findings.*

Minor Criteria

Lower priority considerations are explored briefly below.

Odor Potential

None of the evaluated technologies would contribute to odor potential. Systems with GAC are likely to provide removal of odor-causing compounds until capacity is reached.

Compatibility with Typical POTW Processes

While not proven for wastewater at this time, the proposed technologies are all generally compatible with typical POTW processes. However, streams with high levels of nitrite and nitrate may negatively impact IX performance due to competition with PFAS in the media. There is a risk of biofouling and solids fouling for both GAC and IX. Ideally, these systems would be placed as far downstream as possible while remaining upstream of disinfection or receive filtered influent. IX resin degrades in the presence of chlorine, and GAC can quench it, resulting in minimal residual chlorine in the effluent.

Statutory/Regulatory Requirements

Installing GAC and/or IX contactors in a new or existing POTW requires obtaining the necessary permits from MassDEP. This entails submitting detailed engineering plans, hydraulic studies, and any pertinent performance data to demonstrate the treatment systems will function as intended. Past performance of the technology in Massachusetts is also taken into account. In instances where performance data is limited, MassDEP reserves the right to require piloting of the technology. No unique requirements for installing either GAC or IX systems in POTWs are listed in MassDEP's wastewater and sewer regulations or "Guidelines for the Design, Construction, Operation, and Maintenance for Small Wastewater Treatment Facilities with Land Disposal."

Resiliency to Regulatory Changes

The PFAS regulatory landscape continues to change rapidly. Regulations may manifest in the form of additional species being regulated, or requirements for municipalities to treat to lower levels. In the case where additional short-chain PFAS compounds are regulated, GAC performance may suffer, as it is less effective in removing short-chain PFAS. However, in the case where regulatory limits are decreased further, GAC may perform more favorably than IX, as it can be re-activated and re-used, and is less likely to be considered a hazardous material. On the other hand, IX can treat short-chain compounds effectively, but a PFAS-specific resin is not regenerable. The resin, as noted above, may need to be incinerated or landfilled. Both approaches are viable under the current regulatory environment, but landfilling is often the more economical approach.

Centralized vs Decentralized Installation

Since GAC and IX systems can be provided for systems at very low flows, there are limited advantages to centralization apart from economies of scale. Furthermore, a centralized facility would require extensive hauling or pumping of wastewater to the facility.

3.6.2 Sludge Volume Reduction and PFAS Treatment Technologies

Below is a non-cost evaluation of the technologies selected for further analysis as described in Section 3.1.2. Major and minor criteria for sludge volume reduction and PFAS treatment technologies are the same as for wastewater treatment technologies. Dewatering is a well-established and relatively well-understood technology and so was omitted from this analysis. Thermal drying, which includes belt dryers, rotary drum dryers and other technologies, is evaluated as a general technology type. Pyrolysis and gasification are similar technologies and so are combined.

Major Criteria

A synopsis of the relative performance of each technology (mesophilic anaerobic digestion, thermal drying, pyrolysis/gasification, and supercritical water oxidation) compared to the others according to the highest priority criteria is provided below. Green indicates a non-cost criterion that is relatively favorable for that technology; orange is relatively unfavorable; and yellow is neutral or mixed.

Table 3-35. Rating of Sludge Volume Reduction and PFAS Treatment Technologies by Priority Criteria Identified by MassDEP

	Mesophilic Anaerobic Digestion	Thermal Drying	Pyrolysis/Gasification	Supercritical Water Oxidation
Air Emissions	May contribute to methane emissions if digester is not properly designed and operated	Requires significant energy input. Some dryers produce NOx. May contribute dust if not properly operated.	Emissions will contain NOx, carbon monoxide and dust	May produce CO during startup and shutdown if fossil fuels are used
Required Footprint	Largest among these technologies due to required hydraulic retention time	Can vary significantly among drying technologies	Relatively large footprint, including associated dryer	Moderate footprint
Reliability/Treatment Efficacy	High reliability for volume reduction, gas production, and stabilization for sludge containing primary solids	Can vary among drying technologies and designs, but generally well-established and reliable	Limited full-scale experience for wastewater feedstocks. High reliability for woody biomass. Continual conveyance of material into units has been problematic/difficult	Uncertain reliability at large scale
Operational Flexibility and Complexity	Relatively simple operation	Can vary significantly among drying technologies	Operation can be adjusted to produce more gas or more char, depending on client preference and feedstock. Complex operation	Very complex operation
Technology Maturity	Well-established technology	Well-established technology	Well-established for other industries, but not widely adopted for wastewater	In developmental phase
Degree of PFAS/Other Contaminant Reduction	No demonstrated reduction of PFAS	No/limited reduction of PFAS	Preliminary research shows high reduction from existing installations	Preliminary research shows high reduction from pilot units
Climate Impact	Produces a biogas which can be used for digester and building heating, power production and vehicle fueling.	Requires energy input to dry solids. Typically natural gas (though biogas and syngas can offset). End product is typically land applied, which has climate benefits.	Produces a syngas with significant fuel value. Combination with drying allows syngas to provide needed fuel for drying operations.	Depending on unit size, feedstock, and operation, may produce energy

Minor Criteria

Lower-priority considerations are explored briefly below.

Odor Potential

Thermal drying and pyrolysis/gasification are likely to contribute the most odors; however, this is dependent on the manufacturer, volume of air treated, sludge type (e.g., primary, waste activated,

co-digest), upstream digestion (which reduces odors) and the odor control technology used. Anaerobic digestion may result in odors to a limited degree. Finally, SCWO, since its emissions are contained, would produce the lowest amount of odors.

Compatibility with Typical POTW Processes

Each of the sludge treatment technologies presented here are unlikely to have impacts on the liquid stream of POTWs, regardless of process. For facilities with nitrogen limits, the ammonia and phosphorus produced as a by-product of anaerobic digestion can impact processes which receive the recycle stream from the digester (i.e., centrate). However, their compatibility with solids treatment should be carefully considered. Anaerobic digestion may reduce the quantity of solids for downstream processes, allowing for smaller facilities downstream. Anaerobic digestion also produces biogas, which may reduce the amount of energy available in any syngas produced in pyrolysis/gasification. Dryers are best suited for plants without primary sludge, or those that digest primary sludge before drying. Dryers with condensers in their air emissions process can return a significant condensate flow to the wastewater treatment process.

Resilience to Regulatory Changes

Digesters and dryers, as established and long-running technologies, are less likely to be susceptible to changes in regulations for the technologies themselves; however, both produce materials that are typically land applied, which is susceptible to regulatory change. Pyrolysis/gasification and SCWO are more likely to come under increased scrutiny as more facilities are constructed, and large-scale operations become better understood. USEPA (2021) issued a notice of intent to regulate pyrolysis and gasification systems.

Centralized Versus Decentralized Installation

Unlike the wastewater treatment technologies, the solids handling technologies typically have a higher threshold in flow rate that makes implementation of the technology feasible. Larger plants may be able to justify the cost of a digestion or drying system, whereas smaller plants would primarily benefit if they could haul their solids to a regional facility (as the capital cost could be cost prohibitive to install these technologies at smaller facilities, as shown in Section 3.4 and 3.5).

3.6.3 Anaerobic Digestion in Combination with PFAS Treatment Technologies

Anaerobic digestion can be combined with PFAS treatment technologies, though some combinations are more effective than others. SCWO can be used downstream of anaerobic digestion, but it tends to perform better independently because anaerobic digestion reduces the energy content of the sludge, potentially necessitating additional fuel supplementation. Similarly for pyrolysis and gasification, digestion upstream reduces the energy content of the sludge, resulting in less syngas for the drying process. However, for pyrolysis and gasification there is an advantage to having digestion upstream for plants that produce primary sludge, as drying undigested primary sludge tends to be problematic. Installations of all of these technologies would benefit from the volume reduction associated with digestion, which would allow for smaller sizing and cheaper operation of downstream equipment.

3.7 Considerations for Regional Sludge Facilities

Pursuing a regional approach to biosolids management can unlock opportunities otherwise inaccessible to a single agency and may be the only option for many smaller communities to gain access to complex technologies. Additional benefits include cost efficiency through shared expenses, shared risk management and increased purchase power. Collaboration reduces environmental impact by optimizing transportation and enhancing biosolids recycling efforts. Municipalities also

gain scalability and flexibility to meet growing needs, ensuring long-term reliability and regulatory compliance. Additionally, regional biosolids facilities can facilitate resource recovery by generating renewable energy, reducing waste streams, and supporting sustainable agriculture.

Regional facilities are not without challenges, however. Processing sludge from various POTWs in one location concentrates risk, as well as environmental justice impacts. Participating utilities become reliant on the O&M procedures of another entity, which can be disruptive during planned or particularly unplanned outages at the regional facility. Intermunicipal agreements are also notoriously difficult to finalize and maintain.

A municipal partnership for a regional biosolids solution involves collaboration among multiple municipalities to send material to a shared facility owned and operated by the collaborative, a single municipality, a private entity, or some combination of these options. When considering a regional biosolids solution, it's essential to focus on four elements: economics, logistics, permitting and relationships.

3.7.1 Economics

The economics of a regional facility can be analyzed in various ways, including those described below.

Needs Assessment: Identifying the biosolids management needs of each participating municipality includes understanding the current and projected future volume and characterization of the sludge or biosolids, existing infrastructure, and current and future constraints.

Value for Money (VfM) Analysis: This method is used by public sector entities to ensure ratepayer value when considering a regional arrangement or Public-Private Partnership (P3) instead of managing an activity themselves. This analysis is frequently used in the transportation and waste management sectors. The process starts with creating a Public Sector Comparator (PSC), which is a hypothetical scenario where the government handles everything—financing, risks, and the entire program. This gives the agency a baseline to compare against a regional or private solution.

When evaluating participation in a regional biosolids facility, each agency would develop a PSC based on cost and risk forecasts of their current biosolids management. If the regional solution can deliver the same results for less, the agency may then proceed with continued negotiations toward a commitment. If not, the agency may pause involvement or attempt to resolve sticking points. It's important to consider nuances, such as risk-sharing and managing revenue from product development. Since these decisions often hinge on small margins, a tiny change in project performance assumptions can sway the entire analysis.

Lastly, VfM analysis is an ongoing effort. As the project evolves and transport and tipping bids are received, the VfM analysis is updated to reflect the latest information. The goal is to ensure the final regional arrangement delivers the best value. More information on Value for Money assessments can be found on the U.S. Department of Transportation's website that offers a "P3 Guidebook for Value for Money Assessment."

Cost Sharing and Funding: Securing initial funding and establishing sustainable financing models can be challenging. Municipalities will want to leverage their combined biosolids volumes and willingness-to-pay to secure the best per-ton rates and attract capable vendors and investor interest. This may involve binding tonnage commitments. Financing options available to public sector entities may require the entity to exert more ownership over the facility and possibly take on more risk. Understanding the cost of and access to capital through various scenarios is critical. For example, Massachusetts Clean Water State Revolving Funds (SRF) are exclusive to public entities, whereas public and private entities can access Water Infrastructure Finance and Innovation Act (WIFIA) loans.

3.7.2 Logistics

Early consideration of critical factors for the site for a regional facility and how the facility will be operated on a daily basis will be important to ensure all partners are in agreement.

Site Selection: Several factors must be considered when selecting a site. Participating municipalities will naturally want to choose a location accessible to all participating municipalities and one that is expected to not have significant permitting challenges. However, early community awareness and ultimate acceptance may have the most bearing on the final site location. In addition to proper zoning and hauling access, a regional facility will typically require utility connections for electricity, communications, water, sewer and natural gas. A site with existing connections reduces site development costs. Wastewater utilities within this region should also explore having a participating utility serve as a host facility. This option can lead to lower capital and operation costs by leveraging existing infrastructure, utilities, zoning and permitting, site security, and transportation corridors.

Operational Plan: It's often wise to develop an initially high-level operational plan detailing the daily operations, material handling procedures, staffing requirements, and maintenance schedules. A high-level understanding of operations will assist with accurately assessing operations and maintenance costs, as well as acting transparently with community members and negotiating with private operating partners.

3.7.3 Permitting

Permitting must be considered regardless of the location of a potential regional biosolids management facility. Local permitting is usually required to meet zoning requirements, conservation commission requirements, building permits, site plan and other local requirements. State permitting ensures compliance with applicable state environmental statutes. In Massachusetts, MassDEP issues these permits, and the local regional MassDEP office will facilitate the permitting process. Pre-permitting meetings with the permittee and MassDEP will address the permitting pathway for the specific project.

A regional facility at a POTW would likely fall under that POTW's existing permitting structure. However, when sludge is treated at a facility not falling under the state water pollution abatement laws (M.G.L. c. 21, §§ 26 through 53) it falls into the definition of "solid waste," and hence permitting would likely fall under solid waste regulations (Title 310 CMR 19.000 - Solid Waste Management). Qualifying new solid waste facilities requires site assignment (310 CMR 16.00), which can be a lengthy process involving public hearings and coordination between MassDEP and the Department of Public Health.

A regional biosolids management facility would likely meet at least one Massachusetts Environmental Policy Act (MEPA) threshold, requiring a MEPA project review and certification. The MEPA Environmental Notification Form and Environmental Impact Report process will be required to obtain a MEPA certificate for the project. This is a critical and necessary process as MassDEP will not issue and, in some cases, will not start a permit until the MEPA certificate has been issued.

The MEPA certification and MassDEP permitting process can span months or years. It is a public process with multiple public comment and regulatory response periods required. Project planning needs to account for the time and expense associated with the rigorous project approval process through MEPA and MassDEP. Note that depending on the site and process selected, additional permitting requirements, not addressed directly in this section, may be required.

3.7.4 Relationships

Utilities aiming to enter regional project partnerships must prioritize building strong, collaborative relationships to ensure successful outcomes. These relationships are foundational for fostering trust,

aligning goals, and navigating the complexities of shared responsibilities. The following considerations explore how utilities can effectively develop and sustain these partnerships, creating a pathway for impactful regional collaborations.

Community Impact and Engagement: Understanding the potential community impact, both positive and negative, is crucial. Factors such as location, truck traffic, and facility operations influence how the project affects local residents in terms of environmental, social, and economic factors. Public-private partnerships may bring in expertise and efficiency but could raise concerns about profit motives overriding community interests. Joint ownership models might balance these aspects but require clear communication and coordination among municipalities to address community concerns effectively. The choice of technology should reflect how well it aligns with the community's priorities and how effectively it can mitigate potential negative impacts.

Gaining public support for a regional facility is essential not only for securing project approval but also for ensuring smooth and successful ongoing operations. This involves engaging with the community early in the planning process, transparently addressing concerns such as potential environmental impacts, traffic increases, and property value effects. Effective communication and education about the benefits of the transfer station, including cost savings, improved waste management, and environmental protections, can help build trust and alleviate fears. Additionally, offering opportunities for public input and demonstrating a commitment to addressing community feedback can further strengthen support and foster a positive relationship between the project developers and the community.

Performance Metrics: Performance metrics enable municipalities to evaluate the effectiveness and efficiency of the regional facility. This includes monitoring tonnage processed, operational and maintenance costs, and social and environmental impact. Establishing contractual performance metrics, penalties, and off-ramps fosters transparency and accountability among all parties and builds trust.

Distribution of Risk: Municipalities must carefully consider the distribution of risks, which varies significantly across different models. In a full municipal ownership model, the municipality bears most, if not all, financial, operational, and regulatory risks, including potential cost overruns, operational inefficiencies, and compliance with environmental regulations. In contrast, in a public-private partnership (P3) model, risks can be shared or transferred to the private partner, who might take on construction, operation, and certain financial risks, often in exchange for compensation or a share in revenue. Joint ownership with other municipalities allows for the spread of risks across multiple entities, reducing the burden on any single municipality but requiring strong coordination and governance to manage the shared responsibilities effectively. The chosen model should align with the group of municipalities' capacity to manage these risks and their strategic objectives for the project.

Governance Structure: Establishing a governance structure that outlines the roles, responsibilities, and decision-making processes for all partners will be critical. This might include forming a regional powers authority to design, construct, and operate a facility, an inter-municipal agreement with a private vendor, or some combination of these options.

Table 3-36. Governance Options Between Municipalities and with a Private Entity		
Governance Structure	**Advantages**	**Disadvantages**
Private Entity Each town contracts directly with a company that owns, designs, builds and operates the biosolids facility.	• Easiest to implement • Least administration • Risk placed on the private merchant	• Limited to merchant facility arrangement • Limited control on member equity • Limited control on future participants • Might limit process selection
Lead-Municipality Contract One municipal entity takes the lead to deliver the project and establishes individual contracts with others for use of the facility. The lead entity does not need to also host or own the facility.	• Streamlined operational decisions • Vendor negotiations and contract may only be subject to the lead municipality's procurement rules • Some entities may be better resourced than others to deliver a project	• Authority limited to lead municipality • There may not be one municipality within the regional with capacity to serve as lead-municipality
Joint Powers Agreement Municipal entities enter into a joint agreement to deliver the project within the power and authority of one lead municipality.	• Commitment to deliver project spans across participating utilities versus the lead municipality taking on all aspects of delivery • Vendor negotiations and contract may only be subject to the lead municipality's procurement rules	• Authority limited to lead municipality
Joint Powers Agency Municipal entities form a new Joint Powers Agency that functions independently with the power and authority needed to deliver the project.	• Highest level of authority, budget control and project management	• Bylaws must clearly address transparency, oversight and accountability • Highest level of binding commitment and participation
Two-tier Joint Powers A core of municipal entities could enter into a joint powers agreement or form a Joint Powers Agency and remaining interested entities could contract with the core group for use of the facility	• Provides municipal entities the choice of two-tier participation	• Increased complexity

3.7.5 Case Studies

In 1996, Wisconsin revised its state biosolids regulations to go beyond what the EPA's 40 CFR Part 503 required. One aspect of the revision was the mandate for 180 days of storage during cold weather, due to freezing ground complicating liquid biosolids injection. As a result, several agencies in Western Wisconsin needed a storage solution, and some required treatment upgrades. Town leadership in Hudson and River Falls began to consider a regional solution instead of each community building separate storage facilities and digesters. They enlisted the help of Wisconsin's Department of Natural Resources and a Republican and Democrat from the State Legislature to address the legalities and requirements. Motivated by the fact that on-site or adjacent storage at their treatment plants was not an option, Hudson agreed to champion and be the public face of the project. Their efforts were successful. Working closely with the DNR and State Representatives, 11 agencies formed a Joint Powers Agreement (JPA) in 1997 to build the West Central Wisconsin Biosolids Facility (WCWBF). As part of joining the JPA, towns had to commit all or a portion of their biosolids to the regional facility, which went online in the early 2000s.

According to individuals involved in the effort at that time, there were two major challenges: siting the facility and determining the appropriate technology. The project team identified several logistically suitable locations but faced vehement local opposition at each site. After years of effort, the Village of Ellsworth offered land adjacent to its treatment plant and agreed to host the facility. The WCWBF plant is located next to a cheese plant and dairy farms. As of 2024, no issues have been raised by the Town of Ellsworth. The second challenge was selecting suitable technology. The founding agencies initially chose a Class A lime stabilization and heat treatment process developed by Enviro. They later replaced that process with a similar Class A process developed by Bioset, featuring a higher pH system. The WCWBF JPA built, owns, operates, and maintains the facility. The founding agencies agreed that, for the facility to effectively and equitably produce a dewatered product, each agency would receive back the same volume of water removed from solids as the amount of sludge they delivered to the facility. Although a discharge pipe was installed from the facility to the City of Ellsworth sewers, it has not been necessary because each participating agency is satisfied with the backhaul arrangement. WCWBF wastewater delivered back to each agency then goes into that contributing plant's headworks. As of 2024, no town has had an issue with taking back its portion of wastewater. The 11 founding agencies remain part of the WCWBF, along with an additional 11 "contract users" from Wisconsin and Minnesota. The contract users joined at a higher rate and do not have voting rights. The governing board consists of five founding agencies, rotated among the original 11. Voting is proportional to the amount of biosolids contributed. Pricing is consistent across all founding agencies regardless of distance, ensuring a degree of location neutrality. It is worth highlighting that the WCWBF has remained under municipal governance. The WCWBF is a non-profit entity, government staff run the facility, and the founding members control rates and long-term sustainability. Because the WCWBF is its own public entity, the facility was eligible for Clean Water Fund dollars. It is also worth noting that the WCWBF's cooperative-style model is not unfamiliar in Western Wisconsin, where farming cooperatives are common across the state.

Below are descriptions of three regional facilities that have been successfully implemented. These case studies are provided as examples of efforts that have navigated the challenges of setting up regional facilities and structures that have proven effective for sludge management.

Lystek Facility at the Fairfield Suisun Sanitary District (FSSD), Fairfield, California

Before engaging with Lystek, FSSD had been sending their biosolids to landfill for use as daily cover. In the early 2010s, regulatory changes began requiring biosolids to be diverted from landfills to land application. In addition, other San Francisco Bay Area agencies expressed the need to develop regional biosolids management solutions due to rising tipping and transport costs and a broad desire for reliable, long-term reuse.

Known as the Fairfield Organic Material Recovery Center (OMRC), this regional biosolids facility was established under a 25-year (+10) contract between FSSD and Lystek. The facility became operational in 2016, manages all of FSSD’s biosolids, and serves 16 neighboring utilities. The center is owned and operated by Lystek, leveraging under-utilized infrastructure and assets at the FSSD plant.

This successful P3 partnership between FSSD and Lystek has offered Bay Area agencies a reliable, sustainable and cost-controlled biosolids management solution. Generators now have a convenient resource recovery facility which produces and manages a Class A biosolids fertilizer and is capable of reducing GHG emissions through additional biogas recovery in the FSSD digesters. The successful LysteGro management program has sold and applied more than 350,000 tons (as of 2021) of registered fertilizer and is in demand from area farmers and ranchers.

Grand Valley Regional Biosolids Authority, Grand Rapids, MI

Grand Rapids had an aging facility in need of updates and was facing increasing costs to send biosolids to the landfill. The City of Wyoming produced Class B biosolids for liquid land injection but struggled with rising energy and transportation costs and limited availability of local land. Both cities anticipated unfavorable changes in local regulations. In 2003, they merged West Michigan's two largest sewage plants to form the Grand Valley Regional Biosolids Authority to modernize their wastewater systems. The Authority included Grand Rapids' Deputy City Manager, City Commissioners, City Engineer, Wyoming administrative staff, and WWTP staff from both cities. The regional facility became operational in 2009 and produces a variety of Class A products, such as liquid fertilizer, pellets, compost, and renewable energy.

The 2008 recession led to significantly reduced volumes sent to the facility and rising processing costs. However, both cities remain committed to the Authority.

3.7.6 Future Considerations

New England towns, particularly those in Massachusetts, tend to maintain isolated, self-sufficient jurisdictions. Getting town leaders to collaborate, let alone enter into contractual relationships, can be challenging. Consequently, some mayors and city councils have been reluctant to embrace regionalization. However, if the status quo of escalating tipping and transit fees persists and reuse options diminish, town leaders may be compelled to reconsider regional options more seriously. Conversely, one successful facility, even between just two or three entities, could quickly shift local attitudes and interest, particularly if the regional facility were designed with additional capacity to receive some merchant sludge from non-founding municipalities. As noted in (3.5.6) forming regional partnerships allows municipal entities to pool resources, share expertise, and leverage economies of scale, enabling them to pursue advanced treatment options or infrastructure projects that would be financially unattainable if undertaken independently. By collaborating, municipalities can distribute costs more equitably, access broader funding opportunities, and implement innovative solutions that improve service delivery while minimizing individual financial burdens.

3.8 Potential Funding Sources

Federal and state funding sources and programs are continuously evolving and influenced by legislative initiatives and regulatory drivers which can impact funding program priorities, program authorizations and appropriations, and project applicability. The $1.2 trillion Infrastructure Investment and Jobs Act, also known as the Bipartisan Infrastructure Law (BIL), and the Inflation Reduction Act (IRA) have significantly increased the availability of federal and statewide funding for water-related projects.

Federal, state, and local grant and loan funding sources are potentially available for research, design and construction of PFAS and biosolids projects. However, grants and low-interest loan funding programs typically target specific types of projects and/or have specific objectives that a project must achieve, therefore requiring a close fit of the project to the intent of the funding program priorities to be competitive in securing funds.

The purpose of this section is to outline potential external funding programs (low-interest loans and grants) that may be leveraged to offset the capital costs of system upgrades. If the plant upgrades include the production of renewable power (i.e. anaerobic digestion and cogeneration), there may be an opportunity to utilize federal and state grant and loan programs, as well as incentives from local power utilities. The status of federal and state funding programs should continue to be monitored as PFAS and biosolids projects move into design and construction in order to better identify and

leverage current funding opportunities that may be available to reduce the overall impacts of project costs on communities.

Settlements in lawsuits against the manufacturers of PFAS are thus far limited to drinking water utilities, but pending or future lawsuits brought on behalf of wastewater utilities or by the Commonwealth could be a future source of funding for pilots or full-scale projects.

3.8.1 Loan Programs

Massachusetts DEP Clean Water State Revolving Fund

The EPA allocates low interest loans through the State Revolving Funds (SRFs); specifically clean water projects (including wastewater, stormwater and non-point source) are funded through the Clean Water State Revolving Fund (CWSRF). The SRF programs are administered by the states, provide a low-cost financing method that communities can take advantage of to ensure they are meeting water-quality standards. The SRF program also provides loans for energy related upgrades at wastewater treatment facilities. Funding is available for the planning and construction of a wide range of projects, including new wastewater treatment facilities and upgrades of existing facilities, and nonpoint source pollution abatement projects.

The CWSRF program in Massachusetts finances approximately 25 to 70 projects annually with a low-interest loan rate of 2%. In recent years, the program has offered between $494M and $932M in financing through the CWSRF program. Sludge treatment projects would typically qualify to compete for SRF funding, though basic sludge volume reduction projects (e.g., dewatering) typically do not score well. Projects that produce green energy, such as anaerobic digestion, receive additional points in the scoring system. Pyrolysis and gasification generate syngas that can be used to dry biosolids or for other purposes, also a use of renewable energy. Design costs are typically not eligible for SRF financing in Massachusetts, but design and construction phase costs are eligible for PFAS projects (typically up to 10% of the total estimated project cost).

In recent years, the Base Capitalization Grants for the State Revolving Fund have been significantly impacted by Congressionally Directed Spending (earmarks) and higher construction costs. The Clean Water base grants have decreased by about 50% since 2021, from $53.9M to $27.7M due to the award of Congressionally Directed Spending which is awarded as grants, not as loans which revolve back into the fund. Each base grant dollar that the Massachusetts Clean Water Trust receives from USEPA can leverage funds up to three times. So, the annual loss of approximately $26M from the Clean Water base grant results in an annual loss of nearly $80M in loans for Clean Water projects.

As part of the Infrastructure Investment and Jobs Act, $1 billion was appropriated over five years (FY 2022 – 2026) nationwide to CWSRF to address emerging contaminants (ECs). With the Massachusetts Clean Water Trust, MassDEP offers 0% interest rate loans for PFAS mitigation projects. Initially targeted at drinking water projects, since 2021, wastewater projects (that impact drinking water sources) have been eligible. Using IIJA Funding, communities have been awarded PFAS Mitigation Loans through the CWSRF process. Note that “pilot studies” are explicitly listed as “eligible project costs” in the Massachusetts policy document on CWSRF eligibility (MassDEP, 2023); other states (e.g., North Carolina) have made CWSRF-EC funding available for pilot-scale studies of PFAS treatment technologies.

U.S. EPA Water Infrastructure Finance and Innovation Act

The Water Infrastructure Finance and Innovation Act (WIFIA) program established in 2014 is a low-interest loan program administered by EPA for eligible water and wastewater infrastructure projects through a competitive application process. The WIFIA program was established to fund large dollar value water, wastewater, stormwater infrastructure projects. Projects that serve large communities

(over 25,000 people) must have a minimum project cost of $20M to apply for WIFIA and the program provides up to 49% of the project financing. Multiple projects can also be grouped in a WIFIA application if they serve a common purpose, are completed within a 5 to 6-year timeline and the loan is repaid from the same revenue stream. In previous years, WIFIA has funded major capital improvements for wastewater facilities, including several biosolids programs.

To pursue the program, at a minimum, preliminary design to 30% design documentation is required as well as sufficient project definition to clear environmental review. It should be noted that projects that qualify for SRF funding may also qualify for WIFIA funding.

3.8.2 State and Federal Grant Funding for Anaerobic Digestion

To simplify the cost analysis in Section 3.4 the economic value of biogas from anaerobic digestion was not considered (beyond digester heating); however, significant value can be realized via a range of uses (electrical power generation, pipeline injection). These uses have environmental benefits (typically from offsetting the use of fossil fuels), and funding mechanisms therefore have been established to encourage the adoption of digestion with beneficial use of the resulting biogas. Several programs are discussed below. Eligibility and availability are based on the programs' status at the time this report was written. Additional programs may be available in the future, and requirements of existing programs may change as clean energy regulations, demand, and technology evolve.

MassSave CHP Incentive

Combined Heat and Power (CHP) installations associated with digestion upgrades at POTWs may be eligible for a one-time incentive through the MassSave program. The key elements of the CHP incentive include utilization of nearly all the thermal energy being produced by the system, and minimal parasitic load (less than or equal to 5%). It is important to note that oversized systems (greater than the electrical demand of the host site) are not eligible in this program. The application process encourages early involvement with Eversource or National Grid to ensure qualification requirements are met.

MassDEP/DOER Gap Funding Program

The MassDEP and Department of Energy Resource (DOER) Gap Funding Grant Program was intended to assist Massachusetts drinking water and wastewater facilities reduce energy use, increase energy efficiency, and generate renewable energy (such as using biogas from digestion to generate electricity). The grants are intended to expedite implementation of previously assessed energy efficiency and clean energy generation projects at municipal treatment facilities and other facilities. The program was designed to fill the "gap" in project financing, enabling facilities to first utilize incentives and funds from other sources, then apply through this program for remaining financial needs. There have been three prior rounds of Gap funding, and there may be additional releases of this program in future years. This program is expected to be a competitive solicitation due to limitations on funding. MassDEP should be consulted at the time of design as to whether the projects are expected to be eligible for participation if a new round of the Gap program has been initiated. The maximum funding available through the 2022 Gap III program was $200,000 per project. Applications for Gap IV funding are anticipated to be released in 2025.

Massachusetts DOER Alternative Energy Portfolio Standard Alternative Energy Certificates

The Massachusetts DOER Alternative Energy Portfolio Standard (APS) was established in 2009 to provide incentives for installing eligible alternative energy systems, which are not necessarily renewable, but contribute to the state's clean energy goals by increasing energy efficiency and reducing the need for conventional fossil fuel-based power generation. The APS has several

programs: Renewable Thermal, CHP, Flywheel Storage, and Fuel Cells. The most applicable routes to funding via Alternative Energy Certificates (AECs) for potential plant solids upgrades include Renewable Thermal and CHP.

Eligibility for the Renewable Thermal route requires that a renewable thermal generation unit must comply with the following requirements:

- Generate useful thermal energy using sunlight, biomass, biogas, biofuel, or naturally occurring temperature differences in ground, air, or water.
- Deliver a useful thermal load to a facility located in Massachusetts.
- Have an operation date of January 1, 2015, or later.

DOER additionally specifies eligible renewable thermal sources. This includes biogas fuel that is produced by the bacterial decomposition or thermal gasification of eligible biomass fuel and organic refuse derived biomass fuel.

With respect to the CHP route, a CHP generation unit must comply with the following requirements to qualify under the APS:

- The CHP unit shall provide for the metering of electrical energy generated, useful thermal energy produced, and fuel consumed.
- The CHP unit shall deliver useful thermal energy to an end-use load located in the Commonwealth of Massachusetts.

The mechanism for funding via the APS is via the acquisition of AECs. AECs are earned based on the net energy savings produced by a DOER-certified CHP system.

Department of Energy Funding

Grant funding has been made available through the federal Department of Energy as part of the IAC or CHP Onsite Energy Tap assessments. While the federal grants are specifically earmarked for small manufacturers, municipal WRRFs are eligible. Applications can include energy efficiency equipment and systems, as well as onsite energy generation projects, such as CHP through biogas utilization.

3.8.3 Grants for Other Technologies

USEPA Wastewater Efficiency Grant Pilot Program

This federal program has provided grants to POTWs that pursue waste-to-energy projects. Anaerobic digestion is explicitly included. Pyrolysis and gasification could fall under the “other new and emerging, but proven, technologies that transform waste to energy” category as these technologies generate syngas that can be used to dry biosolids. SCWO could also potentially qualify. Authority for this program runs through 2026; however, funding for it has not been appropriated in some years. (Note: The grant program itself is a pilot. It is not specifically intended to provide grants to pilots of new technologies.)

USDA Rural Utilities Water and Environmental Programs

The U.S. Department of Agriculture Rural Utilities Water and Environmental Programs for small communities has provided loans and grants for projects for small communities. Wastewater projects would be funded through the Water and Waste Disposal Program.

3.8.4 Other Incentives

Massachusetts DOER Renewable Energy Portfolio Standard Renewable Energy Certificates

The Renewable Energy Portfolio Standard (RPS) was established in 2003 to incentivize renewable energy generation and enable retail electricity suppliers to meet a requirement to obtain a percentage of the electricity they serve to their customers from qualifying renewable energy facilities. These suppliers meet their RPS obligations by acquiring a sufficient quantity of RPS-qualified Renewable Energy Certificates (RECs) that are created, traded, and tracked at the New England Power Pool Generation Information System, which tracks all electricity generated within the ISO New England (ISO NE) control area and fed onto the New England grid. In the case of Massachusetts, a REC represents the positive environmental attributes associated with 1 MWh of RPS-qualified electricity generated and provided to the New England grid.

RPS breaks down qualified electricity generating facilities into five classifications. Anaerobic digestion and other biomass conversion qualify as Class 1.

Massachusetts DOER Clean Peak Energy Standard

The DOER Clean Peak Energy Portfolio Standard (CPS) is designed to provide incentives to clean energy technologies that can supply electricity (such as anaerobic digestion) or reduce demand during seasonal peak demand periods established by DOER in a way that increases the availability of clean energy during peak demand periods, when net demand of electricity is highest. Qualified Clean Peak resources receive NEPOOL GIS certificates called Clean Peak Energy Certificates (CPEC), which are used only for compliance with the Massachusetts Clean Peak Energy Minimum Standard. One CPEC is equivalent to 1 MWh of energy generated or avoided via a CPS-qualifying resource.

The funding mechanism via CPS for plant solids upgrades that produce electricity would involve the sale of CPECs to retail electricity suppliers, which are required to purchase a certain amount of CPECs each year to meet their obligations under the Advance Clean Energy Act of 2018. Retail electricity suppliers have the option of making Alternative Compliance Payments (APC) to comply with these requirements. For 2024, the APC has been set at $45, effectively setting the cap for CPEC sales at $45.

Renewable Fuel Standard/RINS

The Renewable Fuel Standard (RFS) is a U.S. policy designed to increase the use of renewable fuels in the transportation sector. Established under the Energy Policy Act of 2005 and expanded by the Energy Independence and Security Act of 2007, the RFS mandates that a certain volume of renewable fuels, like ethanol and biodiesel, be blended into gasoline and diesel each year. The goal is to reduce greenhouse gas emissions, decrease dependence on imported oil, and promote the development of renewable energy sources. The program sets annual blending targets and provides a framework for trading renewable fuel credits, known as Renewable Identification Numbers (RINs), to ensure compliance and flexibility for fuel producers and blenders. For POTW upgrades that include biogas conversion to renewable natural gas, this revenue stream can be considered for offsetting operational costs.

Clean Electricity Investment Tax Credit

A new technology-neutral Clean Electricity Investment Tax Credit (48E) goes into effect in 2025. This credit acts as a reimbursement of a portion of capital costs for qualified projects that generate electricity where the “greenhouse gas emissions rate is not greater than zero” (IRS, 2024). The IRS has yet to provide clarification on exactly how emissions rates will be calculated, but typical municipal anaerobic digester projects generating biogas for combined heat and power systems have a carbon intensity greater than zero in the model being proposed (Greenhouse Gases, Regulated

Emissions, and Energy Use in Transportation (GREET)). Projects could possibly use carbon dioxide from the exhaust to bring emissions below zero. Credits under this program, which are available directly to public utilities as direct payments, are set to phase out the latter of 2032 or when emission targets are achieved.

3.8.5 Public-Private Partnerships

Public-Private Partnerships (P3) can provide an opportunity for alternative project delivery, particularly when considering capital investment and long-term operations for managing biosolids and source separated organics. As the state looks to decarbonize in the coming decades, the role of WRRFs in organics diversion is anticipated to increase. The P3 structure provides a source of funding reducing the initial capital investment burden on rate payers and allowing for integrated regional programs for solids and organics management that align with emission reduction goals. However, the structure of a P3 can influence the eligibility for federal grants and loans.

P3s are being utilized by municipal agencies for public infrastructure and climate action projects across the country and can provide an opportunity to leverage private capital and technical resources. One recent biosolids example includes the collection and addition of organic waste to enhance biogas production in the anaerobic digesters at the Newtown Creek Water Resource Recovery Facility in New York City (NYC). High strength organic waste (HSOW) in the form of food scraps from schools and NYC Department of Sanitation's curbside program is collected and pre-processed at an organics recycling facility operated by Waste Management of New York. The processed slurry is then delivered to Newtown Creek and co-digested with sewage sludge in the facility's anaerobic digesters to create biogas. The NYC DEP also partnered with National Grid to increase the beneficial use of the biogas generated at Newtown Creek by installing a new biogas cleaning and pipeline injection system. In exchange for financing the design, construction, operation, and maintenance of the biogas purification system, DEP will provide the gas to the local grid and once costs have been recouped, profits from renewable natural gas (RNG) sales will be shared between the two entities.

The interest of private entities to partnership with Massachusetts POTWs will depend on the size of the system to be constructed, the potential revenue stream(s) associated with its operation, and fair distribution of risk between various parties in the P3 partnership. If the production of an RNG product becomes part of the biosolids management strategy for Massachusetts WRRFS, the local gas utilities will be a critical entity for P3 success.

Section 4

Contributions of PFAS Into POTWs

4.1 Introduction

4.1.1 Objectives & Scope of Work

This study aimed to determine if source control measures can be effective in reducing the presence of PFAS in wastewater influent, effluent, and sludge and identify high-impact approaches to reducing upstream PFAS sources. In addition, statistical analyses of available PFAS monitoring data combined with land use and environmental justice (EJ) indices were performed to assist MassDEP in understanding the influent PFAS baseline for "domestic" wastewater (e.g., wastewater in communities with limited industrial/commercial impact) and assess whether EJ communities in Massachusetts are disproportionately impacted by PFAS in wastewater to help guide future regulatory/legislative actions.

The Scope of Work for this task includes:

- Literature review of how other states and wastewater utilities have investigated sources of PFAS in publicly owned treatment works (POTW) influent and used source control to reduce PFAS concentrations in wastewater influent, effluent and sludge.
- Review influent, effluent, sludge and industrial discharge PFAS data from the MassDEP PFAS database to develop an understanding, to the extent possible, of PFAS sources within the collection system.
- Develop a list of the PFAS that are most relevant to POTWs.
- Identify indirect discharge sources that contain PFAS.
- Calculate mass loadings to select POTWs where sufficient data exist.
- Analyze the feasibility of PFAS source reduction.

4.1.2 Background

Introduction to PFAS and its impact on POTWs

There are thousands of individual chemical formulations or species that fall into the broad category of PFAS. These chemicals have been developed over the past eight decades and have been incorporated into many thousands of consumer products, industrial process chemicals, and firefighting foams. These products are ubiquitous throughout society and, as such, PFAS appear in our homes, solid waste, and wastewater. PFAS have also been released to the environment from many sources including industrial discharges to air, soil and water; firefighting operations and training; and controlled and uncontrolled disposal of PFAS-containing products (e.g., litter). These releases have occurred over many decades, and PFAS can be found in soils, surface water and groundwater all over the world because of their mobility and persistence in the environment.

Wastewater is comprised of all the liquid waste from society's homes and businesses that flows to the sewer pipe. It contains many types of pollutants at widely varying concentrations. POTWs use a combination of physical, biological and chemical processes to produce clean water from influent wastewater, removing pollutants before releasing treated effluent to the environment.

PFAS have only recently been recognized as pollutants; POTWs were not designed to remove them. As such, PFAS that enters the plant in the influent wastewater generally leaves the plant in either the clean water discharge or the sludge that is removed from the water. While research continues to evolve, it also appears that some species of PFAS are transformed into other species of PFAS while passing through the plant. Because POTWs do not generate PFAS or add PFAS to the wastewater during the treatment process, lower overall PFAS levels in the influent of a POTW should lead to lower overall PFAS levels in the effluent and sludge, which is generally supported by the data analyzed in this report. Therefore, there is value in considering sources of PFAS in wastewater influent and exploring means to reduce those contributions.

Some PFAS have been found to be harmful to human health and have become a focus of regulatory attention to protect public health. Research is ongoing on all aspects of PFAS use, health effects, transformations, fate and transport in the environment, exposure pathways, destruction techniques, and more. Some results have raised concern with the disposal of wastewater sludge and the land application of processed wastewater biosolids, suggesting that the presence of PFAS species may increase potential exposure pathways that could impact public health.

In some jurisdictions, these concerns have led to legislation and/or regulations that curtail or severely limit some of the sludge disposal or biosolids reuse options that are available to POTWs. Part 1 of this study documented the implications for sludge management that these restrictions have (Tighe & Bond and Brown and Caldwell, 2024a, Section 7).

4.1.3 Review of Relevant Literature

Some states and some individual wastewater treatment utilities have made significant progress in better understanding the sources of PFAS entering wastewater influent. In some cases, these entities have taken steps to reduce those inputs, such as requiring dischargers to implement effluent pretreatment and/or product replacement.

Michigan Department of Environment, Great Lakes and Energy (EGLE)

IPP PFAS Initiative

The Michigan Department of Environment, Great Lakes, and Energy (EGLE) has reported substantial success in the reduction of PFAS in both effluent and sludge through source control. EGLE, Water Resources Division (WRD), initiated an IPP PFAS Initiative in February 2018 as part of the National Pollutant Discharge Elimination System (NPDES) program. The primary aim of the initiative is to reduce or eliminate certain PFAS from industrial sources that may pass through POTWs and enter lakes and streams.

The Michigan EGLE IPP PFAS group consists of a manager, two IPP PFAS Specialists that work regionally, and one PFAS treatment technology specialist. As of March 2022, there were 97 approved IPPs in Michigan with 903 regulated Significant Industrial Users. Michigan is a delegated state where EGLE acts as the Approval Authority for IPPs that are prepared and implemented by the local municipality or sewer authority that acts as the Control Authority that issues individual industrial user permits. The PFAS group reviews PFAS data, PFAS status reports submitted by the POTWs with IPPs, and PFAS compliance for the POTWs with IPPs.

The Initiative was developed after EGLE identified PFOS in the Flint River at concentrations exceeding the state's water quality standard in June 2017, which was traced to a POTW's discharge, then traced upstream to one of its industrial users. At the time, Michigan had developed water quality standards for only two PFAS, PFOS and PFOA. Effluent sampling determined that 31 POTWs in Michigan had exceeded the water quality standard of 11 ng/L for PFOS, while only one exceeded the water quality standard of 420 ng/L for PFOA. These are the most stringent values established in MI

Rule 57 for noncancer human values in surface waters that are used for drinking water. Therefore, EGLE focused efforts on reducing PFOS in POTW effluent (EGLE, 2020a).

The IPP PFAS Initiative followed a structured approach to identify and control industrial sources of PFOS to POTWs by using established authorities under the IPP to enforce regulations and control measures. This regulatory framework was crucial in ensuring compliance and efficacy in reducing PFOS discharges.

Identification of PFOS Sources

The initiative included POTWs that served industrial users whose discharges were likely to contain PFOS. POTWs reviewed records, conducted interviews with industry staff, and required discharge sampling for industrial users likely to have used PFOS and/or PFOA contemporaneously or in the past.

Primary PFOS sources to POTWs included landfills that accepted industrial wastes containing PFOS, metal finishers, and contaminated sites associated with industries or activities with PFOS usage. Table 4-1 summarizes the PFOS sources identified and presented in Michigan's report.

Table 4-1. Sources of PFOS to WWTPs in Michigan[1]			
Industry/Category/Type	Total Number Evaluated[2]	Number (%) Sources of PFOS by Type[3]	Range of Discharged PFOS exceeding screening level of 12 ppt
Landfills	56	49 (88%)	13-5,000
• Type II Sanitary Landfills	48	44 (92%)	20-5,000
• Active	25	25 (100%)	29-5,000
• Closed	23	19 (83%)	20-420
• Type III Sanitary Landfills	7	4 (57%)	13-4,000
• Active	3	1 (33%)	33-100
• Closed	4	3 (75%)	13-4,000
• Hazardous Waste Landfill	1	1 (100%)	60
Metal Finishing	320	47 (15%)	20-240,000
• Chrome Plating	50	33 (66%)	24-240,000
• Chrome Conversion Coating4	23	9 (39%)	16-9,950
• Other or Unknown	247	5 (2%)	20-250
Contaminated Sites	40	20 (50%)	14,34,000
• Metal Finishers	11	6 (55%)	20-8,000
• Miscellaneous Sources	12	3 (25%)	14-37.51
• Mixed Manufacturing	4	3 (75%)	86-34,000
• Former Landfills	6	2 (33%)	18-42
• Paper Manufacturing	3	2 (66%)	24-240
• Paint Manufacturing	2	2 (100%)	360-6,047
• Leather Tannery	1	1 (100%)	19-514
• AFFF Infiltration	1	1 (100%)	82-456
Centralized Waste Treaters (CWTs)	16	12 (75%)	13-8,400
Paper Manufacturing, Packaging	14	9 (64%)	16-410
Commercial Industrial Laundry Facilities	12	5 (42%)	24-69
Chemical Manufacturers	17	4 (24%)	18-4,600,000
AFFF-contaminated Sewers	2	2 (100%)	240-45,000

1. *Adapted from (Michigan Industrial Pretreatment Program (IPP) PFAS Initiative: Identified Industrial Sources of PFOS to Municipal Wastewater Treatment Plants, 2020).*
2. *Estimated based on 2018 WWTP IPP Annual Report data for total metal finishers; others estimated based on industries surveyed and/or sampled during the IPP PFAS Initiative. The number of types per subcategory may be low, since sewer users that did not meet local screening criteria may not have been sampled. The information presented was compiled from many sources including compliance submittals, laboratory reports, voluntary surveys, emails, internet searches and personal communications. These sources contained variable levels of detail. The document represented the authors' best effort to compile, organize, and summarize available information at the time of writing (Bush, 2023).*
3. *"Sources" are those exceeding the screening level of 12 ppt PFOS at least once.*
4. *Excludes chromate conversion coaters that also perform chrome plating.*

Implementation and Impact of Source Reduction

Once key PFOS sources were identified, EGLE worked with POTWs that exceeded PFOS water quality standards to implement source reduction strategies with the goal of decreasing PFOS concentrations

in POTWs' influent, effluent, and sludge. Source reduction efforts were implemented at multiple industrial facilities, including pollutant minimization plans, equipment and pipe cleaning and/or replacement, product substitution, and installation of treatment systems to remove PFAS before discharge to the sewer system.

As of August 2020, pretreatment measures had been installed for industrial discharges ranging from 5,000 gallons discharged twice a week to 400,000 gallons per day.

Source reduction measures were successful in reducing POTWs' PFOS effluent concentrations, many to levels below the 12 ng/L water quality standard. There have been corresponding reductions in PFOS concentrations in sludge, although these improvements lag those seen in effluent. Sludge sample results at two POTWs showed reductions in PFOS concentrations of nearly an order of magnitude within two years of source reduction program implementation.

Interim Strategy for Land Application of Biosolids Containing PFAS

Michigan developed an Interim Strategy for the land application of biosolids containing PFAS in 2021, as discussed in prior sections (Michigan Department of Environmental Quality Water Resources Division, 2018). The strategy established thresholds of PFOA and PFOS concentrations that triggered restrictions on application rates and required implementation of source reduction plans. The Michigan Department of Environmental Quality published a procedure entitled "Recommended PFAS Screening a & Evaluation Procedure for Industrial Pretreatment Programs" that provides the following guidance (Michigan Department of Environmental Quality Water Resources Division, 2018):

- Identify Potential Sources
- Identify Probable Sources
- Develop a Monitoring Plan
- Work with Industry to Reduce and/or Eliminate these Pollutants
- Monitor Effluent
- Reporting

Table 4-2 shows PFOS and PFOA concentrations in POTW sludge (ng/g dry weight) from the initial statewide study and from data submitted for each calendar year under Michigan's Interim Strategy since its inception in 2021. These data document that controlling sources of PFOS and PFOA through the IPP has successfully lowered mean PFOS and PFOA wastewater sludge concentrations each year.

Table 4-2. PFOS & PFOA Concentrations in Wastewater Sludge

	PFOS (ng/g)[2]		PFOA (ng/g)[2]	
Year	Mean	Median	Mean	Median
2018[3]	184[3]	13	25	7
2021	21	9	8	4
2022	16	10	7	3
2023	11	7	6	3
2024[4]	8	5	5	2

1. *Unpublished data previously presented publicly and provided to Tighe & Bond by MI EGLE.*
2. *Concentrations are reported on a dry-weight-basis.*
3. *Includes data from industrially impacted sources as part of a statewide study.*
4. *Data updated as of 7/31/2024, including 139 POTWs.*

Vermont Department of Environmental Conservation (VTDEC)

PFAS Inputs to Wastewater Facilities (Weston & Sampson, 2022)

VTDEC contracted with Weston & Sampson and researchers at the University of New Hampshire to collect 53 PFAS samples from two POTWS. Sample locations were selected to isolate wastewater flows from residential, commercial, and industrial sub-sewersheds. Samples were collected weekly in August 2021 from the selected collection system locations and from POTW influent and effluent. Concentrations of 24 individual species were quantified within the broad PFAS category at an analytical laboratory using a modified EPA 537.1 method ("Standard assay"). In addition, Total Oxidizable Precursor (TOP) assays were performed once for each sub-sewershed area and for each POTW's influent and effluent to measure the total quantity of polyfluoroalkyl substances capable of being oxidized into perfluorinated terminal end-products.

Eight PFAS species were detected at both POTWs. Figure 4-1 through Figure 4-4 summarize the findings for the Middlebury and Essex Junction POTWs. Note that the y-axes on each plot are different so that "bar heights" are not comparable between graphs.

Different industries show widely different total concentrations and species distributions. While the residential samples collected from Middlebury's sewershed had 25% lower total PFAS than the Essex Junction residential total, that variability is small compared to variability of industries and commercial districts.

The TOP assay data plots show that the PFAS precursor compounds can be present at concentrations that are 2-70 times greater than the Standard assay, indicating that precursors may be the predominant source of PFAS in wastewater. This theory is supported by the fact that the Standard assay showed that total effluent PFAS concentration was higher than the influent at both POTWs, while TOP assay data show a reduction in precursors from influent to effluent. Similarly, data presented at NEWEA in 2023 draws a similar conclusion about influent and effluent PFAS concentrations in California.

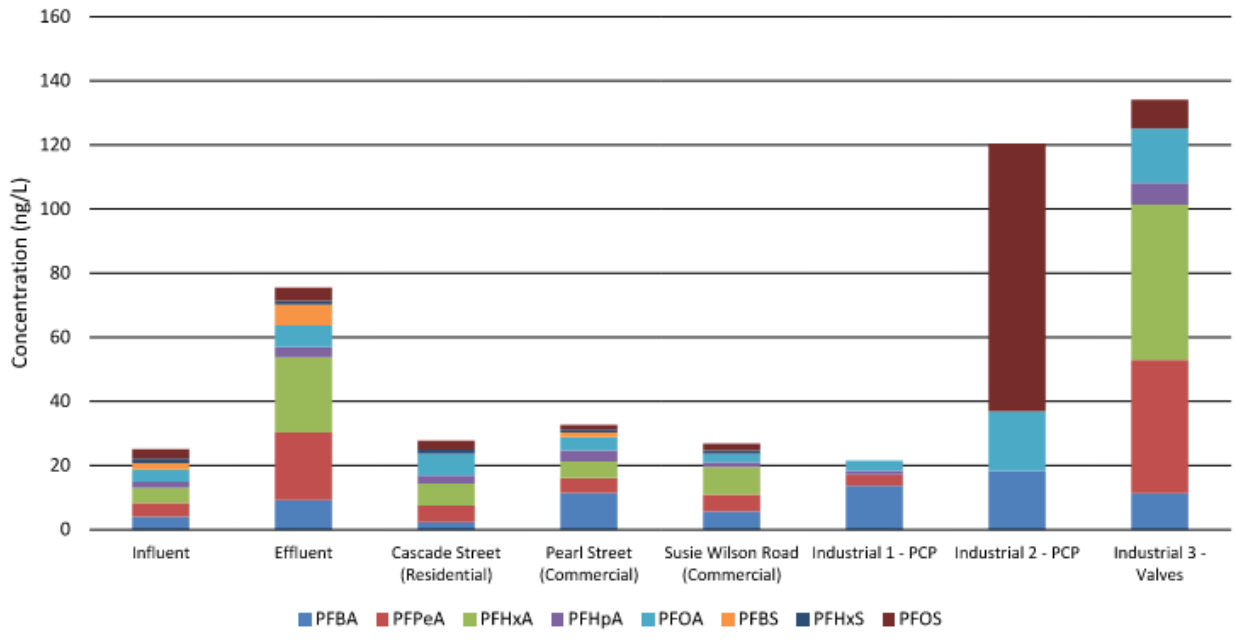


Figure 4-1. Essex Junction Wastewater Treatment Facility Standard Assay Summary

Adapted from VTDEC's 'Poly- and Perfluoroalkyl Substances Inputs to Wastewater Treatment Facilities Summary Report' (Weston & Sampson, 2022)

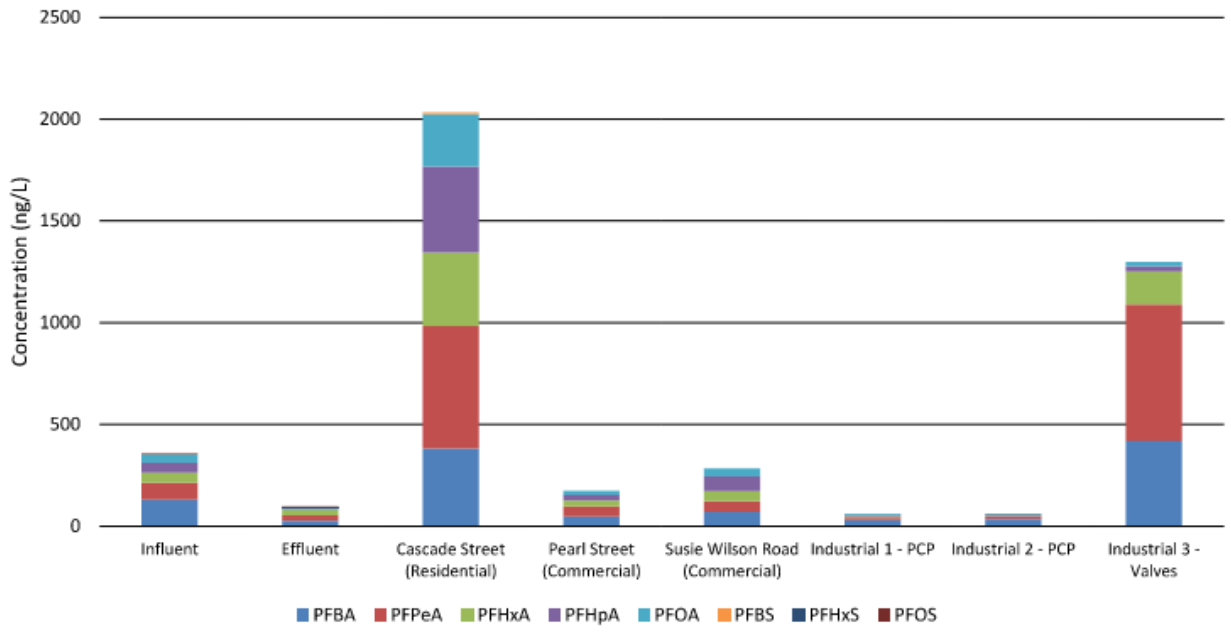


Figure 4-2. Essex Junction Wastewater Treatment Facility TOP Assay Summary

Adapted from VTDEC's 'Poly- and Perfluoroalkyl Substances Inputs to Wastewater Treatment Facilities Summary Report' (Weston & Sampson, 2022)

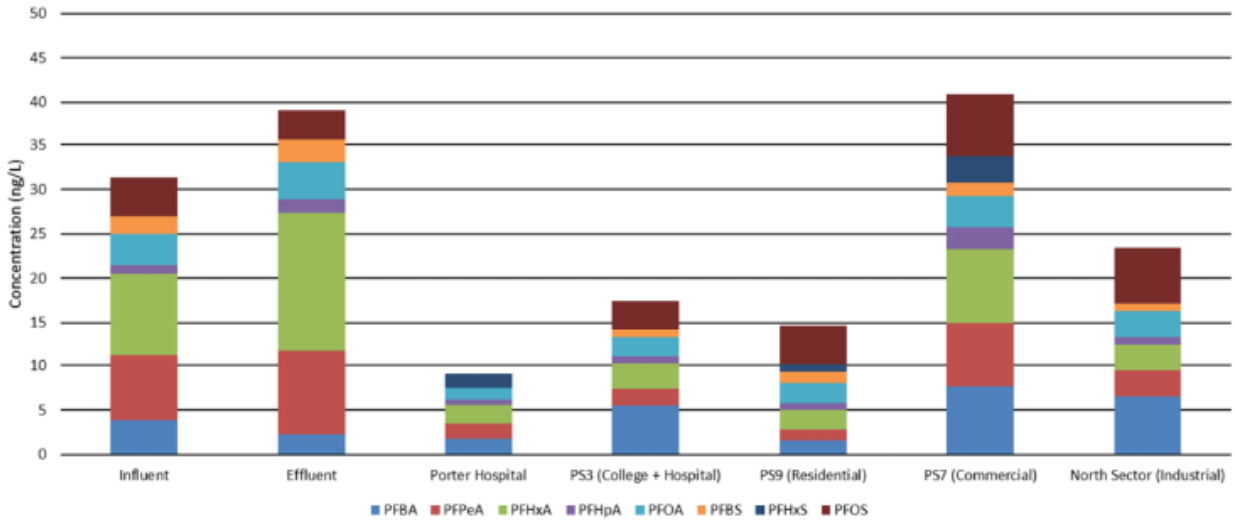


Figure 4-3. Middlebury Wastewater Treatment Facility Standard Assay Summary

Adapted from VTDEC's 'Poly- and Perfluoroalkyl Substances Inputs to Wastewater Treatment Facilities Summary Report' (Weston & Sampson, 2022)

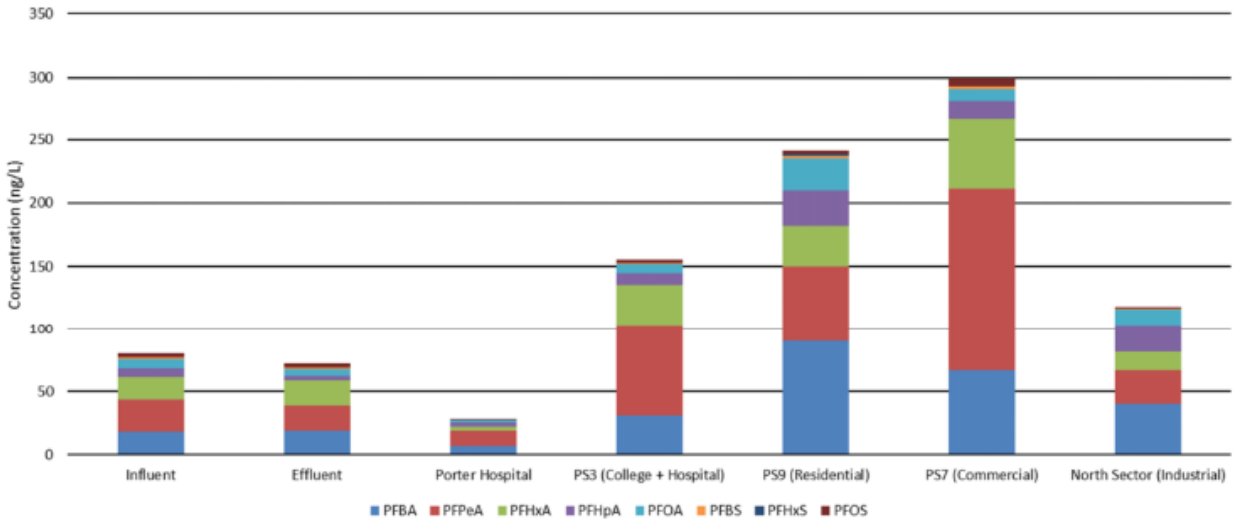


Figure 4-4: Middlebury Wastewater Treatment Facility TOP Assay Summary

Adapted from VTDEC's 'Poly- and Perfluoroalkyl Substances Inputs to Wastewater Treatment Facilities Summary Report' (Weston & Sampson, 2022)

While the Summary Report indicated that flow data were not available to calculate mass loadings of PFAS to the POTWs, VTDEC published an executive summary with this report that contained the mass loading figures, reproduced here as Figure 4-5 VTDEC concluded that the mass of PFAS measured in wastewater originating from residential communities was as great or greater than that from commercial or industrial discharges in these municipalities and that industrial facility discharges accounted for <1% of the total mass of PFAS entering the POTW.

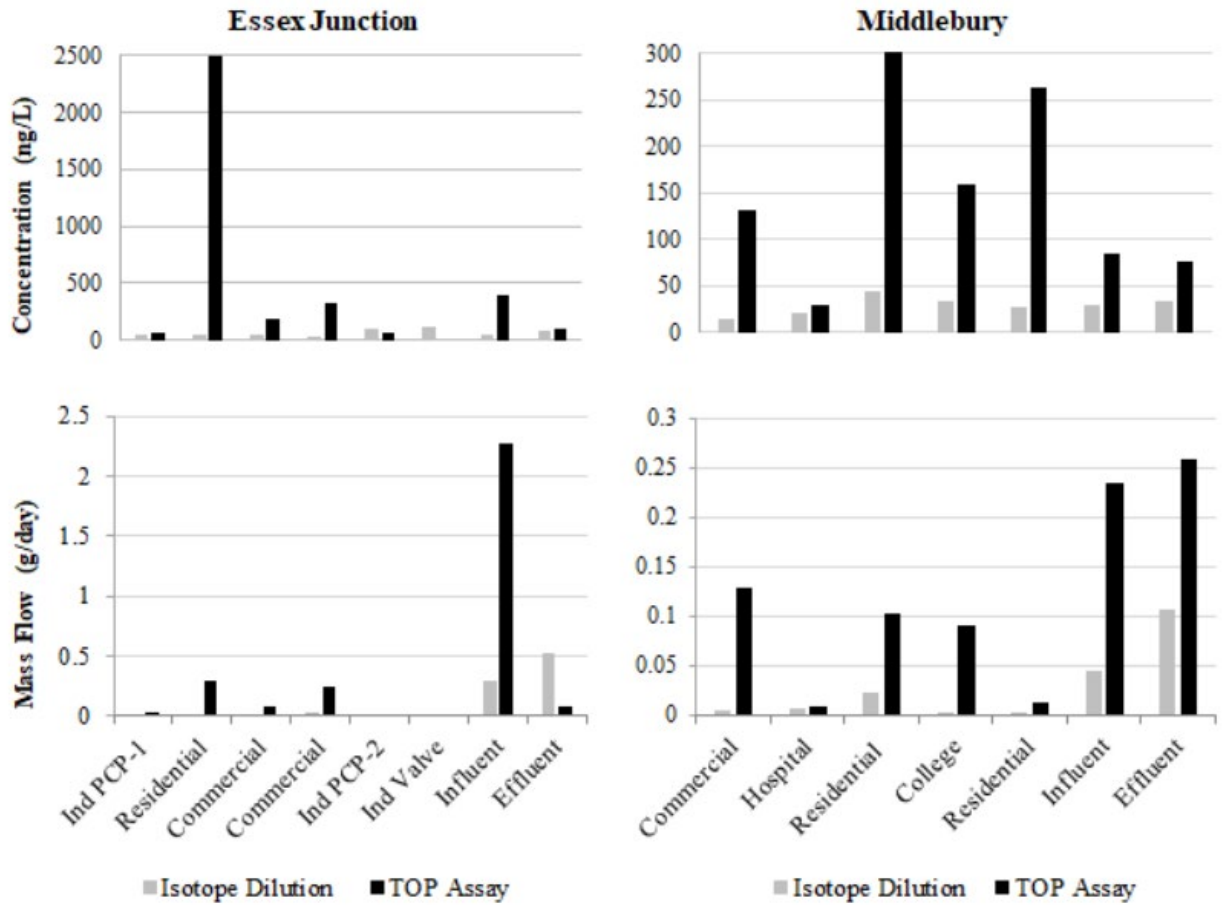


Figure 4-5. Summary of PFAS contributions to PFAS loading at two Vermont POTWs

Adapted from the Executive Summary of VTDEC's 'Poly- and Perfluoroalkyl Substances Inputs to Wastewater Treatment Facilities Summary Report' (Weston & Sampson, 2022)

<u>PFAS in Landfill Leachate</u> (Weston & Sampson, 2020)

Weston & Sampson completed a report in January 2020 on the contribution of landfill leachate to influent and effluent concentrations of PFAS at POTWs.

One of the goals of this study was to assess the variability of PFAS concentrations in leachate and POTW-related media. Weston & Sampson collected leachate samples from three closed and one active landfill on eight separate occasions during the fall of 2019:

- Chittenden Solid Waste District Landfill – Closed and Capped
- City of Burlington Rathe Cell IV Landfill - Closed and Capped
- New England Waste Services of Vermont – Active
- Randolph Landfill – Closed and Capped

POTW influent, effluent, sludge, and/or septage samples were collected from 30 individual POTWs, six of which accept landfill leachate. In total, 124 influent, 136 effluent, 75 sludge (Class A and Class B combined), and five septage samples were collected. Surface water samples were collected upstream and downstream of the Montpelier POTW discharge on three occasions.

Samples were analyzed by Alpha Analytical using their proprietary modified EPA 537.1 method, which incorporates isotope dilution, to quantify 24 individual PFAS. These include the five regulated

PFAS associated with drinking water quality in Vermont: perfluorohexanesulfonic acid (PFHxS), perfluoroheptanoic acid (PFHpA), PFOA, PFOS, and perfluorononanoic acid (PFNA).

Results from the four landfills and 19 POTWs included in the report indicated that PFAS are present in landfill leachate (Figure 4-6) and POTW influent, effluent and sludge, and that POTW influent and effluent PFAS concentrations are greater at the 6 POTWs that receive landfill leachate than at the 13 that do not (Figure 4-7). Numerous PFAS that are currently unregulated were observed in addition to the five PFAS regulated in Vermont. In many cases, the concentrations of non-regulated PFAS exceeded the concentrations of the five regulated PFAS, although the report does not include a figure showing a broader range of non-regulated PFAS.

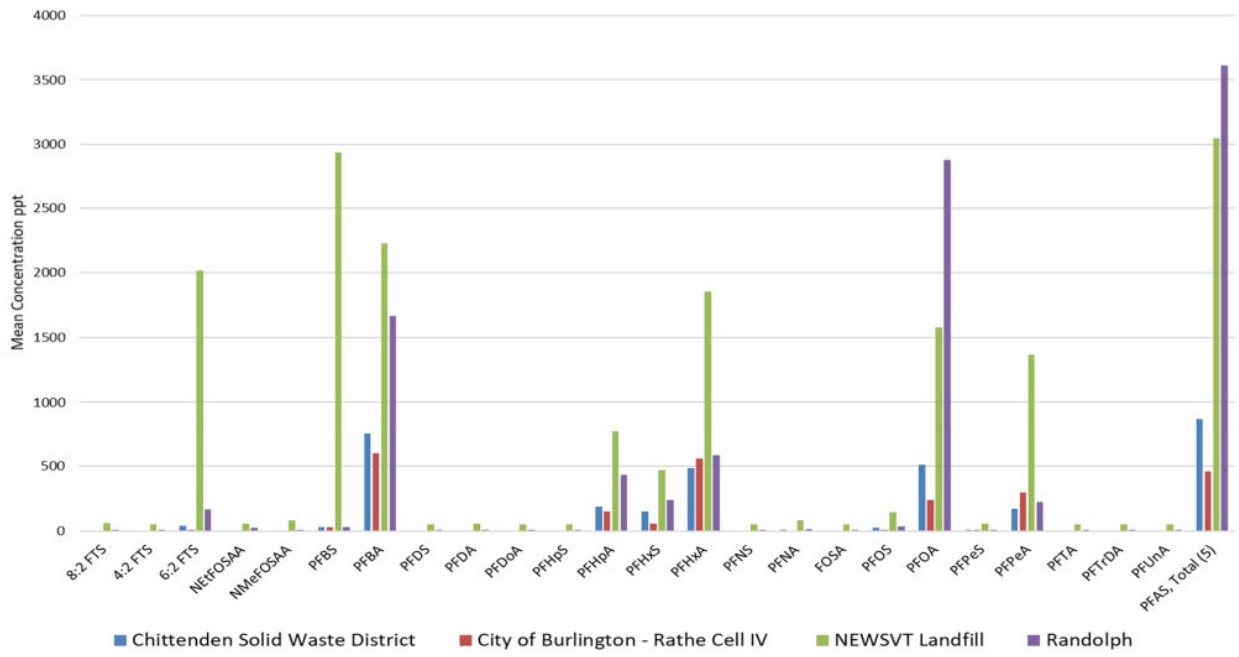


Figure 4-6. Average PFAS Concentrations in Landfill Leachate from Four Vermont Landfills

Adapted from VTDEC's 'Poly- and Perfluoroalkyl Substances at Wastewater Treatment Facilities and Landfill Leachate 2019 Summary Report' (Weston & Sampson, 2020)

The individual species detected in the VT landfill leachate samples are consistent with the compounds detected in the MA landfill leachate samples shown in Figure 27. The concentrations in the MA samples were as much as an order of magnitude less than the VT samples, but more information onsite specific conditions would be necessary to compare the results directly.

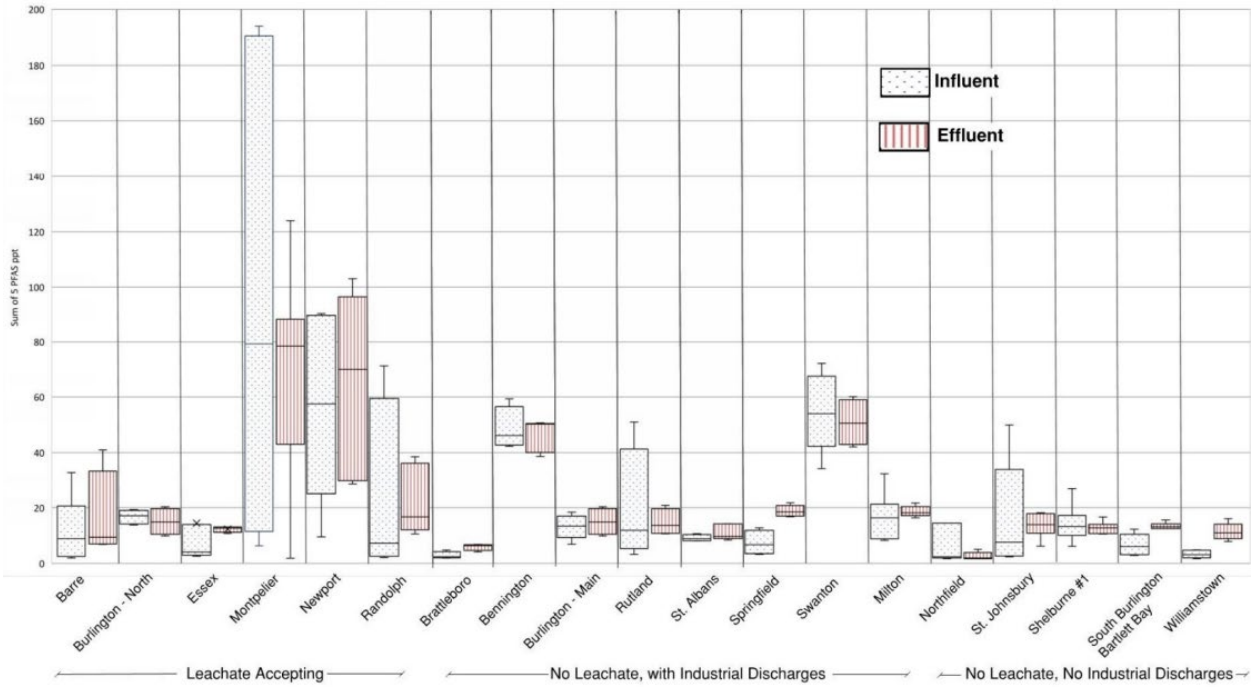


Figure 4-7. Sum of POTWs' PFAS Concentrations for the Five Regulated PFAS in Vermont

Adapted from VTDEC's 'Poly- and Perfluoroalkyl Substances at Wastewater Treatment Facilities and Landfill Leachate 2019 Summary Report' (Weston & Sampson, 2020)

As an example of the difference in PFAS concentrations between a POTW that accepts landfill leachate and one that does not, Figure 4-8 and Figure 4-9 present influent and effluent PFAS concentrations for all species of PFAS measured at Newport (leachate-accepting) and at St. Johnsbury (no leachate and no industrial wastewater). These charts illustrate the higher concentrations of several PFAS concentrations at the POTW that accepts landfill leachate. For example, PFOA was measured at about 43 ng/L in Newport and at about 3 ng/L in St. Johnsbury. Note the different range of concentrations shown on the Newport graph than the St. Johnsbury graph: The difference between concentrations at the two POTWs is greater than implied by the relative bar heights.

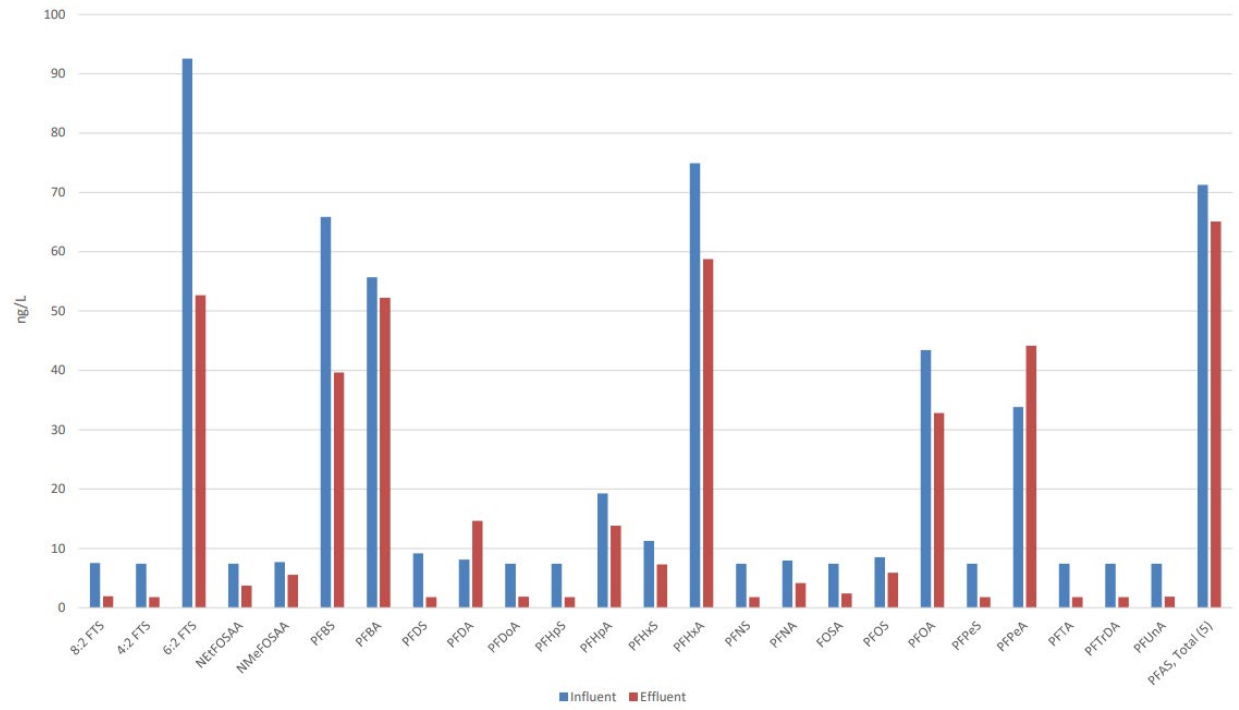


Figure 4-8. Average PFAS Concentrations at the Newport Wastewater Treatment Facility

Adapted from VTDEC's 'Poly- and Perfluoroalkyl Substances at Wastewater Treatment Facilities and Landfill Leachate 2019 Summary Report' (Weston & Sampson, 2020)

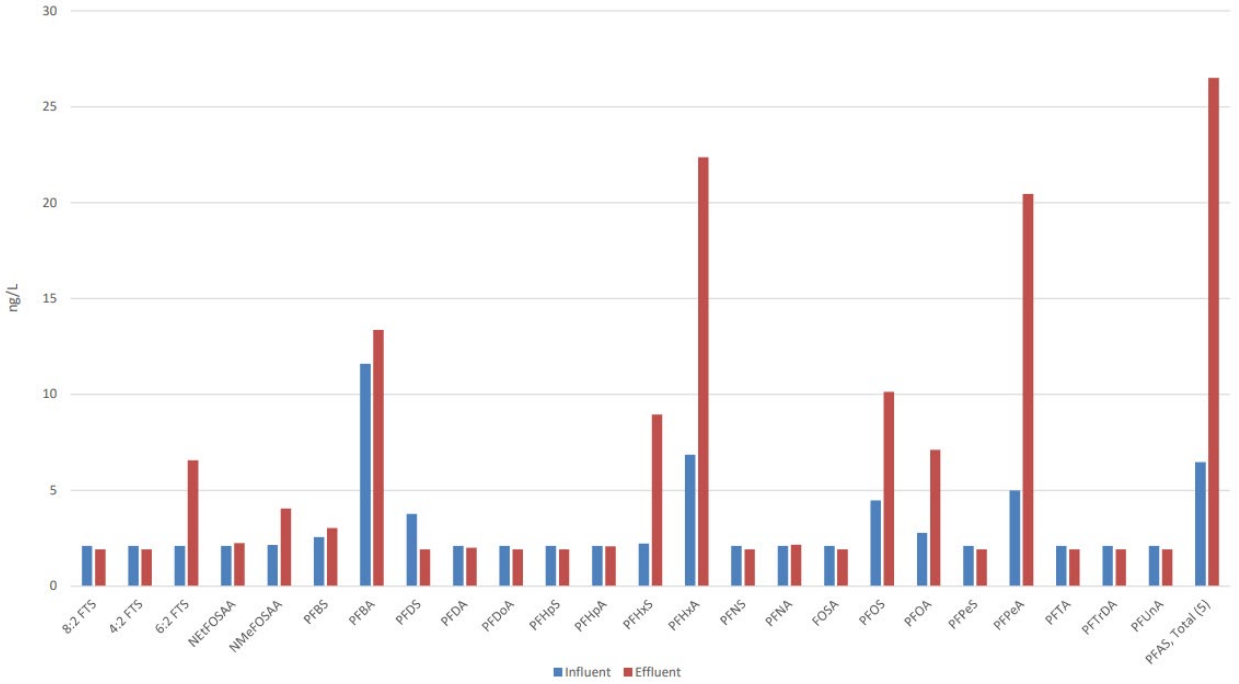


Figure 4-9. Average PFAS Concentrations at the St. Johnsbury Wastewater Treatment Facility

Adapted from VTDEC's 'Poly- and Perfluoroalkyl Substances at Wastewater Treatment Facilities and Landfill Leachate 2019 Summary Report' (Weston & Sampson, 2020)

4.2 Methods

4.2.1 Compilation of Existing Data

The scope of this study is limited to gathering data from existing sources, including the Massachusetts Executive Office of Energy and Environmental Affairs Wastewater NPDES PFAS Data Portal database (PFAS Data Portal) and additional data provided by individual POTWs for this project. The data that populate the Data Portal database are PFAS monitoring results submitted by POTWs to comply with their discharge permit conditions as described below (MA EEA, n.d.).

Under authority provided by the Clean Water Act, the EPA promulgated regulations that prohibit the discharge of any water containing pollutants to Waters of the United States. The permit program is called the National Pollutant Discharge Elimination System (NPDES). Under the NPDES program, the EPA or delegated states issue permits to entities that discharge treated wastewater directly to surface water, including POTWs, industries, institutions, and other privately owned sources. In Massachusetts, EPA retains the NPDES permit authority, while Massachusetts concurrently issues a state Surface Water Discharge permit.

The NPDES program and the state Surface Water Discharge program began to require permit-holders to monitor and report PFAS concentrations in influent, effluent and sludge as part of permit renewals beginning in 2022. Since 2022, PFAS monitoring requirements have continued to be added to permits being renewed. Not all POTWs had this requirement at the time of this study. These permit renewals also include requirements to sample industries that discharge to the POTW's collection system. These data are also included in the Data Portal.

Domestic Wastewater PFAS Monitoring Data

The PFAS Data Portal is a growing database of these PFAS monitoring data reported by NPDES permit-holders, including both POTWs and privately-owned domestic WWTFs, in compliance with NPDES requirements. This database provided the majority of the data included in the present study.

Additional PFAS monitoring data were voluntarily provided by multiple Massachusetts POTWs to supplement these analyses and were combined with data downloaded from the PFAS Data Portal. The combined data include 51 of 114 Massachusetts POTWs with NPDES permits. Note that an additional 13 Massachusetts POTWs are regulated by groundwater discharge permits, which do not yet include requirements for PFAS monitoring.

PFAS monitoring data were combined with publicly available land use and environmental justice data obtained from the Massachusetts Executive Office of Technology Services and Security Bureau of Geographic Information (MassGIS). Where applicable, the data were also combined with POTWs' responses to the POTW Sludge Management Survey conducted during Part 1 of the present study.

Industrial PFAS Monitoring Data

The PFAS Data Portal includes two types of industrial data: industrial NPDES permit holders, and indirect industrial dischargers. Industrial NPDES permit holders are industries that treat their own wastewater and discharge treated effluent to surface water. Some Industrial NPDES permit holders have begun to monitor and report PFAS data in compliance with their renewed permits. Indirect industrial dischargers are industries that treat their wastewater to a lesser degree and discharge to a POTW's collection system. The POTW then treats the industrial wastewater along with the other wastewater it receives. POTWs with certain types of indirect industrial dischargers are required to test these industries in compliance with their renewed permits. Both types of industrial PFAS data were downloaded from the NPDES PFAS Data Portal.

Recent NPDES permit renewals for POTWs have included requirements to annually monitor and report PFAS concentrations at regulated industries using EPA's electronic reporting tool for DMRs (called "NetDMR" or their state's electronic discharge monitoring report tool (state eDMR). Massachusetts concurrently issues a state Surface Water Discharge permit, which requires PFAS testing for all industries identified as Significant Industrial Users ([reference]), and for all industrial user testing data to be uploaded to MassDEP's eDEP system for processing and subsequent publication to the PFAS Data Portal. EPA provides the following list of industries to monitor:

- Commercial car washes
- Platers/metal finishers
- Paper and packaging manufacturers
- Tanneries and leather/fabric/carpet treaters
- Manufacturers of parts with polytetrafluoroethylene (PTFE) or Teflon-type coatings (i.e., bearings)
- Landfill leachate
- Centralized waste treaters
- Contaminated sites
- Firefighting training facilities
- Airports
- Any other known or suspected sources of PFAS

Massachusetts POTWs operating under older NPDES permits do not yet have requirements to monitor industrial users' PFAS concentrations. Some of these POTWs have been proactively monitoring individual industrial or commercial dischargers in their sewersheds and agreed to share their data for inclusion in this report. Therefore, industrial PFAS data from eight POTWs' industrial users representing 80 industrial users were assembled for subsequent processing.

Land Use and Environmental Justice Data

Publicly available land use and environmental justice data were obtained from the Massachusetts Executive Office of Technology Services and Security Bureau of Geographic Information (MassGIS) using the MassMapper interactive mapping tool.

MassGIS' standardized assessors' parcel mapping data set, containing property (land lot) boundaries and database information from each community's assessor, was mapped via the Property Tax Parcels tiled layer. The Census 2020 Environmental Justice Populations data layer, developed by the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) based on 2020 Census blocks, was combined with a statewide sewer service area map developed by Tighe & Bond's GIS team for a previously completed MassDEP project: *Enhancing Resilience and Emergency Preparedness of Water Utilities Through Improved Mapping - 2021 - 2022 Final Report* and overlaid on the mapped parcel data. The combined data were then exported for subsequent processing.

4.2.2 Data Processing

PFAS Monitoring Data

Data compilation yielded nearly 23,000 domestic wastewater influent, effluent, and sludge, sewershed, septage, and industrial wastewater PFAS measurements from 760 samples that were collected between April 2022 and August 2024 and uploaded to the Massachusetts Executive Office of Energy and Environmental Affairs Wastewater NPDES PFAS Data Portal as of October 11, 2024.

Processing efforts included rewriting various text fields to consistent spelling, defining data qualifiers, and incorporating supplemental information to the data, including facility flow rates, information gathered from the *POTW Sludge Management Survey* conducted for Part 1 of this report, and categorization data for each industry. Data were omitted when data qualifiers could not be interpreted or when the data could not be appropriately reprocessed based on laboratory-reported qualifiers. For example, data were omitted from samples that may have been contaminated based on the associated control sample's failure to meet laboratory-established acceptance criteria. In total, 286 measurements were omitted from the overall analyses by the authors, although the potential influence of these data on loading to POTWs is discussed on a case-by-case basis in Section 3.5.

Laboratories are required to set method detection limits (MDLs) and method reporting limits (MRLs) for each quantified PFAS species according to Sections 9.2.2 and 9.2.3, respectively, of EPA Method 1633 (USEPA, 2024a). For each set of samples from each laboratory, measurements below the MDL were considered to be equal to zero, and measurements between the MDL and the MRL (commonly noted with the "J" data qualifier) were redefined as the MRL divided by the square root of two as described by Hornung and Reed (1990), shown in Equation 4-1 (Hornung & Reed, 1990):

$$\frac{MRL}{\sqrt{2}} \qquad (4\text{-}1)$$

To facilitate comparison between liquid and sludge samples using nonparametric statistical methods, discussed further in Section 4.3, PFAS concentrations for liquid samples were converted from units of ng/L to units of ng/g, assuming a constant density of 998.2 g/L, approximately equal to the density of water at 20°C. Septage samples were assumed to have a percent solids of 2%. Sludge samples reported in units of ng/g were assumed to be reported on a dry basis in accordance with EPA Method 1633 section 15.4.1, which additionally requires sludge data to be reported with percent solids of each sample (USEPA, 2024a). Therefore, sludge samples were converted from units of ng/g on a dry basis to ng/g on a wet basis. For sludge samples that were missing percent solids data, the percent solids was assumed to be equal to the average of the percent solids reported for all other samples from the same facility (preferred) or equal to the average percent solids reported on the POTW Sludge Management Survey, as discussed in Part 1 of this report, depending on data availability. Data are also presented in their original units for consistency with prior reports and for ease of interpretation.

Following initial processing, average PFAS species concentrations were calculated for replicate samples, yielding over 22,600 PFAS measurements from 760 samples for subsequent analyses.

Land Use and Environmental Justice Data

The combined property parcel, environmental justice, and sewer service area data ("compiled parcel data") were filtered down to the subset of parcels served by 50 of the 51 POTWs represented in the PFAS monitoring dataset described in Section 4.2.1. One POTW with available PFAS monitoring data has no available parcel information and is no longer in operation, so it was omitted from the land use and environmental justice analyses.

Three-digit classification codes provided to identify each parcel's use were aggregated by the major classification indicated by the first digit based on the Massachusetts Bureau of Local Assessment's 2019 guidelines, summarized in Table 4-3 (Bureau of Local Assessment, 2019). For example, parcels designated as "single family" (101) and "condominium" (102) were both categorized as "residential" (1).

Table 4-3. Brief Definitions of Property Use Classifications

Classification	Definition[1]
Multiple-use	Real property used or held for use for more than one purpose, including parcels with multiple detached or attached buildings
Residential	Real property used or held for human habitation containing one or more dwelling units including rooming houses with facilities assigned and used for living, sleeping, cooking and eating on a non-transient basis as well as accessory land, buildings or incidental improvements used exclusively by the residents of the property or their guests
Open Space	Land which is not otherwise classified; is not taxable under the provisions of Chapter 61, 61A, or 61B, or taxable under a permanent conservation restriction; is not held for the production of income but is maintained in an open or natural condition; and which contributes significantly to the benefit and enjoyment of the public
Commercial	Real property used or held for use for business purposes and not specifically included in another class, including but not limited to any commercial, business, retail, trade, service, recreational, agricultural, artistic, sporting, fraternal, governmental, educational, medical or religious enterprise for non-profit purposes
Industrial	Real property used/held for manufacturing, milling, converting, producing, processing, extracting or fabricating materials unserviceable in their natural state to create commercial products or materials; the mechanical, chemical or electronic transformation of property into new products and any use that is identical to or an integral part of such use, whether for profit or non-profit purposes; property used/held for the storage, transmitting and generating of utilities
Personal property	Individuals, partnerships, associations, trusts, limited liability companies and other non-incorporated entities filing for federal income tax purposes as nonincorporated entities; business, manufacturing, and utility corporations and unincorporated entities that file for federal income tax purposes as corporations; machinery, poles, wires, underground conduits, pipes, oil and natural gas pipelines, telecommunications companies, electrical generation plants
Forest land	Land devoted to the growth of forest products. Upon application, the state forester may allow accessory land devoted to other non-timber uses to be included in certification; includes Christmas trees
Agricultural / horticultural land	Land used for raising animals (e.g., cattle, poultry, sheep, swine, horses, ponies, mules, goats, bees, and fur-bearing animals), including for the purpose of selling these animals or their products as part of a regular business. Additionally, land used in ways related to raising animals and preparing them or their products for market. Land used primarily and directly used for growing fruits, vegetables, berries, nuts, tobacco, flowers, sod, trees, nursery or greenhouse products, and ornamental plants for sale, including land used for raising forest products under a state-forester-approved certified management plan aimed at improving the crop's quantity and quality for sale. Additionally, land used in related, customary, and necessary activities for producing and preparing these products for market.
Recreational land	Land of at least five acres maintained in a natural, wild, or open state, landscaped, or managed as a forest under a state-forester-approved certified plan. This condition should significantly preserve wildlife and natural resources, such as water, air, vegetation, and scenic features. Additionally, land of at least 5 acres primarily used for recreational purposes without significantly disrupting its environmental benefits and accessible to the public or members of a non-profit organization; includes areas for hiking, camping, boating, nature study, golfing, horseback riding, hunting, fishing, alpine/Nordic skiing, swimming, picnicking, non-commercial flying, target shooting, and productive woodlots
Exempt	Property which is totally exempt from taxation, such as public service properties, land owned by the Commonwealth of Massachusetts, private educational institutions, charitable organizations, and religious groups

1. *Adapted from the Bureau of Local Assessment's property type classification codes (Bureau of Local Assessment, 2019)*

Compiled parcel data were then summarized at the POTW sewershed level for each use code: Total acreage was calculated by summing the lot size, in acres, of all parcels of each use category and divided by the sum of all parcels within a POTW sewershed to generate the percent land use for each use category in each sewershed.

EJ-designated block groups were aggregated within each POTW's sewershed: The total population, non-Hispanic white population, minority population (as defined in Table 4-4), number of households, and number of households without a person 14 years of age or older who speaks English 'very well' were calculated. The median was calculated for other EJ-designated block groups' parameters,

including median household income, median household income as a percent of 2020 Massachusetts median household income, median municipal household income, and median municipal household income as a percent of 2020 Massachusetts median household income. These procedures allowed for an approximate description of environmental justice communities within each sewershed and, therefore, comparison among POTWs' sewersheds.

Table 4-4. Definitions of Environmental Justice Criteria[1]

Environmental Justice Criterion	Definition
English isolation	≥25% of households lack English proficiency
Income	Annual median household income is ≤65% of statewide annual median household income
Minority[2]	Minorities comprise ≥40% of the population

1. Adapted from Chapter 8 of the Acts of 2021 (Commonwealth of Massachusetts, 2021)
2. "Minority" refers to persons other than non-Hispanic white

4.2.3 Data Analyses

In combination with the evolving regulatory landscape, the ongoing optimization of PFAS detection and quantification methods presents challenges in aggregating data. Since 2008, at least three analytical methods have been used by laboratories for detection and quantification of PFAS species in wastewater. For example, this report includes data measured using several different revisions of Modified Method 537.1 (Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)) and Method 1633 (Analysis of PFAS in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS). While our understanding of these methods' consistency is evolving, differences have been observed by utilities conducting split sample analyses using Modified Method 537.1 and Method 1633. For the purposes of these analyses, differences in method revisions were largely ignored. Therefore, care was taken to note when differences in species measured by Modified Method 537.1 and Method 1633 and several proprietary laboratory methods could contribute to observed trends.

When directly comparing PFAS composition among different types of samples (e.g., influent, effluent, sludge, and industry) using nonparametric analyses, discussed below, the dataset was truncated to omit PFAS that were not detected in any samples and to include only samples for which all remaining 37 PFAS were reported. This procedure resulted in 322 samples from a total of 50 sites and was selected to balance the desire to include both as many species as possible and as many samples as possible, although the nonparametric methods used cannot handle missing data. In addition, sample PFAS concentrations were converted to molar concentration (moles of PFAS per gram of sample on a wet basis) using its molar mass (g/mol). This technique allows for comparison of molar concentrations and calculation of 'total moles of PFAS' in each sample by summing molar concentrations independent of molecule size. Size-dependent metrics such as mass concentrations, while common in similar reports, are biased toward larger molecules, which may lead to inaccurate conclusions regarding perceived species importance. While determining the importance of specific PFAS with respect to health risk or environmental persistence is beyond the scope of this report, ongoing risk-assessment studies are being led by the EPA and others.

As is common for chemical species in environmental matrices, PFAS data are log-normally distributed, yet they are most commonly measured at extremely low concentrations or not detected at all. Descriptive statistics, such as mean, can be sensitive to skew in the data. Including non-detects is useful for understanding the *true distribution* of PFAS concentrations throughout the Commonwealth, while excluding non-detects is useful for determining the relevant PFAS

concentrations *when each species is present*. Therefore, summary statistics were calculated in two ways: 1) by including samples with PFAS concentrations below the method detection limit ("including non-detects") as zero ng/L, as discussed in Section 4.2.2, and 2) by excluding samples with PFAS concentrations below the method detection limit ("excluding non-detects").

The skew and variability among the data prevent the use of parametric statistical tools traditionally used to identify significant relationships among variables, which rely on assumptions about the underlying distribution of the data. For example, statistical tools such as linear regression and t-tests assume the data distribution is approximately normal. In this analysis, nonparametric statistical methods were used to account for the highly skewed nature of PFAS data, including Spearman's rank correlation, permutational analyses of variance (PERMANOVA), and non-metric multidimensional scaling (NMDS). For these analyses, PFAS that were not detected in any sample were omitted from the dataset, and molar concentrations were calculated for samples for which all remaining 37 PFAS were reported. NMDS was used to visualize underlying patterns in the data by reducing the overall number of dimensions (variables) to represent the (dis)similarity between samples (the points) on arbitrary axes. Therefore, the distance between two points on NMDS plots represents how (dis)similar those samples are based on their PFAS species compositions (the number of species and their quantities in each sample). On the resulting NMDS plots shown in Section 4.3, vectors projecting from the origin represent the correlation of PFAS molar concentrations with the arbitrary NMDS axes. That is, a horizontal vector parallel to NMDS1 is highly correlated with that axis and can be interpreted as strongly associated with the (dis)similarity samples along that axis, although the axes themselves are not meaningful. The axes simply represent a combination of many possible parameters that best represent (dis)similarity among the samples. Additional information regarding nonparametric statistical methods can be found in Appendix E.

The metric 'total moles of PFAS,' defined above, for samples with at least 37 reported PFAS was used in the land use and environmental justice analyses discussed in Appendix G. Spearman's rank correlation was calculated for the relationship between percent land use and 'total moles of PFAS' for land use categories to determine whether percent land use is associated total PFAS the content of POTWs' influent, effluent, or sludge. This procedure was repeated for the environmental justice parameters described in Section 4.2.2.

Portions of the analyses were conducted using R Statistical Software (version 4.3.2) (R Core Team, 2023) and RStudio (version 2024.4.2.764) (Posit team, 2024). All packages used are listed in Appendix E. Supplemental figures and tables are included in Appendix F.

4.2.4 Selection Criteria for POTW Case Studies

Thirteen POTWs were selected for detailed analysis of PFAS loadings. In effort to evaluate POTWs representative of Massachusetts' breadth of unique circumstances, the following criteria were considered:

Availability of data – While NPDES permits requiring PFAS monitoring have been issued since fall of this report. POTWs that had participated in Part 1 of the present study were prioritized, as were POTWs that provided residential or industrial PFAS data collected independent of NPDES requirements.

Prevalence of influent PFAS – POTWs were selected with a variety of influent PFAS species at relevant concentrations according to the results discussed in Section 4.3.1.

Size – General NPDES permit categories were used to define POTW size. POTWs were selected to represent small facilities with less than one mgd influent flow, medium facilities with one to five mgd permitted influent flow, and large facilities with greater than five mgd permitted influent flow.

Requirements for PFAS monitoring are being added to NPDES permits as part of NPDES Permit renewals. These requirements have been included in all renewed permits for medium POTWs and some for large POTWs. To represent small POTWs, we selected medium facilities that have reported flows in the small category. Large facilities were selected based on data availability.

Location – MassDEP's administrative regions encompass the Commonwealth's geographic, sociopolitical, and economic diversity. At least two POTWs were included from each of the northeast, southeast, central, and western regions.

Industrial contribution – POTWs serving areas with significant industrial flows as well as those without significant industrial contribution were included to establish the relative PFAS loadings from primarily residential and industrial sources.

Hauled-in waste management – Hauled-in wastes, especially septage and landfill leachate, are likely significant sources of PFAS to POTWs. Based on the results of Part 1 of the present study, POTWs that reported receiving septage, landfill leachate, or other hauled-in wastes were prioritized for comparison with POTWs that do not accept these wastes.

Sludge management – POTWs that rely on land application for sludge management were considered due to potential for PFAS contamination of biosolids.

4.3 Massachusetts Wastewater PFAS

There are several key conclusions to be drawn from this analysis:

- There is an overall decrease in liquid-phase PFAS molar concentrations within a POTW identified through the NMDS analysis.
- Long-chain PFAS tend to accumulate in POTW sludge, exhibiting a distinct "PFAS profile."
- Eight PFAS species are frequently detected in influent and effluent samples at most POTWs, which implies ubiquitous presence regardless of industrial discharges or hauled-in waste contributions.
- Source control at specific individual dischargers (e.g. industry, landfill leachate) may be effective in lowering wastewater and sludge PFAS levels in some instances.
- Broad reductions in PFAS in wastewater and sludge requires removal of PFAS from consumer products or application of treatment technologies.

4.3.1 Overview of PFAS at POTWs

Data from POTWs' influent, effluent, sludge, and industrial dischargers' samples were visualized using NMDS to identify underlying patterns in PFAS compositions (as discussed in Section 4.2.3 and Appendix E). Examination of sample composition elucidates a dominant pattern: POTW influent, effluent, and sludge PFAS compositions are significantly different from each other based on permutational analyses of variance (PERMANOVA) with resulting p-values below the significance threshold of 0.05, as shown in Table F-1 in Appendix F. While significant, the difference between influent and effluent PFAS compositions seems to be associated with an overall decrease in liquid-phase PFAS concentrations during the treatment process: Figure 4-10 shows that effluent samples cluster closer to the origin than influent samples, indicating lower molar concentrations. However, sludge samples exhibit a distinct "PFAS profile," because they cluster farther from the origin and separately from influent and effluent samples. The frequent measurement of some PFAS in sludge that do not appear in the influent or appear in few influent samples, suggest that these compounds (e.g., PFOS, PFDA, NMeFOSAA, and NEtFOSAA) may accumulate in the sludge either by partitioning due to adsorption to sludge or via the transformation of influent species during the treatment process. Adsorption of long-chain PFAS in the sludge has been attributed to their hydrophobicity

relative to shorter-chain PFAS, although the mechanism of PFAS accumulation in wastewater sludge is an emerging area of research that is beyond the scope of the present study.

Figure 4-10 also shows the variation in industrial effluent PFAS compositions, although industrial PFAS could not be categorically compared with influent, effluent, or sludge PFAS compositions. This is because the industrial PFAS data have significantly higher dispersion, a measure of variability, than influent, effluent, and sludge samples. Therefore, it is not possible to determine whether the observed differences between industrial effluent samples and POTW influent, effluent, and sludge samples are caused by true differences between the groups or the high variability of industrial effluent PFAS composition. Industrial effluent samples' PFAS compositions are generally like those of POTW influent and effluent, although at higher concentrations. Yet some industrial effluent samples are in close proximity to the cluster of sludge samples. This result suggests that specific PFAS associated with some industrial dischargers may be more likely to accumulate in POTW sludge than in influent PFAS from domestic loading alone, even if those species comprise a small proportion of total influent PFAS loading. In fact, industrial discharges make up just 2-3% of POTW influent flow for the three POTWs that provided industrial PFAS monitoring data. The role of types of industrial dischargers as sources of PFAS that elevate sludge PFAS concentrations is further discussed in Section 4.3.2. Nevertheless, it is impossible to comprehensively evaluate the true importance of industrial mass loading to POTW influent without the ability to construct mass and energy balance analyses for individual POTWs.

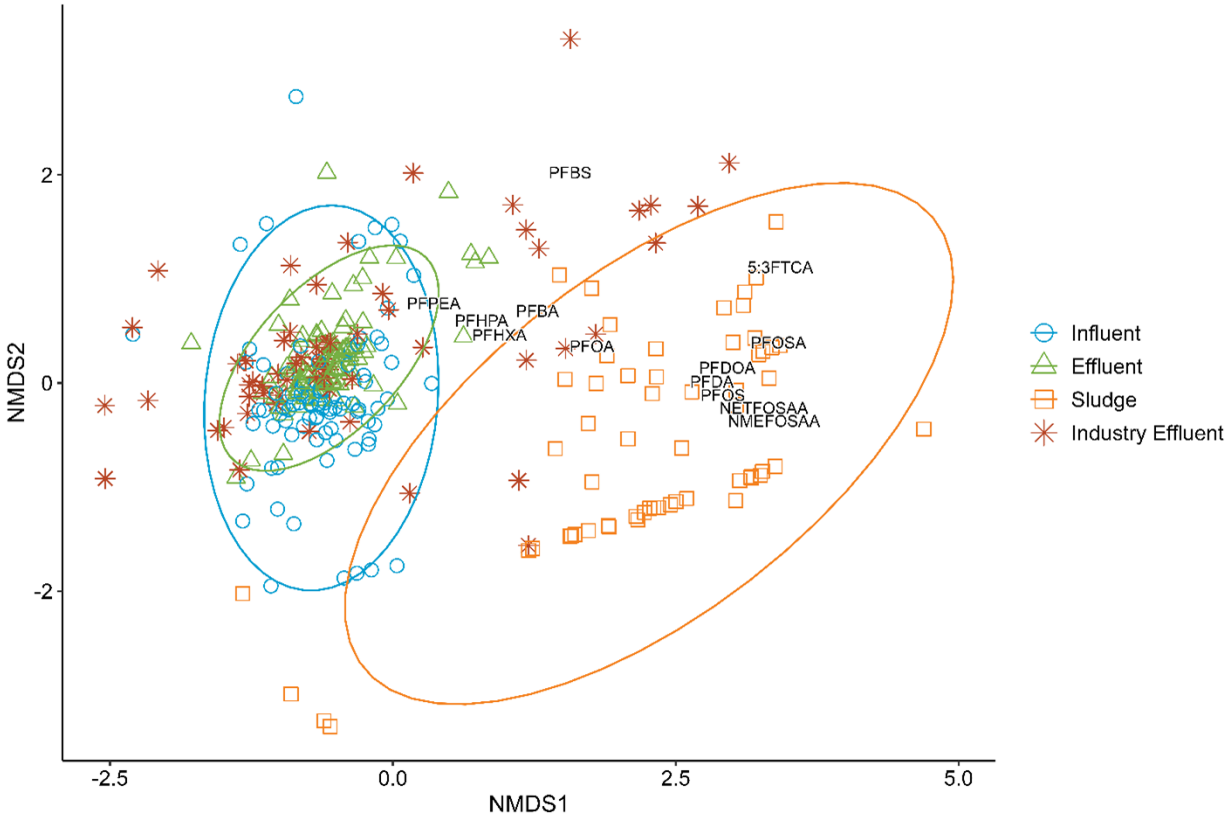


Figure 4-10. NMDS plot of POTW and industrial users' PFAS molar concentrations (µmol/g)

Effluent samples cluster closer together than influent samples, indicating lower PFAS concentrations. Sludge samples cluster separately from liquid-phase samples, indicating a distinct PFAS composition.

Note: The distance between two points represents how (dis)similar those samples are based on their PFAS compositions. PFAS significantly correlated with either axis ($p<0.05$) are shown for moderate-to-strong correlations (Spearman's $\rho \geq 0.3$), although vectors from the origin were omitted for clarity. The NMDS algorithm converged on a two-dimensional solution in 426 iterations with a stress of 0.13.

Relevant PFAS species and concentrations

PFAS were detected in 680 of 760 samples from 65 NPDES-holders. Thus, about 89% of all samples contained some quantity of PFAS, as summarized in Table 4-5. All POTWs, privately-owned wastewater treatment facilities (WWTPs), and industrial users holding individual NPDES permits had at least one PFAS detected on at least one occasion. This is consistent with data from the VTDEC landfill leachate study that sampled influent at 53 POTWs and found that every plant influent contained some PFAS (Weston & Sampson, 2020). The frequency of PFAS detection in MA and elsewhere affirms the extent of this class of chemicals: PFAS were detected in at least 89% of samples from POTWs studied, 89% of samples from industrial NPDES permit-holders studied, and 88% of samples from both privately-owned WWTPs studied.

Table 4-5. Summary of Overall PFAS Detection

Facility Type	# Samples with PFAS detection	# Sites with PFAS detection	Total # Sample	Total # Sites
POTW	603	51	674	51
Influent	159	49	177	51
Influent + Landfill Leachate	2	1	2	1
Influent + Septage	8	1	8	1
Influent + Septage + Landfill Leachate	2	1	2	1
Effluent	165	50	169	50
Sludge	135	42	150	45
Septage	4	1	5	1
Domestic Sewershed	7	1	8	1
Industrial Discharge[1]	121	7	153	8
Industry[2]	59	12	66	12
Influent	9	2	9	2
Effluent	42	12	48	12
Sludge	8	2	9	2
Septage[3]	4	1	4	1
Private Wastewater Treatment Plant	14	2	16	2
Influent	4	2	6	2
Effluent	6	2	6	2
Sludge	4	2	4	2

1. Samples collected from industrial users discharging to a POTW (site)
2. Industrial dischargers (sites) with individual NPDES permits
3. Samples collected from individual septic systems during pumping

PFAS data typically were reported for either six or 40 individual PFAS per sample, depending on permit requirements. Samples for which six PFAS ("PFAS6") were reported were typically analyzed using Modified Method 537.1, which measures fewer species than Method 1633. Method 1633

measures 40 PFAS ("PFAS40"), including those measured by Modified Method 537.1. The limited quantity of available PFAS data indicated that establishing a relationship between the PFAS6 and PFAS40 may enable inclusion of more data in subsequent analyses.

The relationship between the sum of six reported PFAS and the sum of 40 reported PFAS ("PFAS6" and "PFAS40," respectively) is highly variable. Therefore, a POTW-specific relationship must be established to quantify the relationship between PFAS6 and PFAS40 in order to analyze previously reported PFAS6 data together with the PFAS40 required by more recent permits.

While unsurprising, this confirms that the more extensive list of 40 PFAS measured by Method 1633 are relevant to MA POTWs and cannot necessarily be approximated by other methods, including Modified Method 537.1, which measures a smaller number of compounds. For samples that reported data for 40 PFAS, the subset PFAS6 were summed on the basis of both mass and moles of PFAS (PFAS6 subset) and compared to the total PFAS40 concentration for each sample (Figure F-1, Figure F-2 in Appendix F). The PFAS6 subset concentration is significantly correlated with the PFAS40 concentration on both a mass- and mole-basis (Spearman's correlation: ρ_{mass}=0.85, ρ_{mole}=0.86, both $p<2\times10^{-16}$). However, high variability among the data indicate that PFAS40 concentration cannot be estimated from the PFAS6 subset concentration alone (Figure F-1 and Figure F-2). Rather, a location-specific relationship between PFAS6 and PFAS40 concentrations may be established to estimate PFAS40 from previously reported PFAS6 concentrations. Note that PFAS measured by Method 1633 or Modified Method 537.1 both target specific PFAS, which represent a fraction of the PFAS in existence; non-targeted analytical methods such as Total Organic Florine and Total Oxidizable Precursor would likely yield much higher results based on the work done by the University of New Hampshire and VTDEC (discussed in Section 4.1.3).

Three species among the PFAS measured by EPA Method 1633 were not detected in any samples: 11Cl-PF3OUdS, ADONA, and NFDHA. 11Cl-PF3OUdS, a mist suppressant used in the chrome plating industry, has been primarily used and manufactured in China since the 1970s (He et al., 2022) and is not used extensively in the United States. While ADONA was introduced as a replacement emulsifying agent for PFOA in 2008, and NFDHA is the main component of the aqueous film-forming foam FN-3, a fire-extinguishing agent, the availability of alternatives may explain why these species were not detected in any samples (Awad et al., 2020; Liu et al., 2022).

Figure 4-11 identifies the eight PFAS species that were detected in 49% or more of influent samples across the entire dataset: PFOA, PFHxA, PFOS, PFBS, PFPeA, PFHpA, PFHxS, and PFBA. Of the PFAS6, four (PFOS, PFOA, PFHxS, and PFHpA) are detected in more than half of influent samples: PFDA and PFNA were detected in 10.2% and 30.7%, respectively. The ubiquitous nature of these eight species implies that they may originate from sources that are generally common to POTWs, such as residences, restaurants, and common commercial businesses. PFAS that were detected less frequently, especially those detected in very few samples, are more likely to originate from unique dischargers like a specific industrial user or category of industry. The role of specific types of discharges in PFAS loading at POTWs is discussed further in Section 3.2.

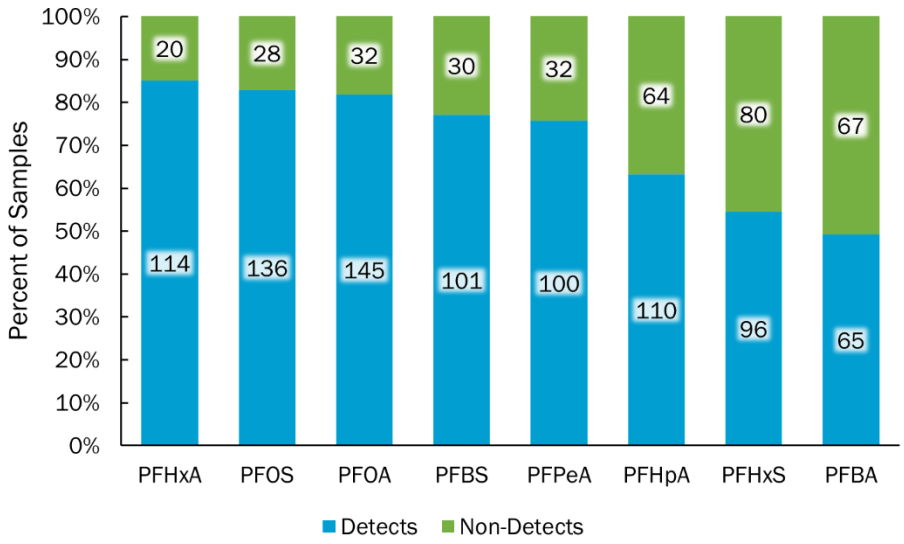


Figure 4-11. Most common PFAS species detected in MA POTW influent

Number of samples with detectable and undetectable concentrations is shown for each species within each bar. Note that PFOS, PFOA, PFHxS, and PFHpA are PFAS6 species.

Table 4-6, Table 4-7, and Table 4-8, summarize the available influent, effluent, and sludge data, respectively, for all Massachusetts POTWs, reflecting all PFAS species that were detected at least once in order of their frequency of detection ("% Detected"). Mean concentrations for each species were calculated in two ways: 1) by including samples with PFAS concentrations below the method detection limit ("including non-detects") as zero ng/L and 2) by excluding samples with PFAS concentrations below the method detection limit ("excluding non-detects"). Including non-detects is useful for understanding the *true distribution* of PFAS concentrations throughout the Commonwealth, while excluding non-detects is useful for determining the relevant PFAS concentrations *when each species is present*. Since there are no regulatory standards for any of these PFAS in wastewater or surface water, it is not possible to compare the mean concentrations or maximum detected concentrations to a useful benchmark. While compiling information on the health or environmental impacts of any of these species is beyond the scope of this study, research is ongoing at the EPA and elsewhere.

Table 4-6. Summary of Influent PFAS Data from Massachusetts POTWs

Species	Total Samples	Number of Samples with Detection	% Detected	Mean (including nondetects; ng/L)	Mean (excluding nondetects; ng/L)	Maximum Concentration (ng/L)
PFHxA	134	114	85.07%	6.25	7.34	54.00
PFOS	164	136	82.93%	9.33	11.25	48.90
PFOA	177	145	81.92%	5.93	7.24	30.00
PFBS	131	101	77.10%	5.82	7.54	240.00
PFPeA	132	100	75.76%	12.00	15.84	200.00
PFHpA	174	110	63.22%	2.17	3.43	14.14
PFHxS	176	96	54.55%	1.96	3.59	18.60
PFBA	132	65	49.24%	4.41	8.96	81.20
PFNA	176	54	30.68%	0.50	1.63	3.68
PFPeS	130	28	21.54%	0.50	2.33	7.50
PFDA	176	18	10.23%	0.14	1.42	3.54
6:2FTS	130	11	8.46%	0.45	5.34	15.06
PFDoS	123	6	4.88%	0.21	4.38	6.16
5:3FTCA	118	4	3.39%	2.53	74.68	135.00
PFHpS	130	4	3.08%	0.03	0.84	1.15
PFDoA	135	4	2.96%	0.06	2.04	3.61
NEtFOSAA	130	3	2.31%	0.14	6.23	16.50
3:3FTCA	118	2	1.69%	2.32	137.15	215.00
NMeFOSAA	126	2	1.59%	0.02	1.42	1.68
PFOSA	130	2	1.54%	0.03	2.02	3.39
PFUnA	134	2	1.49%	0.01	0.52	0.71
NEtFOSE	118	1	0.85%	0.04	4.40	4.40
NMeFOSE	124	1	0.81%	0.03	3.40	3.40
PFDS	134	1	0.75%	0.01	1.54	1.54

Table 4-7. Summary of Effluent PFAS Data from Massachusetts POTWs						
Species	Total Samples	Number of Samples with Detection	% Detected	Mean (including nondetects; ng/L)	Mean (excluding nondetects; ng/L)	Maximum Concentration (ng/L)
PFHxA	131	127	96.95%	21.46	22.14	490.00
PFPeA	129	125	96.90%	20.62	21.28	260.00
PFOA	167	161	96.41%	9.87	10.23	63.80
PFOS	163	148	90.80%	7.63	8.40	57.80
PFBS	127	115	90.55%	9.97	11.01	301.00
PFHpA	170	145	85.29%	2.74	3.21	12.20
PFHxS	168	124	73.81%	2.33	3.16	33.30
PFBA	130	93	71.54%	5.36	7.49	52.40
PFNA	163	86	52.76%	0.98	1.85	28.00
PFDA	165	62	37.58%	0.64	1.71	7.50
PFPeS	130	48	36.92%	0.52	1.42	16.40
NMeFOSAA	123	18	14.63%	0.28	1.89	6.14
PFOSA	124	11	8.87%	0.14	1.54	6.39
NEtFOSAA	126	10	7.94%	0.12	1.56	3.74
6:2FTS	127	10	7.87%	1.36	17.31	119.00
PFHpS	127	7	5.51%	0.82	14.95	98.40
PFUnA	131	4	3.05%	0.03	1.13	2.79
5:3FTCA	122	3	2.46%	0.73	29.53	32.53
3:3FTCA	122	2	1.64%	2.10	128.32	251.00
PFDoA	131	2	1.53%	0.03	1.85	2.82
PFDS	131	2	1.53%	0.02	1.56	2.04
NEtFOSE	117	1	0.85%	0.24	27.90	27.90
PFDoS	122	1	0.82%	0.11	13.00	13.00
NMeFOSA	122	1	0.82%	0.02	2.17	2.17
NMeFOSE	**122**	**1**	**0.82%**	**0.25**	**30.90**	**30.90**
PFMPA	**122**	**1**	**0.82%**	**0.02**	**2.22**	**2.22**
8:2FTS	**125**	**1**	**0.80%**	**0.01**	**0.81**	**0.81**
4:2FTS	**126**	**1**	**0.79%**	**0.02**	**2.58**	**2.58**

Table 4-8. Summary of Sludge PFAS Data from Massachusetts POTWs						
Species	Total Samples	Number of Samples with Detection	% Detected	Mean (including nondetects; ng/L)	Mean (excluding nondetects; ng/L)	Maximum Concentration (ng/L)
PFOS	140	124	88.57%	14.92	16.84	90.90
NMeFOSAA	101	78	77.23%	4.42	5.72	29.20
NEtFOSAA	106	75	70.75%	3.06	4.32	25.10
PFDA	148	94	63.51%	2.75	4.32	46.00
PFHxA	108	59	54.63%	1.74	3.19	62.00
PFOA	145	77	53.10%	2.07	3.91	27.00
PFDoA	110	51	46.36%	0.77	1.67	12.00
PFOSA	99	44	44.44%	0.95	2.13	5.72
PFUnA	107	45	42.06%	0.74	1.76	9.10
5:3FTCA	101	37	36.63%	21.27	58.06	528.00
PFNA	141	46	32.62%	0.77	2.36	21.00
NMeFOSE	89	29	32.58%	6.32	19.39	99.20
PFDS	111	33	29.73%	0.56	1.89	12.80
PFPeA	109	30	27.52%	1.14	4.15	14.00
PFHxS	142	29	20.42%	0.52	2.53	22.00
PFTrDA	111	21	18.92%	0.21	1.12	2.97
PFBS	105	19	18.10%	0.38	2.08	6.19
PFHpA	149	25	16.78%	0.24	1.40	5.52
PFBA	107	17	15.89%	0.79	4.98	22.06
NEtFOSE	92	12	13.04%	2.12	16.23	72.00
7:3FTCA	101	11	10.89%	5.33	48.91	137.89
PFTeDA	102	10	9.80%	0.10	1.02	2.97
PFHpS	107	10	9.35%	0.09	0.96	2.09
8:2FTS	104	6	5.77%	0.35	6.14	22.06
PFPeS	105	6	5.71%	0.06	1.04	2.97
6:2FTS	105	5	4.76%	0.56	11.85	22.06
PFDoS	102	3	2.94%	0.02	0.66	1.32
PFNS	106	3	2.83%	0.12	4.29	9.99
3:3FTCA	101	2	1.98%	0.05	2.76	5.52
NEtFOSA	94	1	1.06%	0.00	0.04	0.04
PFMPA	76	1	1.32%	0.04	2.83	2.83
HFPO-DA	77	1	1.30%	0.09	6.63	6.63
PFMBA	77	1	1.30%	0.04	3.31	3.31
9Cl-PF3ONS	78	1	1.28%	0.08	6.63	6.63
4:2FTS	82	1	1.22%	0.08	6.63	6.63

Overall, 35 PFAS were detected in sludge samples, 35% more species than were detected in either influent or effluent, which each had 26 species detected. Table 4-9 summarizes the species most frequently detected in a majority of POTWs. Influent and effluent samples had similar frequencies of major species; however, the species detected most frequently were different in sludge, which aligns with previous observations that certain species (e.g., NEtFOSAA, NMeFOSAA, and PFDA) have a greater affinity for sludge solids while others (e.g., PFBA, PFBS, PFHpA, PFHxS, and PFPeA) seem to remain dissolved in the liquid fraction.

Table 4-9. Summary of PFAS Species Present in >50% of POTWs

Species	Influent	Effluent	Sludge
PFBA	53%	71%	31%
PFPeA	78%	82%	38%
PFHxA	84%	84%	57%
PFHpA	75%	90%	38%
PFOA	90%	96%	62%
PFNA	47%	65%	52%
PFDA	25%	47%	79%
PFBS	76%	78%	29%
PHxS	76%	76%	38%
PFOS	92%	96%	95%
NMeFOSAA	12%	24%	71%
NEtFOSAA	12%	18%	71%

The average mass concentrations (ng/L), including non-detects, of the eight most-frequently-detected PFAS in POTW influent are shown in Figure 4-11 for each POTW in a cumulative stacked column. These eight PFAS are the same species that were detected at all POTWs in the VTDEC study described in Section 4.1.3. These species are ubiquitous among Massachusetts POTWs, as they appear in samples from most of the POTWs studied, although the relative concentrations of each vary considerably among POTWs. For this reason, these data are particularly useful when broken down by POTW and compared with samples from throughout the collection system or compared with samples from specific dischargers or sub-sewersheds within the POTW sewage collection system to evaluate the potential effectiveness of source controls. This concept is further explored in the case studies presented in Section 4.3.3.

In general, the remaining 36 PFAS were detected at fewer POTWs and at lower average concentrations than the eight most-frequently-detected species (Figure 4-13.). Some species, such as PFNA, are present in low concentrations at many of the POTWs. Other species shown are seldom detected, such as 3:3FTCA, which only was detected at 53.8 ng/L and 29.65 ng/L in one influent sample each from POTW 28 and 60.

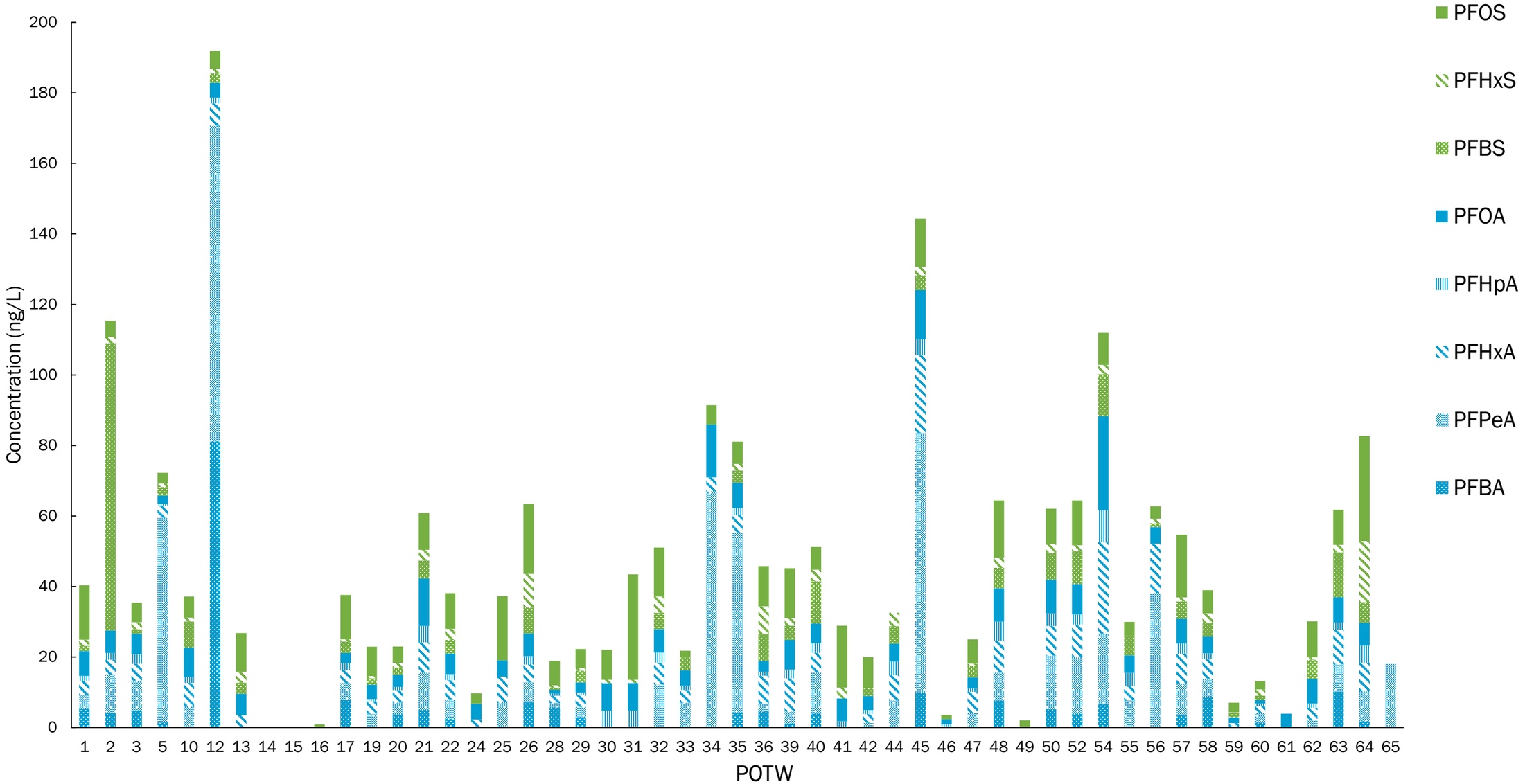


Figure 4-12. Cumulative Average PFAS Mass Concentrations (ng/L) for the Eight PFAS Most Frequently Detected in Massachusetts POTW Influent

Average concentrations shown here include non-detects as 0.

Blue compounds are Perfluoroalkycarboxylic acids, green compounds are Perfluorosulfonic acids, and grey compounds are the remaining PFAS compounds

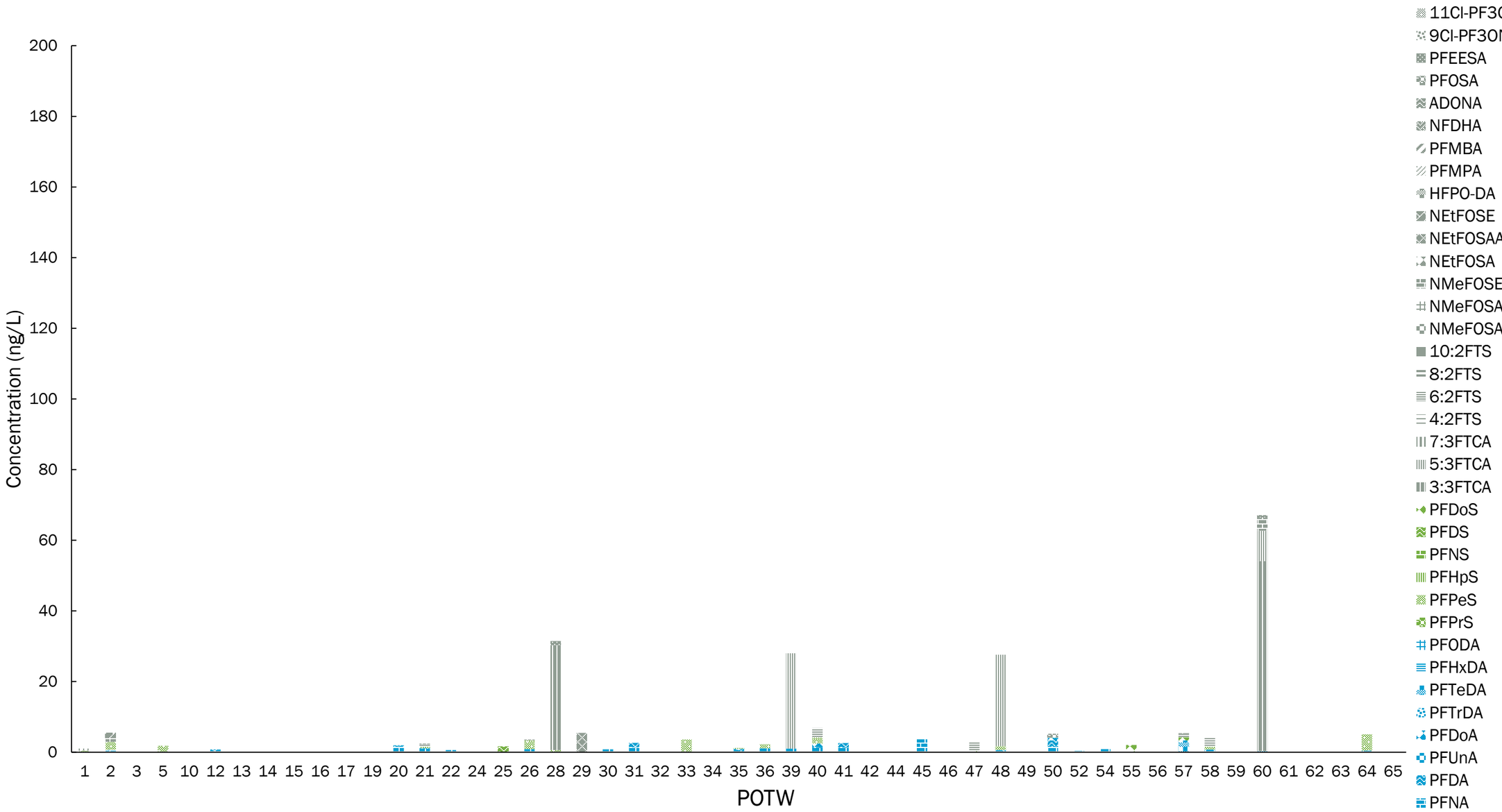


Figure 4-13. Cumulative Average PFAS Mass Concentrations (ng/L) for the Eighteen PFAS Least Frequently Detected in Massachusetts POTW Influent

Average concentrations shown here include non-detects as 0.

Among effluent samples from 49 POTWs, at least two unique PFAS were detected at each POTW, while over 15 species were detected at three POTWs. Figure 4-14 shows average concentrations of the eight species most frequently detected in POTW effluent samples, which are the same eight species that were detected most frequently in influent samples. Visual examination of PFAS concentrations among POTWs reveals a possible pattern: PFPeA and PFHxA tend to be present at higher concentrations than those of PFBA, PFHpA and PFHxS, while concentrations of PFOS and PFOA are more variable.

The effluent data from POTW36 indicates PFAS concentrations that total more than 10 times the concentrations measured in the plant's influent, while most other POTWs show effluent concentrations that are similar to their influent levels. The laboratory data were reviewed, and there are no apparent reasons to discount the results. A more comprehensive analysis of POTW36 would be necessary to verify and explain these results.

Figure 4-15 shows average concentrations of the remaining 36 PFAS that were detected in effluent samples least frequently. While some of these species, such as PFNA, are detected in low concentrations at many POTWs, other species are detected only occasionally but sometimes at relatively high concentrations. Examples of the latter include 6:2FTS in POTW17, NMeFOSE and NEtFOSE in POTW10, 5:3FTCA in POTW36, and 6:2FTS and PFHpS in POTW21.

Seven PFAS were detected in sludge at more than half of the 42 POTWs sampled, as shown in Figure 4-16 PFOS was detected most frequently, at 40 of the 42 POTWs, followed by PFDA, which was detected at 33 POTWs. Figure 4-17 shows cumulative average concentrations for the 28 PFAS that were detected in sludge samples from less than half of the POTWs. Frequency of detection ranged from a high of 20 POTWs for PFOSA and 19 POTWs for PFUNA to a single POTW each for six different species. PFAS detected in sludge at each POTW ranged from zero unique species (such as POTW10 & POTW60) to 25 species at both POTW50 and POTW64 and 24 species at POTW45. It is noteworthy that sludge samples from 78% of MA POTWs have concentrations of PFOA and PFOS below the 20-ppb threshold required for land application in the state of New York. Although the New York threshold is not risk-based and does not address potential impacts to groundwater, surface water or other potential exposure pathways, the current New York values preserve biosolids land application capacity including for biosolids generated in Massachusetts.

Understanding the variability in PFAS detection across different POTWs highlights the need for targeted research into specific sources and pathways of contamination. Identifying patterns in species presence could help clarify factors contributing to higher concentrations, guiding future regulatory efforts and remediation strategies. However, the similarity between the most common PFAS observed in Massachusetts POTWs and those observed in previous studies indicates that these species are likely common in domestic wastewater.

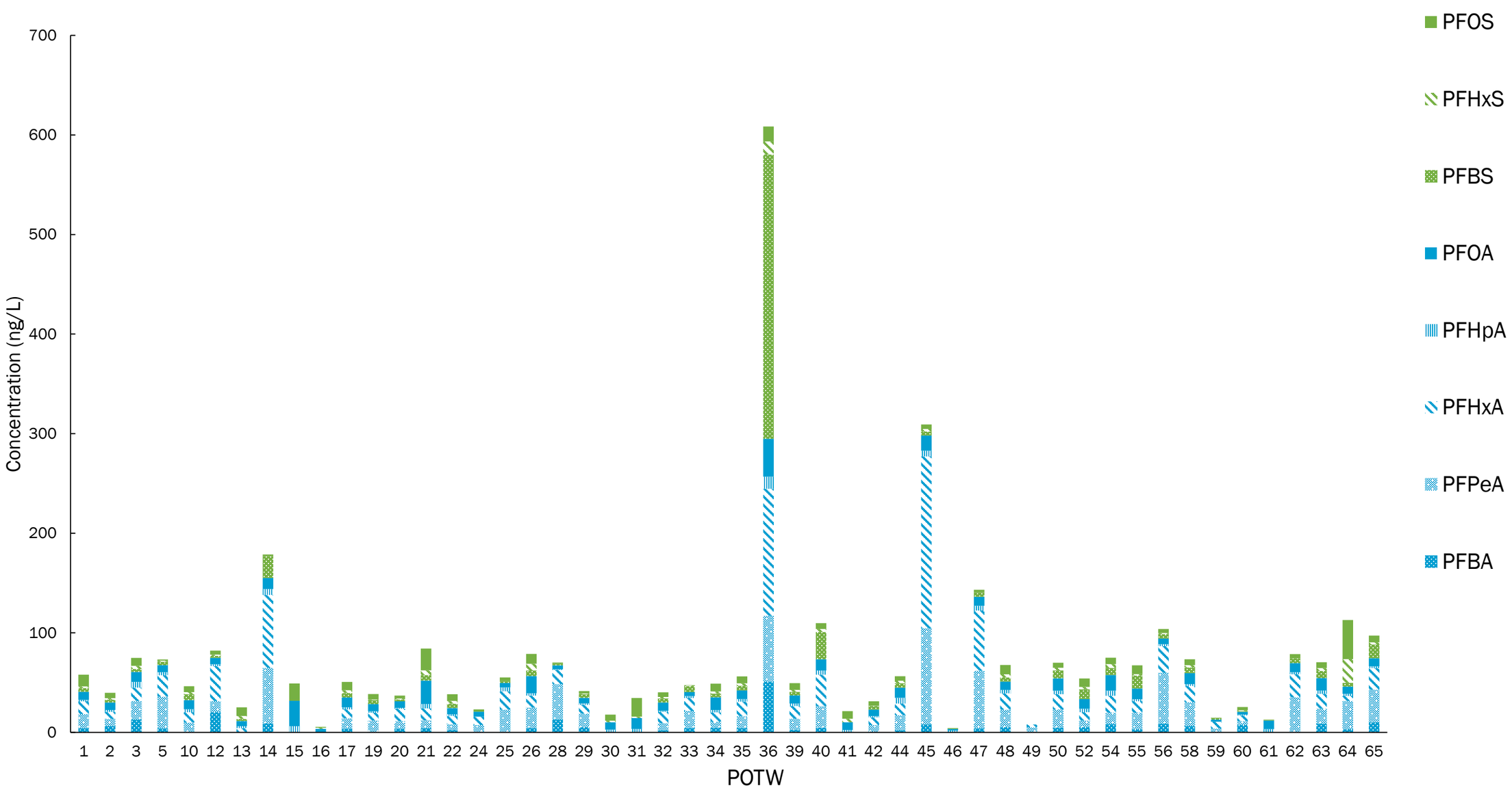


Figure 4-14. Cumulative Average PFAS Mass Concentrations (ng/L) for the Eight PFAS Most Frequently Detected in Massachusetts POTW Effluent

Average concentrations shown here include non-detects as 0.

Blue compounds are Perfluoroalkycarboxylic acids, green compounds are Perfluorosulfonic acids, and grey compounds are the remaining PFAS compounds

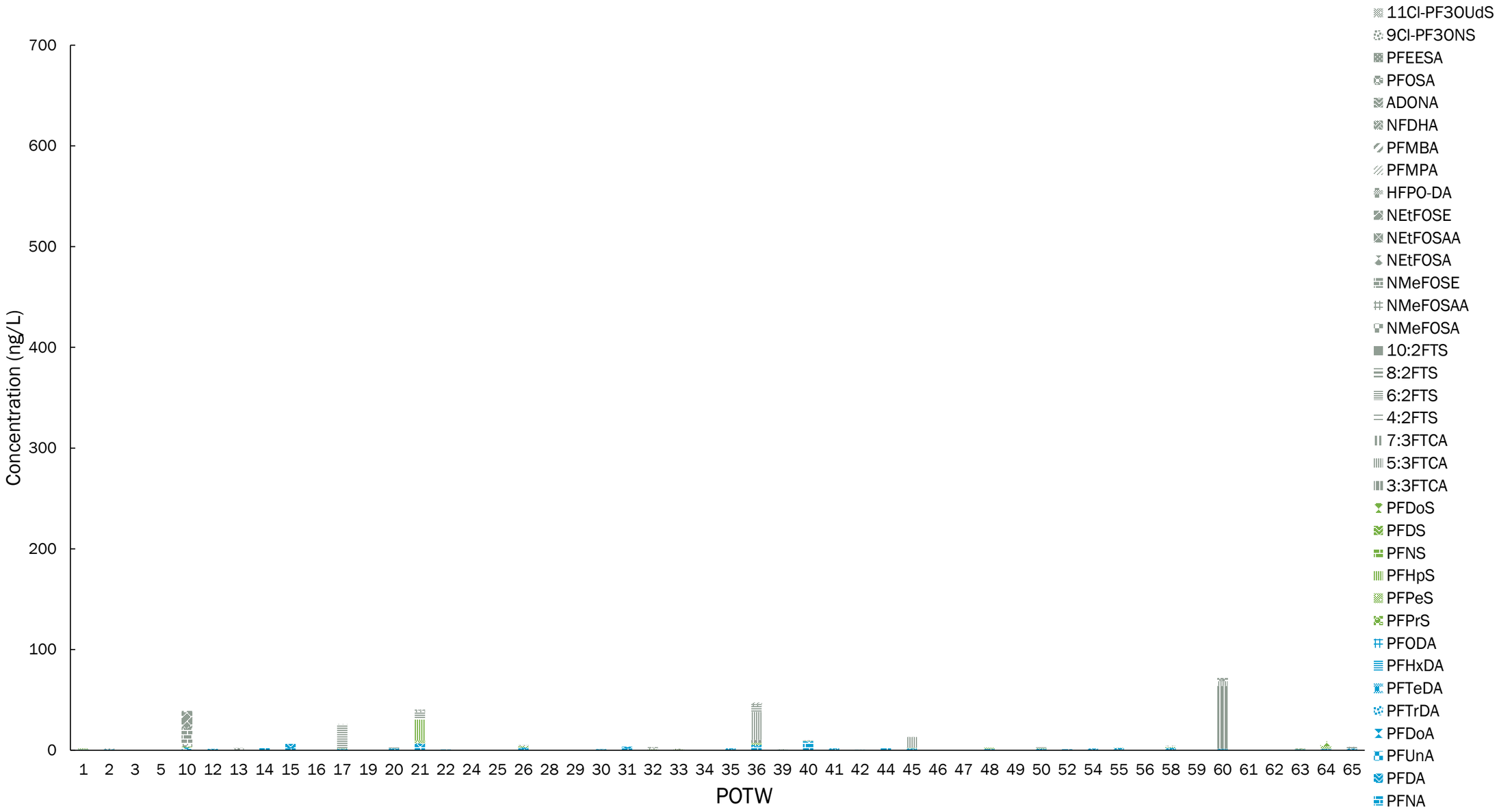


Figure 4-15. Cumulative Average PFAS Mass Concentrations (ng/L) for the 18 PFAS Least Frequently Detected in Massachusetts POTW Effluent

Average concentrations shown here include non-detects as 0.

Blue compounds are Perfluoroalkycarboxylic acids, green compounds are Perfluorosulfonic acids, and grey compounds are the remaining PFAS compounds

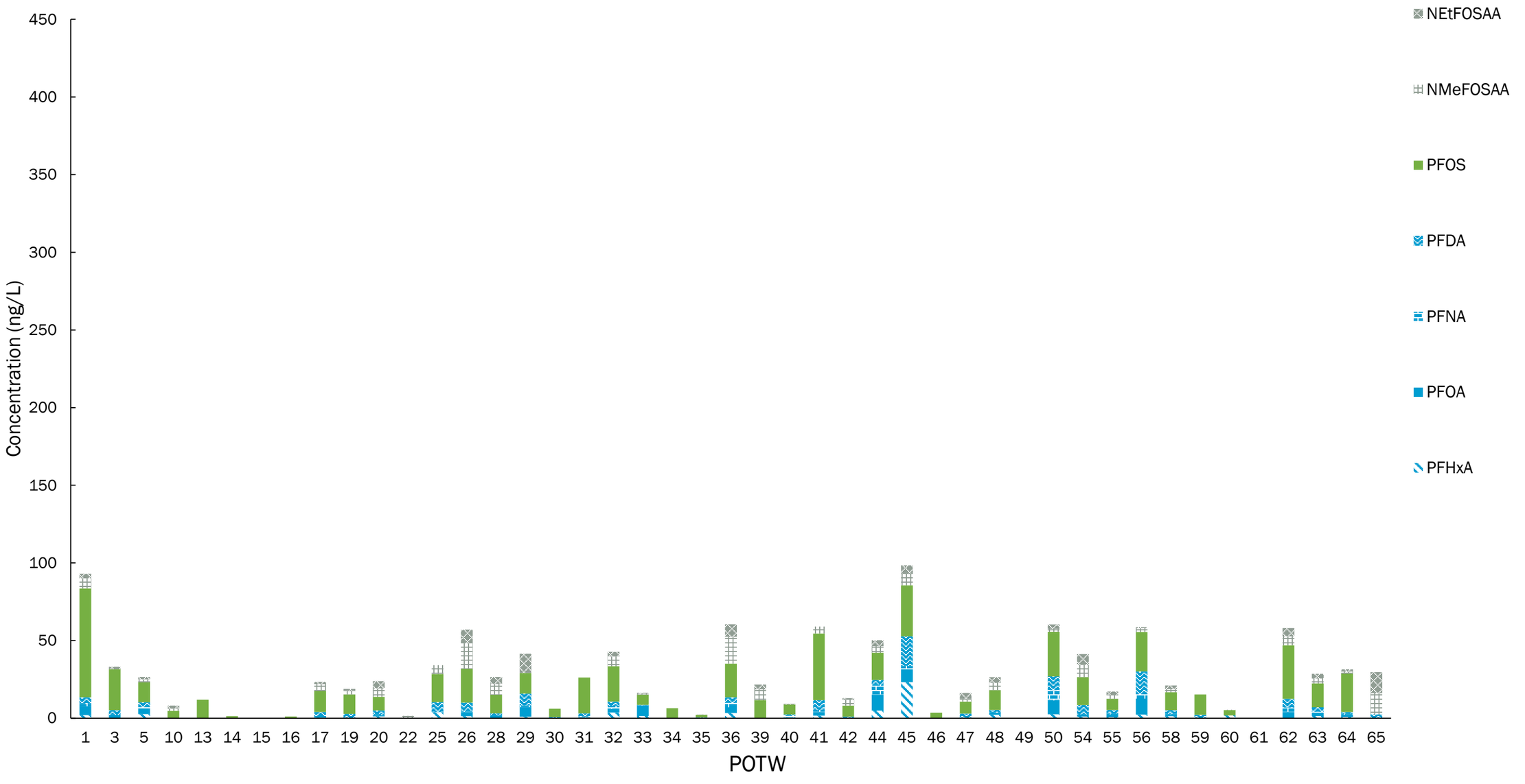


Figure 4-16. Cumulative Average PFAS Mass Concentrations (ng/g, dry) for the Seven PFAS Most Frequently Detected in Massachusetts POTW Sludge

Average concentrations shown here include non-detects as 0.

Blue compounds are Perfluoroalkycarboxylic acids, green compounds are Perfluorosulfonic acids, and grey compounds are the remaining PFAS compounds

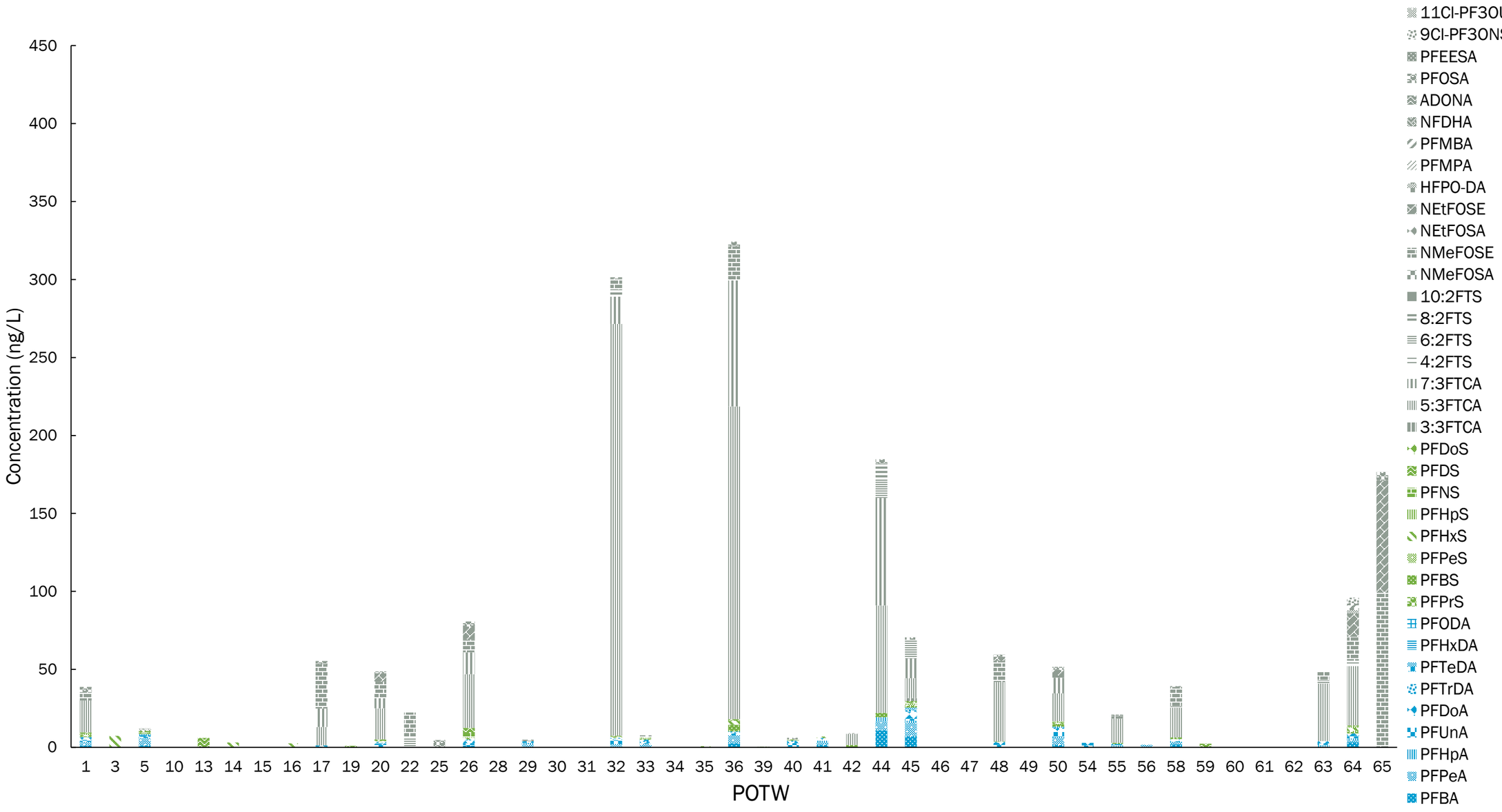


Figure 4-17. Cumulative Average PFAS Mass Concentrations (ng/g, dry) for the 28 PFAS Least Frequently Detected in Massachusetts POTW Sludge

Average concentrations shown here include non-detects as 0.

Blue compounds are Perfluoroalkycarboxylic acids, green compounds are Perfluorosulfonic acids, and grey compounds are the remaining PFAS compounds

4.3.2 Analysis of PFAS Loadings from Specific Sources

One of the first questions that comes to mind in evaluating PFAS in various wastewater streams is, "where is it coming from?" Existing data, while sparse, offer some insights. This section describes what Massachusetts POTWs can learn so far from the limited data gathered to date, supplemented by literature review and interviews with practitioners and researchers. As more data are collected from more sources, additional trends may become evident.

Regulatory Authority for Source Control

EPA's NPDES program protects water quality by authorizing regional, state, and local authorities to perform permitting, administrative, and enforcement tasks for discharges to POTWs (USEPA, 2011). The IPP prevents the discharge of pollutants to POTWs which could interfere with the POTW's operations, use or disposal of municipal sludge, or pass through the POTW, polluting water bodies that receive POTW discharges, as defined in 40 CFR Part 403 (Code of Federal Regulations, n.d. & USEPA, 2016a). EPA Region 1 directly implements and enforces the IPP in Massachusetts.

Under these regulations, individual POTWs have the authority to regulate individual sewer users and to impose monitoring, reporting, and pretreatment requirements on those users such that the users do not adversely affect the POTW's ability to meet its permitted discharge limits or the ability of the plant to dispose of or reuse wastewater sludge. It is through this authority that jurisdictions throughout the country, including Minnesota, Wisconsin, Michigan, South Carolina, and Maryland, have begun using source control as a means of reducing wastewater PFAS levels (Michigan's program is described in Section 1.3.1).

Industrial and commercial sources

Overview of Sources Included

Table 4-10 provides a breakdown of the categories of industries in Massachusetts for which data have been evaluated in this report, as described in Section 4.2.1.

Table 4-10. Summary of Industrial Sampling Data		
Category		Number of Companies Analyzed
Centralized Waste Treaters[1]		1
Commercial Car Wash		2
Landfill Leachate		2
Manufacturers of Parts with Polytetrafluoroethylene (PTFE) or Teflon Type Coatings		2
Platers/Metal Finishers		14
Tanneries and Leather/Fabric/Carpet Treaters		1
Other (52 total)	Ceramics and Plastics	4
	Drinking Water Treatment Residuals	8
	Electronics Manufacturing	12
	Food	7
	Laundering	4
	Medical/Pharma	7
	MSW to Energy	2
	Power Plants	1
	Soaps	1
	Specialty Manufacturing	5
	Textiles	1
	Colorant Manufacturing	1
	Printing	1
	Paper	2
	Packaging	1

1. *Defined as a facility that processes waste products that are challenging to dispose of otherwise, such as restaurant grease or household hazardous waste.*

PFAS Compositions for Specific Source Categories

Nonparametric statistical analyses discussed at the beginning of section 3.1 include 54 samples from a variety of industrial users discharging to four POTWs and three individual industrial NPDES permit-holders. Figure 4-18 shows the same data as in Figure 4-10, but industrial effluent data are grouped by type of industry, while POTW influent, effluent, and sludge data are shown as small grey symbols for reference. Industries with fewer than three samples are grouped together as "other."

Results indicate that different types of industries have significantly different PFAS compositions (overall PERMANOVA, p=0.005). Although non-constant dispersion among data from different types of industries precludes testing for significant differences by pairwise PERMANOVA, Figure 4-18 suggests that several types of industry may have distinct "PFAS profiles." For example, landfill leachate, specialty manufacturing, and drinking water residuals samples form clusters distinct from other industry samples. It is particularly interesting that samples from these industries, especially

landfill leachate, are associated with PFAS that accumulate in POTW sludge (e.g., PFOA). However, given the scarcity of data from relatively few industrial dischargers and only a handful of POTWs, further examination of industrial land use trends and substantially more monitoring data industrial users is required to fully elucidate factors driving these differences. In fact, landfill leachate samples were only provided from one POTW, and only one specialty manufacturer is included in the dataset. The specific "specialty manufacturing PFAS profile" shown here is therefore unlikely to be characteristic of other specialty manufacturers, although this result does suggest that manufacturers that do not fit into other designated categories, "specialty manufacturers," may warrant additional monitoring.

Figure 4-19 through Figure 4-33 show average concentrations of PFAS for 16 different industrial categories. Categorization of industries provides a means to observe data such that POTWs can prioritize individual dischargers within their collection systems while investigating potential source reduction opportunities. Landfill leachate (Figure 4-26) is the only category of the 15 shown that shows average concentrations of several PFAS in the range of 50-350 ng/L. The species detected in leachate were very similar to the species measured from landfill leachate in VT, although the concentrations in VT were as much as an order of magnitude higher than the results shown in Figure 4-26. Direct comparison of concentrations, however, is not appropriate because of the lack of information on from where and how each sample was collected. For example, samples from an open landfill are much more likely to be diluted by rainwater than leachate from a closed and capped landfill.

Landfill leachate is one of multiple waste streams periodically hauled to some POTWs for treatment. Hauled-in wastes treated by POTWs can also include septage, discussed below as residential sewage; fats, oils, and grease; sewer grit; brewery waste; farm waste; and more. To our knowledge, there is no information available for how these types of waste might contribute to PFAS loading at POTWs. However, these wastes typically contain high concentrations of organic (semi-)solids and could therefore contribute to increased concentrations of PFAS that tend to accumulate in POTWs' sludge.

Figure 4-33 shows an average concentration of 2,450 ng/L of PFBS (average of two samples) from a single tannery, indicating that source control would probably effectively reduce influent loading of PFBS from this industry, depending on the typical flow rate from that industry.

Other industrial categories show some individual PFAS with average concentrations in the 20–100 ng/L range. The potential for concentrations in this range to impact POTW influent depends on the mass loading from the individual discharger as compared to the mass loading in the POTW influent. Mass loading evaluations are essential in considering the potential effectiveness of source control, discussed further in the case studies included in Section 4.3.3.

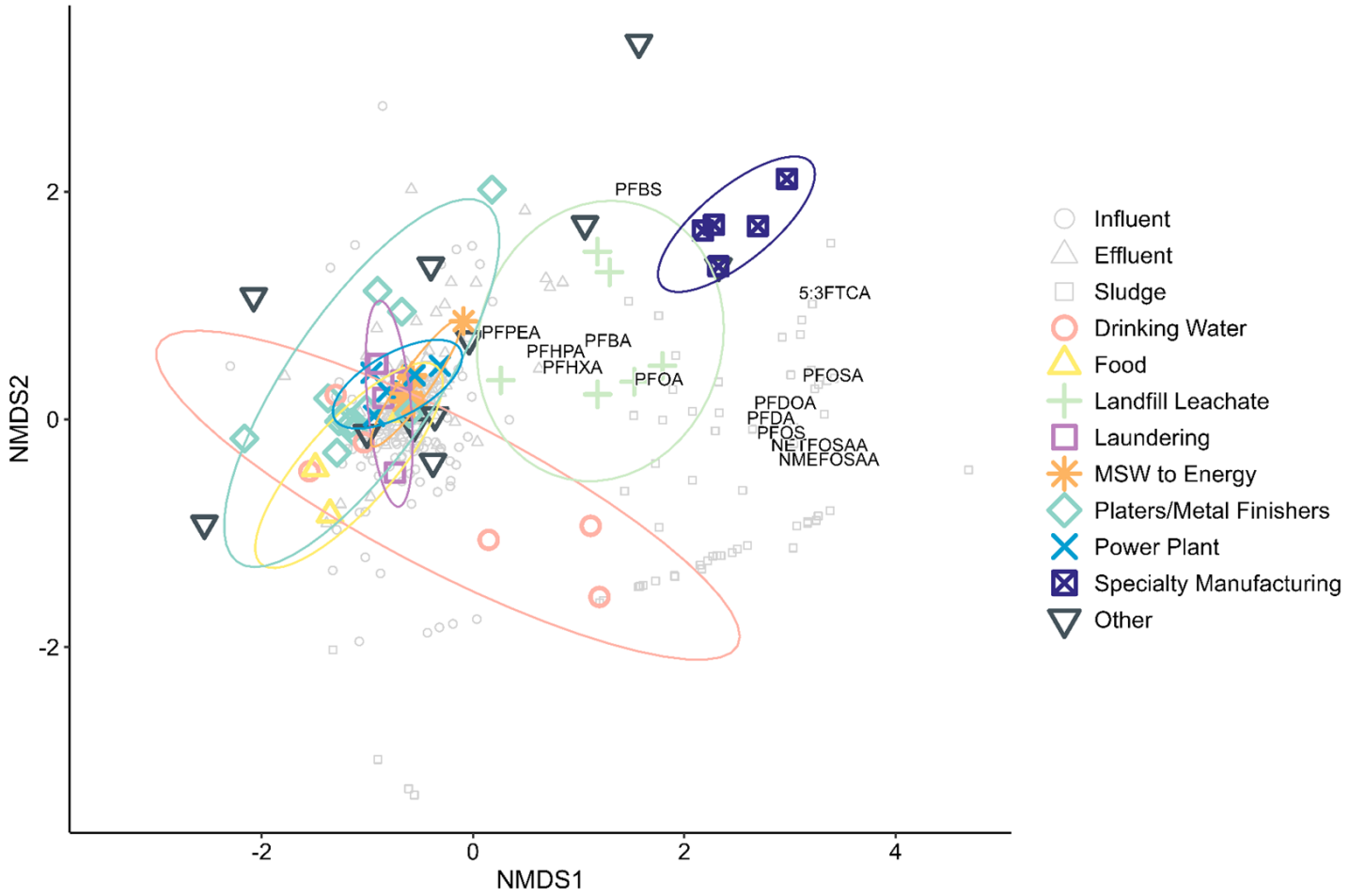


Figure 4-18. NMDS Plot of POTW and Industrial Users' PFAS Molar Concentrations (µmol/g) by Industry Type

Industry types cannot be statistically compared due to a lack of data and non-constant dispersion, but several industries exhibit distinct "PFAS profiles" by forming clusters (e.g., landfill leachate). Note: The distance between two points represents how (dis)similar those samples are based on their PFAS compositions. PFAS with concentrations significantly correlated with either axis ($p<0.05$) are shown for moderate-to-strong correlations (Spearman's $\rho \geq 0.3$), although vectors from the origin have been omitted for clarity. The NMDS algorithm converged on a two-dimensional solution in 436 iterations with a stress of 0.13. The NMDS algorithm converged on a two-dimensional solution in 133 iterations with a stress of 0.13, indicating an acceptable fit.

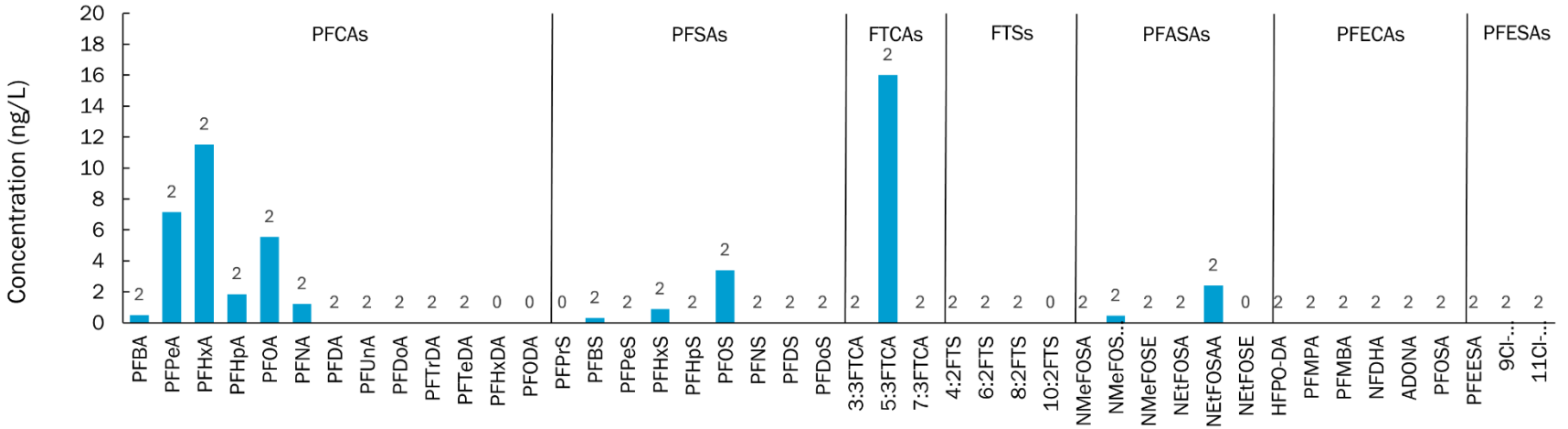


Figure 4-19. Average PFAS Concentrations for Centralized Waste Treaters

Numbers above the bars indicate the n-value, the total number of samples collected and measured for each compound including non-detects as 0

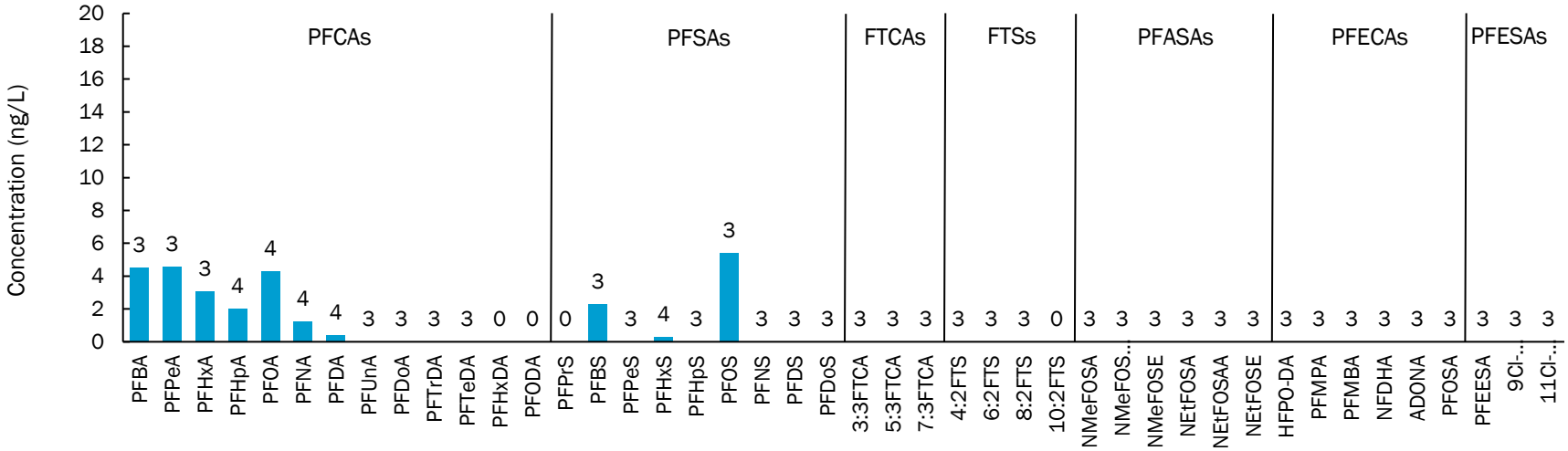


Figure 4-20. Average PFAS Concentrations for Ceramics and Plastics

Numbers above the bars indicate the n-value, the total number of samples collected and measured for each compound including non-detects as 0

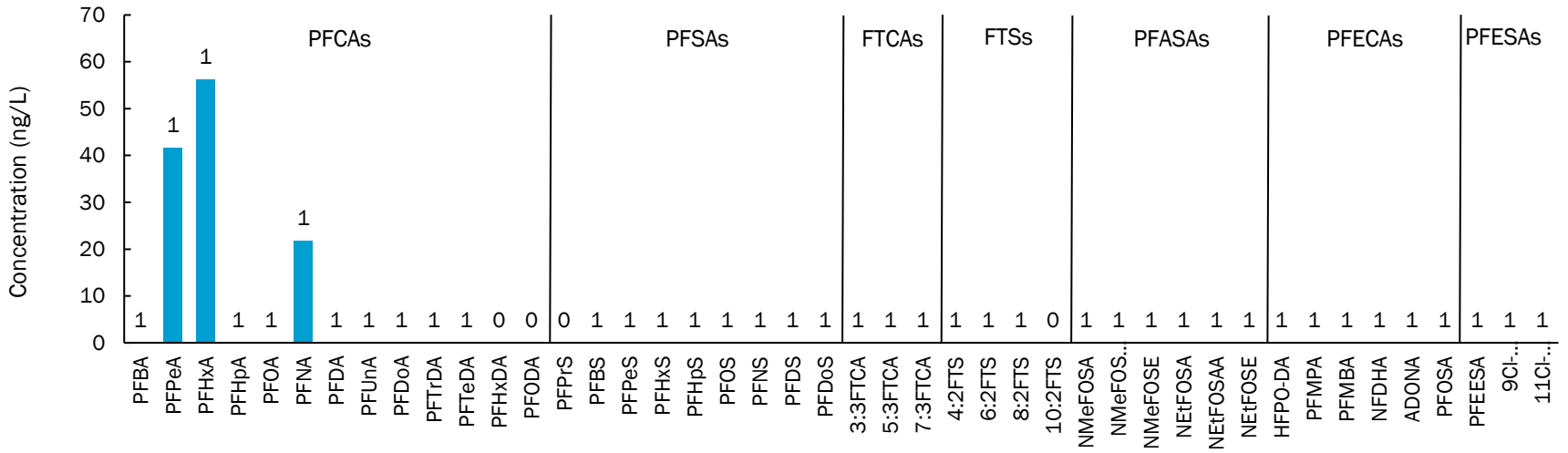


Figure 4-21. Average PFAS Concentrations for Coloring Manufacturing

Numbers above the bars indicate the n-value, the total number of samples collected and measured for each compound including non-detects as 0

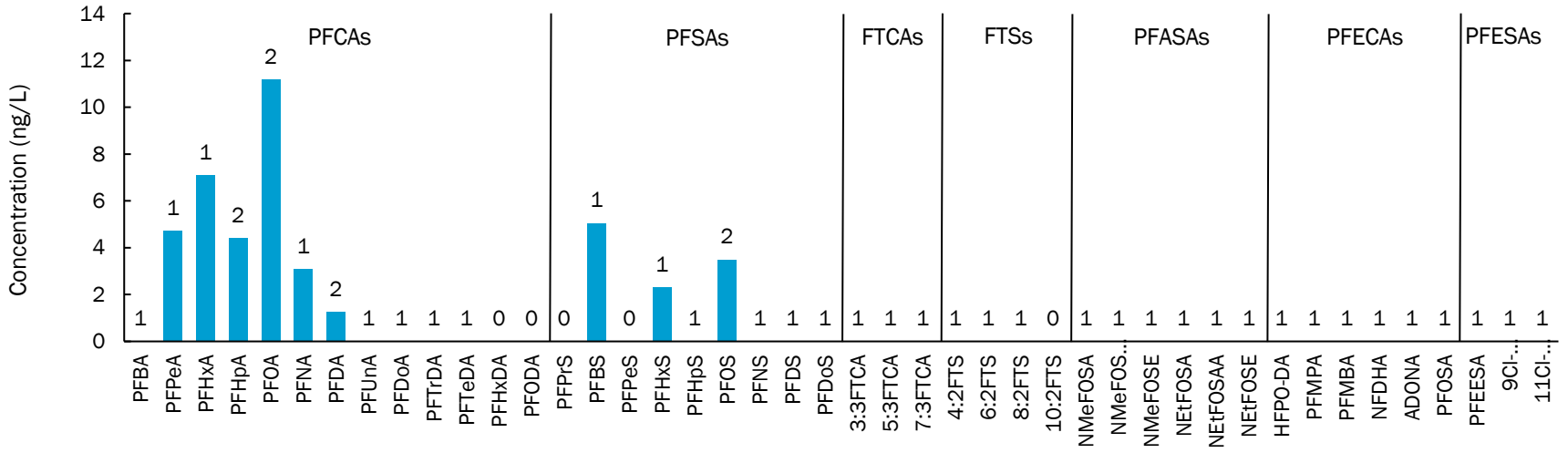


Figure 4-22. Average PFAS Concentrations for Commercial Car Washes

Numbers above the bars indicate the n-value, the total number of samples collected and measured for each compound including non-detects as 0

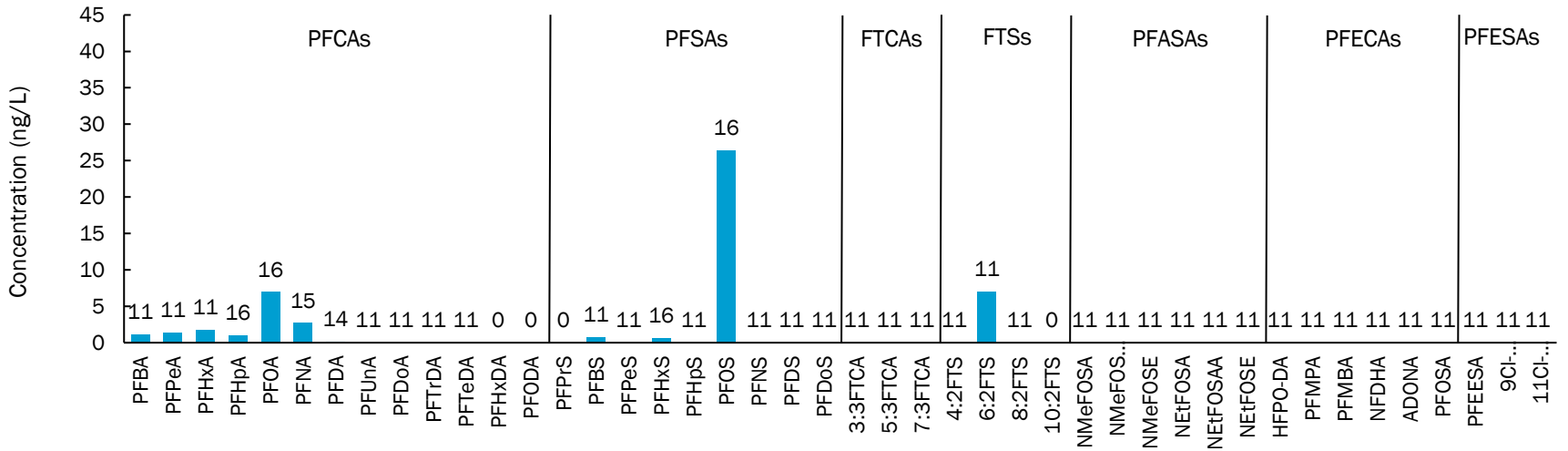


Figure 4-23. Average PFAS Concentrations for Drinking Water Treatment Residuals

Numbers above the bars indicate the n-value, the total number of samples collected and measured for each compound including non-detects as 0

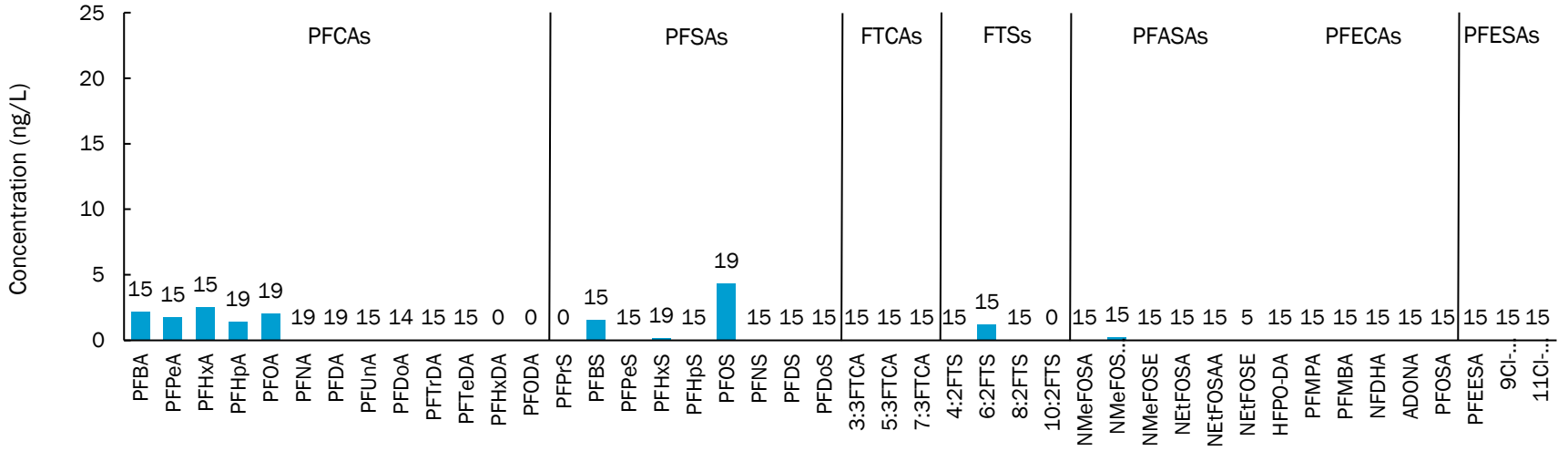


Figure 4-24. Average PFAS Concentrations for Electronics

Numbers above the bars indicate the n-value, the total number of samples collected and measured for each compound including non-detects as 0

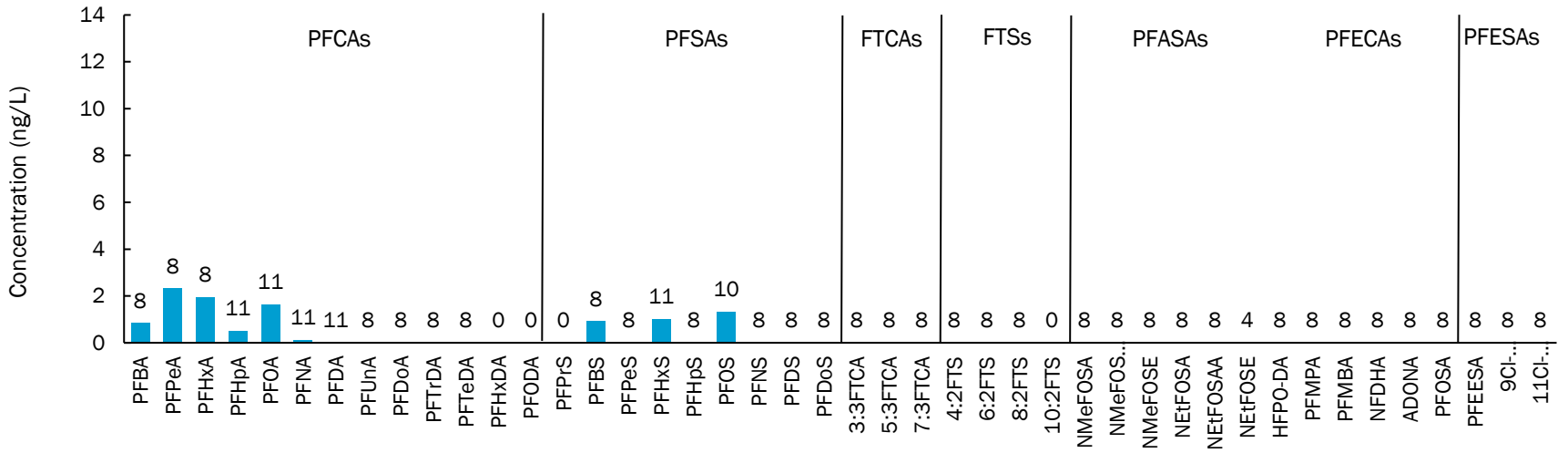


Figure 4-25. Average PFAS Concentrations for Food

Numbers above the bars indicate the n-value, the total number of samples collected and measured for each compound including non-detects as 0

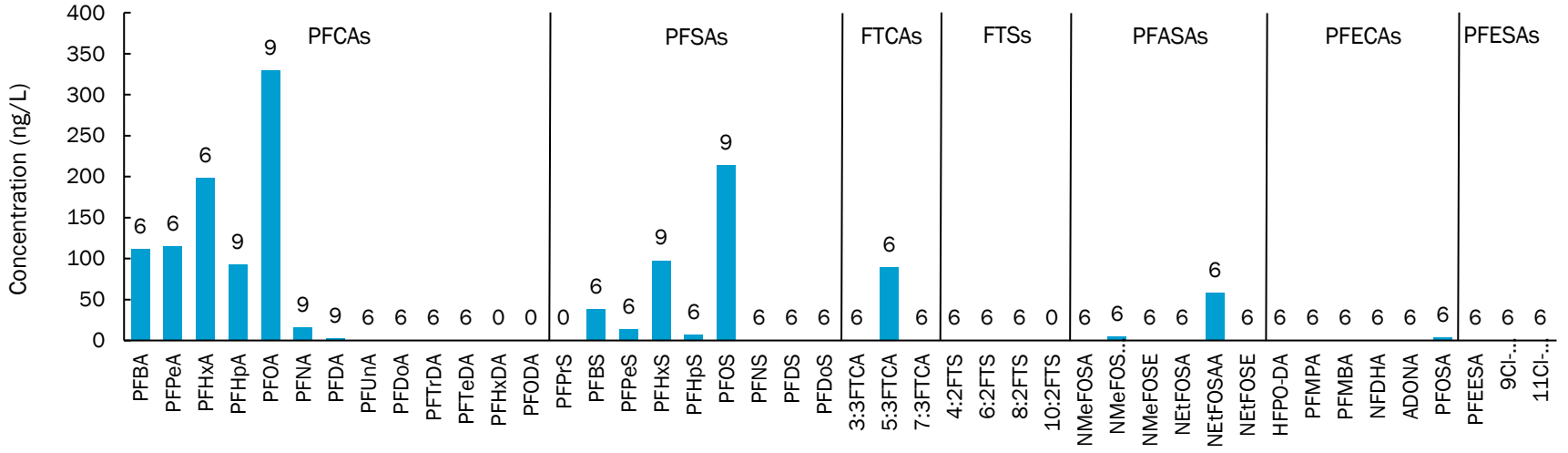


Figure 4-26. Average PFAS Concentrations for Landfill Leachate

Numbers above the bars indicate the n-value, the total number of samples collected and measured for each compound including non-detects as 0

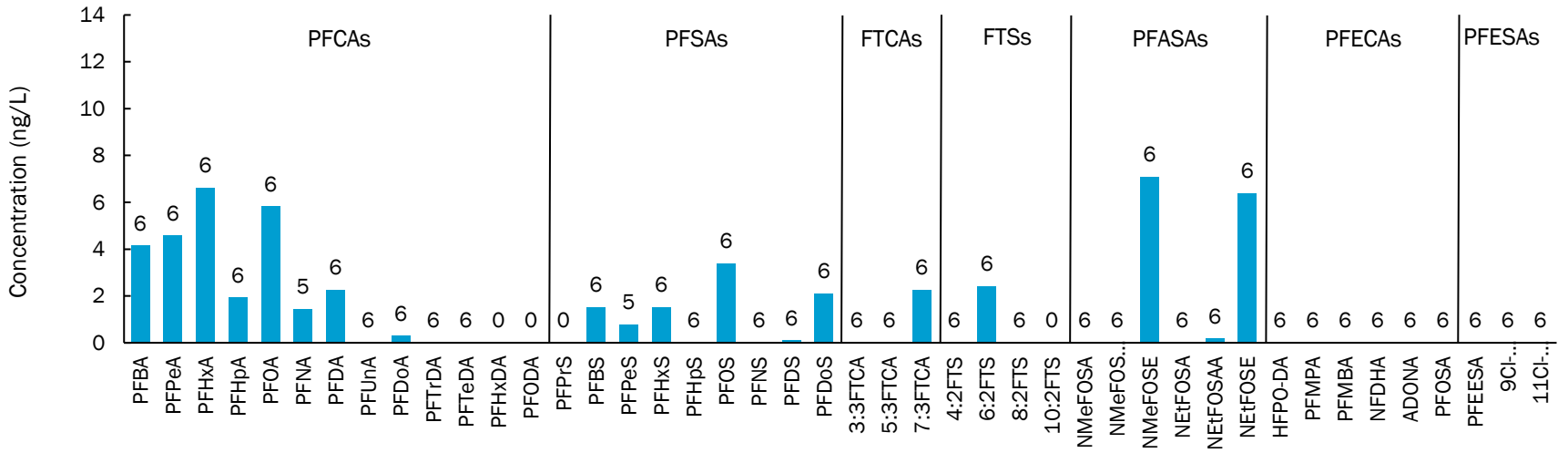


Figure 4-27. Average PFAS Concentrations for Laundering

Numbers above the bars indicate the n-value, the total number of samples collected and measured for each compound including non-detects as 0

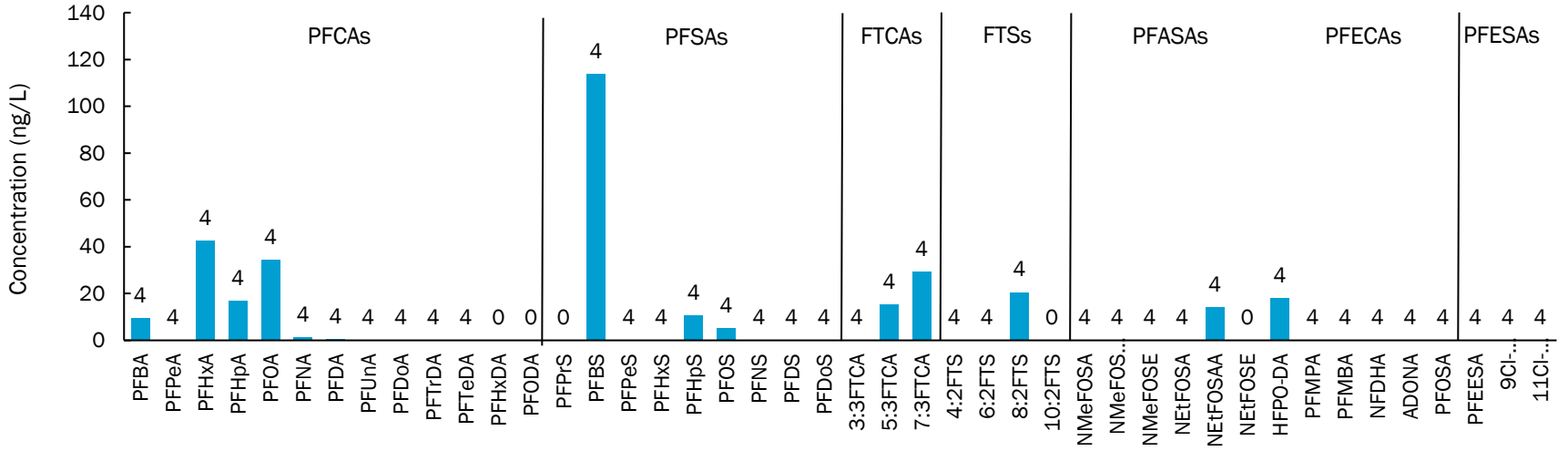


Figure 4-28. Average PFAS Concentrations for Manufacturers of Parts with Polytetrafluoroethylene (PTFE) or Teflon-type coatings

Numbers above the bars indicate the n-value, the total number of samples collected and measured for each compound including non-detects as 0

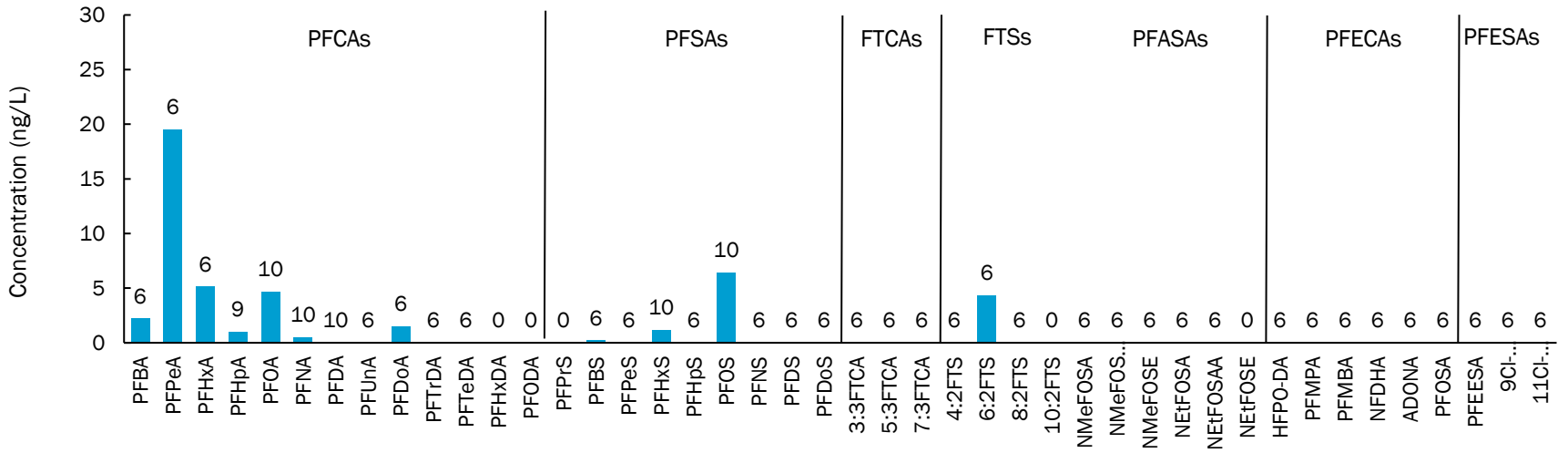


Figure 4-29. Average PFAS Concentrations for Medical/Pharma

Numbers above the bars indicate the n-value, the total number of samples collected and measured for each compound including non-detects as 0

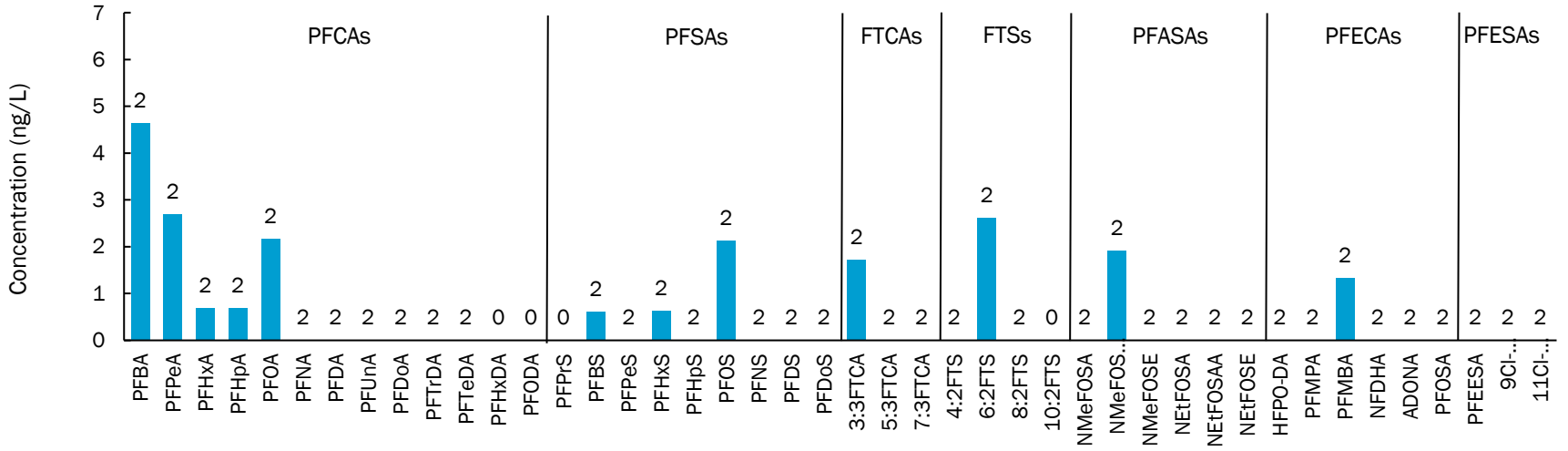


Figure 4-30. Average PFAS Concentrations for Paper

Numbers above the bars indicate the n-value, the total number of samples collected and measured for each compound including non-detects as 0

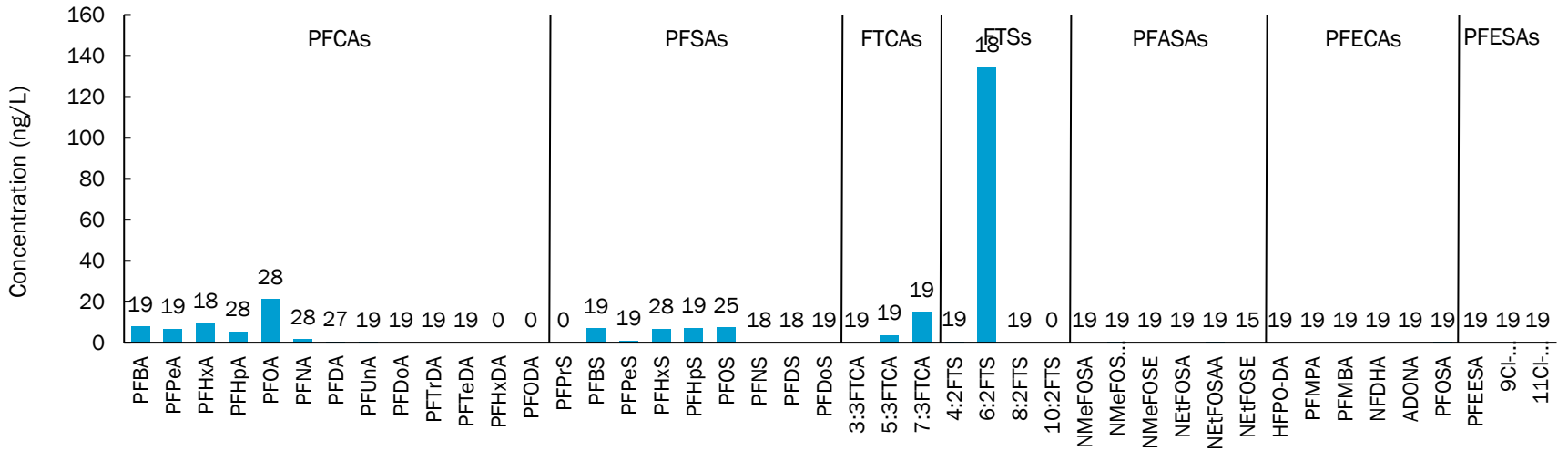


Figure 4-31. Average PFAS Concentrations for Platers/Metal Finishers

Numbers above the bars indicate the n-value, the total number of samples collected and measured for each compound including non-detects as 0

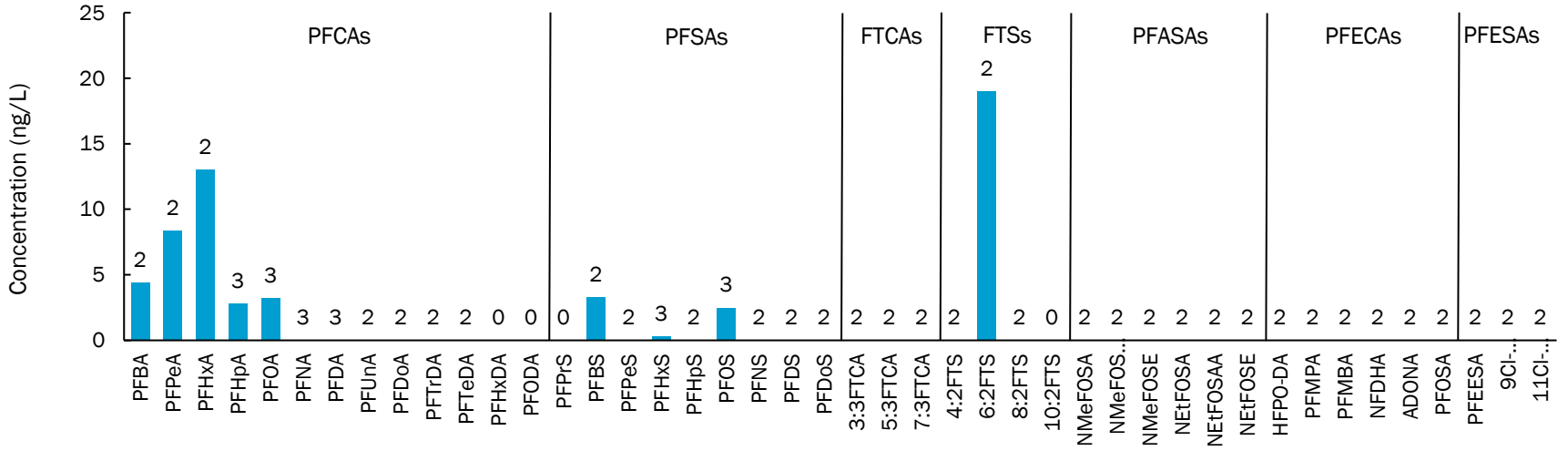


Figure 4-32. Average PFAS Concentrations for Power Plant

Numbers above the bars indicate the n-value, the total number of samples collected and measured for each compound including non-detects as 0

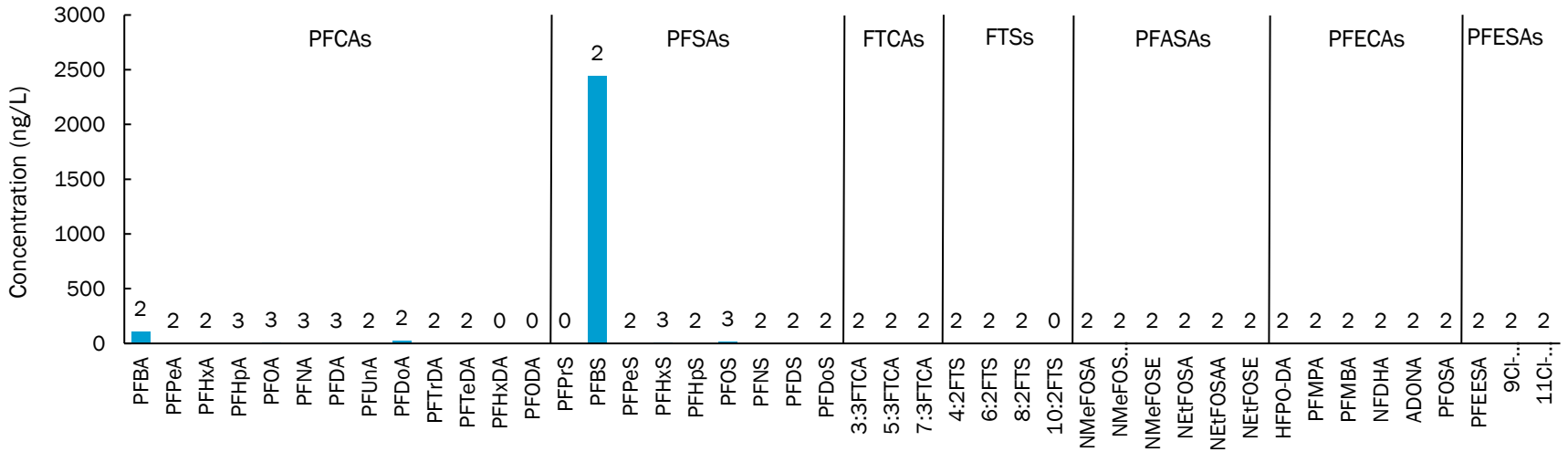


Figure 4-33. Average PFAS Concentrations for Tanneries and Leather/Fabric/Carpet Treaters

Numbers above the bars indicate the n-value, the total number of samples collected and measured for each compound including non-detects as 0

Residential Sewage

It is well-documented that PFAS exist in many common household products, textiles, and even food. Therefore, it is expected that residential sewage will contain PFAS, yet more data collection from residential-only portions of the collection system is needed to better understand residential PFAS load. The few case studies included in Section 4.3.3. for which specific residential or commercial data are available show that domestic PFAS loading represents more than half of the mass PFAS load to the POTW influent. These observations align with previous VTDEC studies, discussed in Section 4.1.3, which concluded that the mass of PFAS measured in wastewater originating from residential communities was as great or greater than that from commercial or industrial discharges in these municipalities.

To further examine residential contributions of PFAS to POTWs, the PFAS mass concentration dataset was filtered to include samples from POTWs with 'primarily domestic' PFAS loading. This subset of data includes POTWs without IPPs for which all of the following criteria are also met based on the land use analysis, discussed further in Appendix G: less than 5% of sewershed land is classified for industrial or commercial use, less than 10% of sewershed land is classified for multi-use, and greater than 50% of sewershed land is classified for residential use. This subset of PFAS samples were assessed with respect to PFAS averaged to generate a "typical domestic" concentration and speciation. Limitations and uncertainties in this analysis include the potential impacts of historical industrial PFAS sources and system inputs related to external sources in the watersheds such as AFFF use.

Additionally, a separate "typical septage" concentration and speciation was calculated by averaging seven samples collected from septic tank pump-outs from two central Massachusetts municipalities. However, septage is expected to have different characteristics than typical domestic, municipal sewage, due to long residence time.

Finally, POTW 57 provided data from a sample collection program undertaken to compare PFAS among samples of POTW influent, POTW influent combined with landfill leachate, POTW influent combined with septage, POTW influent combined with both septage and landfill leachate, and two manholes in primarily residential areas in the sewershed.

These data on domestic sewage, septage, and POTW 57-specific "influent," "influent+," and domestic PFAS profiles are compared in Figure 4-34. Figure 4-34 shows that, for the limited data available, domestic PFAS concentrations are lower for the detected species than any of the combined influent concentrations and the influent only samples. This observation suggests that wastewater discharges from commercial and industrial sources may drive PFAS loading at POTWs in some cases; however, the limited data cautions against overinterpretation of this result. More data are required to determine the extent and variability of domestic loading, and future studies should include targeted manhole sampling and septage sampling.

Large scale septage sampling has not yet been performed in Massachusetts, and our compiled dataset includes only seven septage samples. The Study for Sustainable Management of Wastewater Solids, Septage & Leachate in the State of Maine technical memorandum, prepared by Brown and Caldwell (2023), reports PFOS and PFOA concentrations from 13 septage samples. Figure 4-35 compares the respective septage averages for both data sets as well as the maximum and minimum sampled concentration. Additional sampling of septage is needed and would be informative about the range and typical concentrations of PFOS, PFOA and other PFAS in sewage attributable to domestic sources.

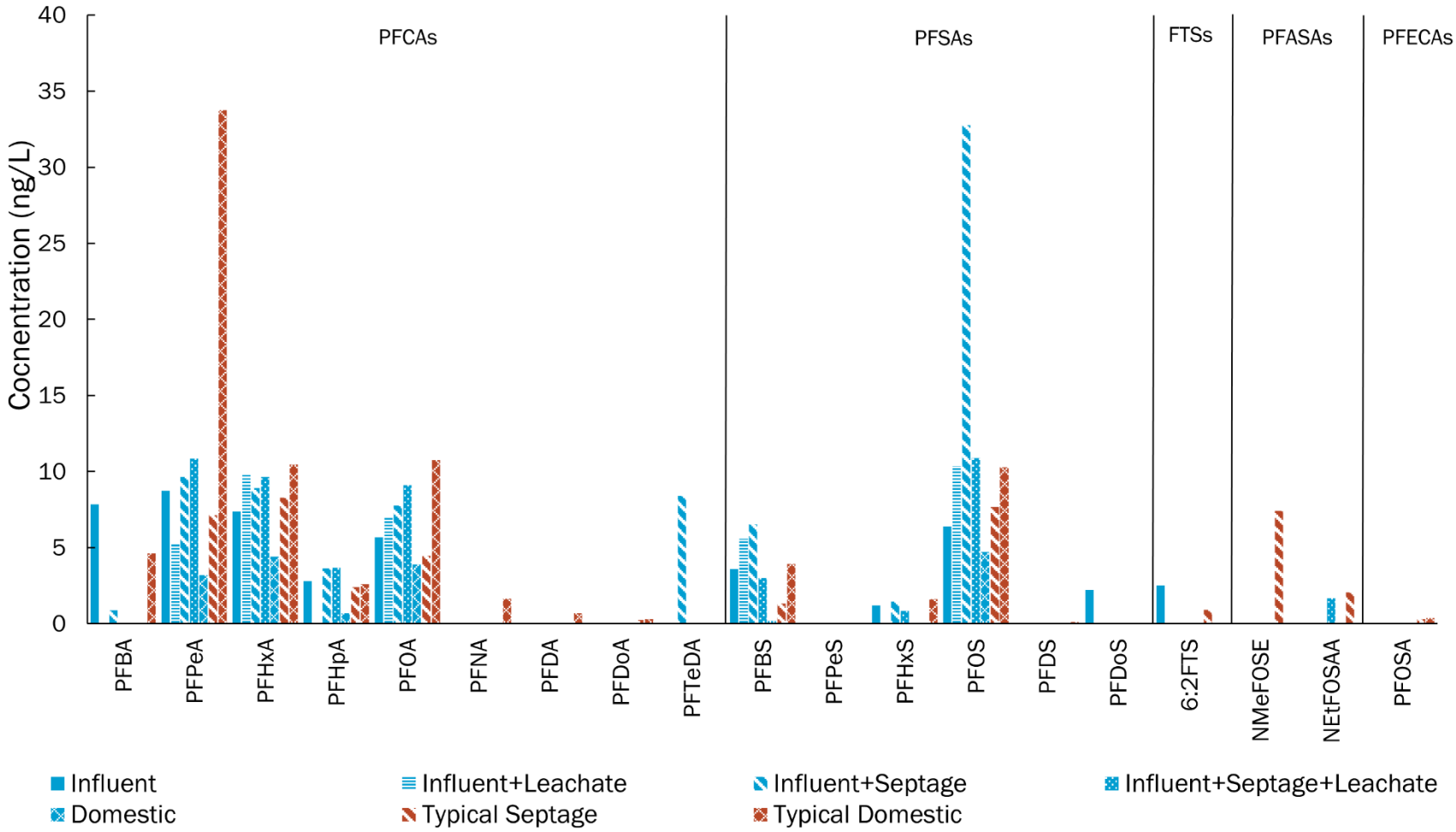


Figure 4-34. Average Influent Concentrations Separated by Influent Sources

PFAS not detected in samples from media shown in this figure were omitted for clarity: PFUnA, PFTrDA, PFHxDA, PFODA, PFPrS, PFHpS, PFNS, 3:3FTCA, 5:3FTCA, 7:3FTCA, 4:2FTS, 8:2FTS, 10:2FTS, NMeFOSA, NMeFOSAA, NEtFOSA, NEtFOSE, HFPO-DA, PFMPA, PFMBA, NFDHA, ADONA, PFEESA, 9Cl-PF3OUdS, and 11Cl-PF3OUdS.

Table 4-11. Comparison of Massachusetts and Maine Septage Concentrations				
	Massachusetts		Maine	
	PFOS	PFOA	PFOS	PFOA
# Samples	7		13	
# Non-Detects[1]	4	2	5	7
Arithmetic Mean (ng/L)	17.9	6.3	16.0	11.0
Range (ng/L)	ND[2] – 35.3	ND[2] – 16.5	ND[3] – 70.8	ND[3] – 49.6

1. *Non-detects (ND) were defined as equal to zero in the calculation of summary statistics.*
2. *The minimum reported PFOS concentration was 7.0 ng/L, and the minimum reported PFOA concentration was 0.8 ng/L. The average method detection limit (MDL) for PFOA was 2.9 ng/L, and the average MDL for PFOS was 3.0 ng/L, although MDLs were not available for five samples.*
3. *The minimum reported PFOS concentration was 1.2 ng/L, and the minimum reported PFOA concentration was 0.8 ng/L; MDLs were not available (Brown and Caldwell, 2023).*

4.3.3 POTW Case Studies

Detailed analyses of PFAS contributions to POTWs were conducted for thirteen individual POTWs. (Table 4-12). summarizes general characteristics of the representative thirteen POTWs based on the selection criteria described in Section 4.2.4.

PFAS data for each plant are presented and evaluated to the extent possible given the very limited dataset (the number of sampling events for each POTW and each industry is typically 4 or less) that exists at the time of writing. Therefore, readers must recognize that the observations made below are limited and could change as new data are gathered. Other limitations to the data include characteristics inherent to the sampling schema. EPA Method 1633, the laboratory analytical method specified by POTW NPDES permits, requires grab samples for PFAS analysis. Therefore, the samples shown are each representative of a single point in time at a single location. As with other characteristics of municipal wastewater (e.g., flow, BOD, etc.), PFAS concentrations likely vary over days, weeks, and seasons. Grab samples may capture a moment in time with abnormally high PFAS concentrations at a particular location, or, conversely, they could capture abnormally low PFAS concentrations. This is coupled with other confounding factors related to temporal variation for PFAS analyses, including dilution due to I/I, inconsistent flow from industries, inconsistent use of PFAS-containing industrial products within industries, acceptance of septage or other hauled-in waste, intermittent plant recycle such as filter backwashing or dewatering centrate, and potential for sample contamination throughout the analytical pipeline or even from personal products used by sample-handling personnel.

Another major factor confounding analyses for individual POTWs is the possibility of transformation of PFAS from one species into another or partitioning of PFAS into the liquid or solid phase. Transport and transformation may partially explain differences in concentration from the influent to the effluent of the plant for many POTWs. However, specific transport and transformation pathways must be analyzed for each species that changes in concentration.

PFAS can broadly be categorized into precursor species or terminal species. Terminal species are the most stable PFAS and include PFCAs (i.e., PFOA or PFBA) and PFAAs (i.e., PFOS or PFBS). If a PFAA or PFCA is higher in concentration in the influent than the effluent, then it is unlikely – but not impossible – that species transformation would be the cause. Alternatively, if a PFCA or PFAA is higher in the effluent than the influent, then it is possible that that species was formed by

transformation of a precursor. That precursor species may or may not be among those species measured by EPA Method 1633.

Partitioning may also explain the different concentrations observed for species in the influent and effluent. Many PFAS are surfactants, with part of each molecule hydrophobic and part hydrophilic. Depending on the relative strength of the hydrophobic part in comparison to the hydrophilic part, individual PFAS either tend to remain dissolved in the water phase or adsorb to the solid phase. One of the main factors that determines hydrophobicity is chain length; the longer a PFAS' chain length, the more hydrophobic it is, and the more likely it is to accumulate in wastewater sludge.

POTW average flow data from the month during which PFAS monitoring samples were collected were used to calculate influent and effluent mass loading when possible. Total mass concentration of PFAS is commonly defined as the total quantity, in mass, of all individual PFAS in a defined sample volume. Mass loading is calculated by multiplying the resulting total mass concentration by the flow rate of a flow stream. Industrial mass loading was calculated using the average discharge flow rate that the industrial discharger reported in the prior year's self-monitoring report, or, in some cases, based on permitted flow rates. These estimation methods are not sufficient for precise calculations that would allow for the development of a more rigorous mass balance. They do, however, offer insight into whether source reduction efforts would impact POTW influent concentrations.

Table 4-12. Summary of Case Study POTW Characteristics

Region	POTW	PFAS prevalence (mg/day) [ng/L]	Approximate Flow Rate (mgd)	Industrial contribution[1]	Hauled-in waste management	Sludge management in 2023[2]
NE	A	8,429 [70]	32.0	IPP	Septage, food waste	Reuse
	B	225 [74]	0.8		Septage	Reuse
	C	5,240 [53]	26.0	IPP	Septage, sewer cleanings/grit	Incineration, landfill, reuse
SE	D	1,789 [112]	4.2		Septage receiving not in use	Reuse
	E	660 [58]	3.0		Septage	Incineration
Central	F	344 [44]	2.1	IPP	Not Reported	Landfill
	G	345 [83]	1.1		Not Reported	Reuse
	H	5,214 [41]	34.0	IPP	Septage, landfill leachate, other commercial waste	Incineration
	I	1,589 [79]	5.3	IPP	Not Reported	Incineration
	J	216 [71]	0.8		Septage	Incineration
West	K	3 [1.5]	0.6		Septage	Incineration, landfill, reuse
	L	1,130 [186]	1.6	IPP	None	Reuse, co-generation
	M	232 [5.5]	12.0	IPP	Septage	Reuse

1. *"Industrial contribution" here denotes whether a POTW has an EPA-approved industrial pretreatment program.*
2. *"Reuse" here refers to land application and/or land reclamation using biosolids.*

Throughout the case studies, total industrial mass loading was calculated for analysis. This differs from previous analysis which used moles and molar mass to compare among POTWs and media types. A mass basis is used to compare sublocations of PFAS loading to and within particular POTWs and not comparing between them. The total industrial mass loading is calculated by tabulating the average concentration for each PFAS for each industry, multiplying the industrial

flow of the respective industry and a conversion factor, then summing the compound across all industries, according to the following equation:

$$Mass\ loading\left(\frac{mg}{day}\right) = Concentration\left(\frac{ng}{L}\right) \cdot Industrial\ Flow\left(\frac{gallons}{day}\right) \cdot 3.79\left(\frac{L}{gallon}\right) \cdot \frac{1\ mg}{10^6\ ng}$$

An example of how the industrial mass loading was calculated for POTW A for PFBA, PFOA, PFBS, and PFOS is shown below in Table 4-13.

Table 4-13. Example Industrial Mass Loading Calculations

	PFAS Compound Concentration (ng/L)				Industrial Flow (gallons/day)	PFAS Compound Mass Loading (mg/day)			
Industry	PFBA	PFOA	PFBS	PFOS		PFBA	PFOA	PFBS	PFOS
Industry A	2.04	2.11	0.41	1.74	8,000	0.06	0.06	0.01	0.05
Industry B	0.00	0.00	0.00	0.00	125,000	0.00	0.00	0.00	0.00
Industry C	0.00	0.00	0.00	1.63	15,700	0.00	0.00	0.00	0.10
Industry D	0.00	1.47	1.26	0.57	15,700	0.00	0.09	0.07	0.03
Industry E	4.57	3.31	8.29	29.15	11,000	0.19	0.14	0.35	1.22
Industry F	1.13	3.78	1.95	62.00	16,050	0.07	0.23	0.12	3.77
Industry G	0.00	3.20	0.80	1.35	850	0.00	0.01	0.00	0.00
Industry H	8.00	0.00	0.00	0.00	125,000	3.79	0.00	0.00	0.00
Industry I	0.00	0.00	0.00	0.00	1,000	0.00	0.00	0.00	0.00
Industry J	0.78	4.25	0.56	6.40	80,000	0.24	1.29	0.17	1.94
Industry K	0.00	0.00	0.00	0.00	8,760	0.00	0.00	0.00	0.00
Industry L	18.95	61.05	226.47	0.71	6,000	0.43	1.39	5.15	0.02
Industry M	5.80	5.96	0.00	3.58	65,000	1.43	1.47	0.00	0.88
Industry N	3.23	3.32	0.99	1.70	16,667	0.20	0.21	0.06	0.11
Industry O	0.00	3.01	0.83	5.63	35,000	0.00	0.40	0.11	0.75
Industry P	0.50	5.54	0.31	3.40	30,000	0.06	0.63	0.03	0.39
Industry Q	0.00	0.00	0.00	0.00	21,000	0.00	0.00	0.00	0.00
Industry R	6.45	5.51	1.98	3.67	2,800	0.07	0.06	0.02	0.04
Industry S	6.84	4.62	0.00	0.00	20,000	0.52	0.35	0.00	0.00
Industry T	4.25	0.00	0.00	0.00	4,000	0.06	0.00	0.00	0.00
Industry U	2.66	3.63	1.09	1.31	66,000	0.67	0.91	0.27	0.33
Industry V	3.17	8.40	1.78	7.69	110,000	1.32	3.50	0.74	3.20
Industry W	0.00	7.71	1.17	9.94	200	0.00	0.01	0.00	0.01
Industry X	15.25	3.23	0.77	11.95	10,000	0.58	0.12	0.03	0.45
Industry Y	0.00	2.47	0.00	0.00	200,000	0.00	1.87	0.00	0.00
					Total	9.68	12.73	7.15	13.28

POTW A

POTW A provided data from POTW samples that were collected from influent, effluent and some of the 23 industries covered under the facility's IPP. The influent and effluent samples were collected quarterly, five times in two years, starting in 2023. The industrial samples were taken once per year for two years.

Figure 4-35 illustrates the influent and effluent mass loadings of the 20 PFAS of the 44 that were detectable at POTW A and includes the average of five samples (including non-detect values as zeroes). The difference in mass loading between the influent and effluent may suggest transformation within the POTW but warrants further study. The total calculated influent PFAS loading, 8,400 mg/day, is half of the total calculated effluent PFAS mass loading, 15,400 mg/day. Some species (PFBA, PFBS, PFHpS, PFOA, PFPeS, and 6:2FTS) had calculated effluent loads notably higher than influent loads, which suggests that these species may have been formed from the degradation of other PFAS. The decrease in PFOA and PFHpS effluent concentrations could be due to partitioning to solids, as they are considered "long-chain" PFAS. Some species (PFPeA and PFBA) had calculated effluent loads lower than calculated influent loads, suggesting that these species degrade into other forms of PFAS; however, PFBA is a terminal species that is unlikely to degrade.

Figure 4-36 shows the mass loadings of detectable PFAS species from industries that are located within POTW A's collection system. These data represent several individual dischargers representing the following broad classifications: platers/metal finishers, electronics manufacturing, food processing, healthcare facilities, textile manufacturing, and wastewater residuals processing. These data show five species with mass loadings greater than 10 mg/day: PFPeA, PFHxA, PFOA, PFOS, and 6:2 FTS. The mass loading of 6:2FTS is more than two times larger than the next highest load.

The data presented in Figure 4-37 show the mass loading of PFAS to POTW A from industrial sources compared to the mass loading for the entire plant influent. The percentage of the entire plant's influent mass loading that can be attributed to industrial users has also been calculated. 6:2FTS in POTW A influent appears to be entirely from industrial source; percent industrial contribution is over 100% of influent mass loading. PFDA has the next highest industrial percent contribution at 9%, with all other percentages less than 2%. 6:2FTS and PFDA were found primarily in medical/pharmaceutical and metal finishing industries. Therefore, industrial loading from these industry groups comprises a substantial PFAS load to POTW A, indicating that removal of this species from the industrial load will likely reduce influent load. However, the low percent contributions from industrial users for the remaining species indicate that pretreatment of any or all industrial sources would only slightly decrease plant influent PFAS. The low industrial percent contributions imply that the other PFAS instead come from moderate-to-low concentrations from a large number of sources rather than from specific industrial users, demonstrating that PFAS are ubiquitous and therefore part of the waste from every sewer user, or very high concentrations from another individual source that has yet to be identified and sampled.

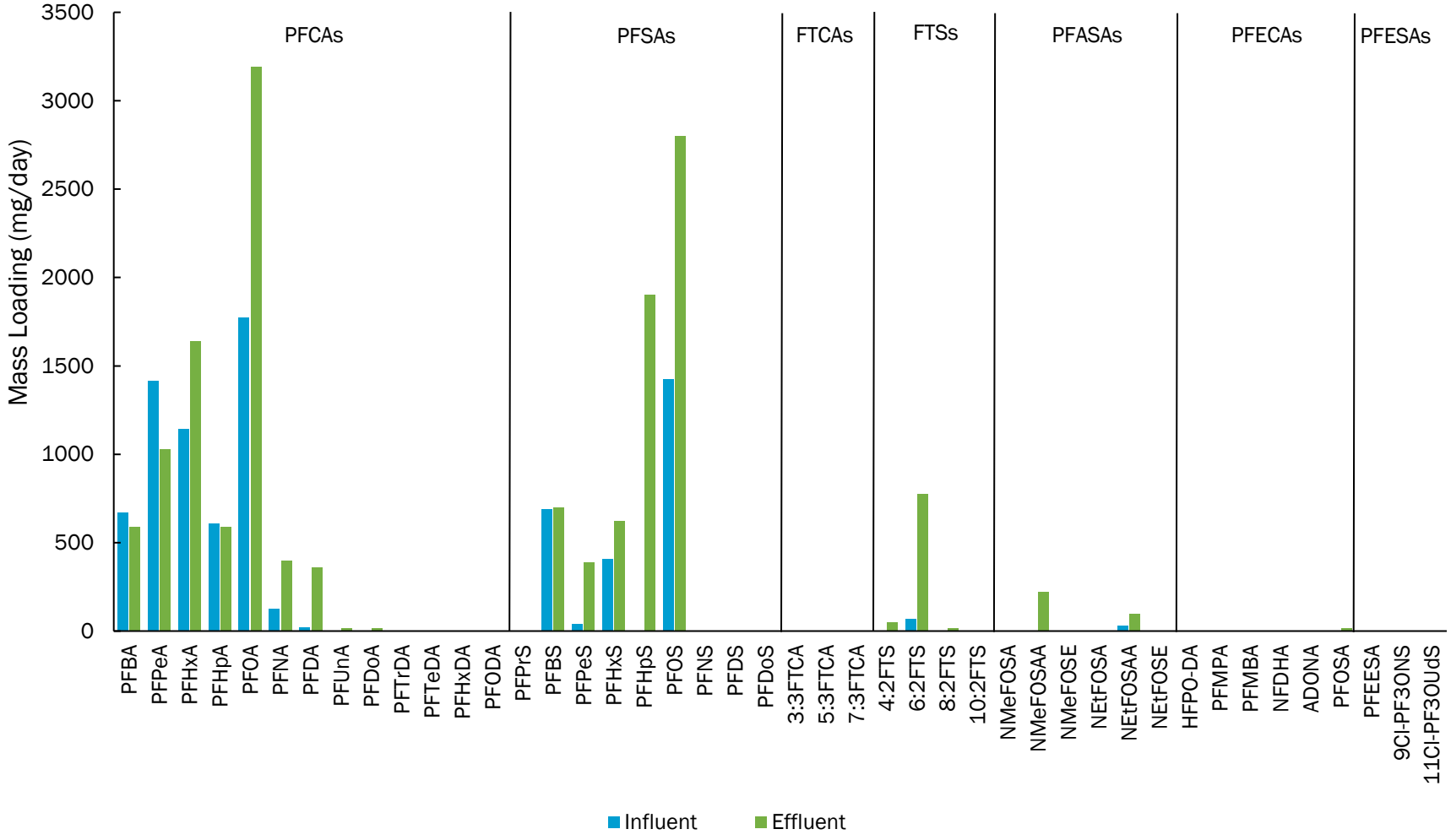


Figure 4-35. Influent and Effluent PFAS Mass Loading for POTW A

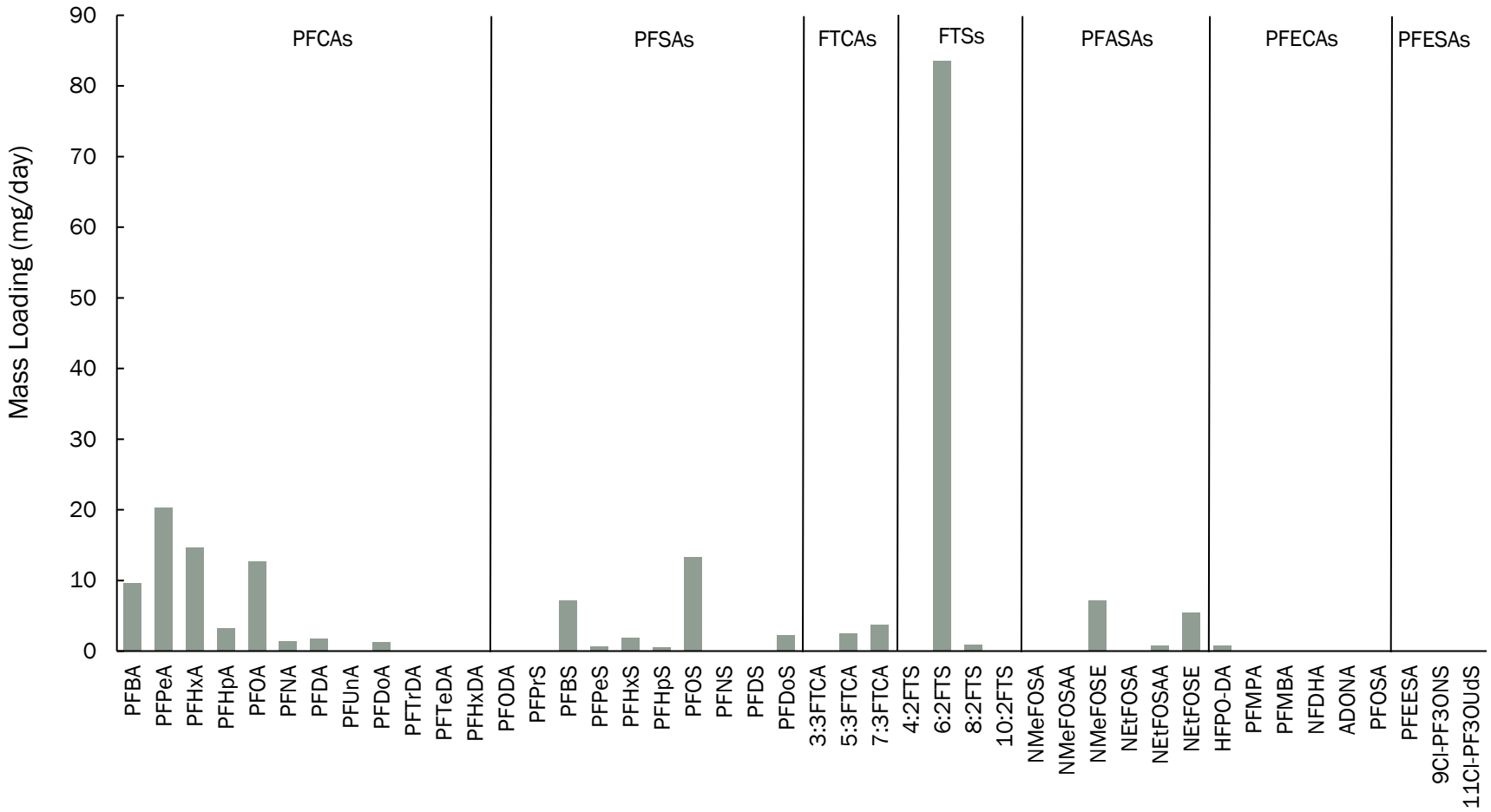


Figure 4-36. Mass Loading of PFAS from Industrial Sources for POTW A's Sewershed

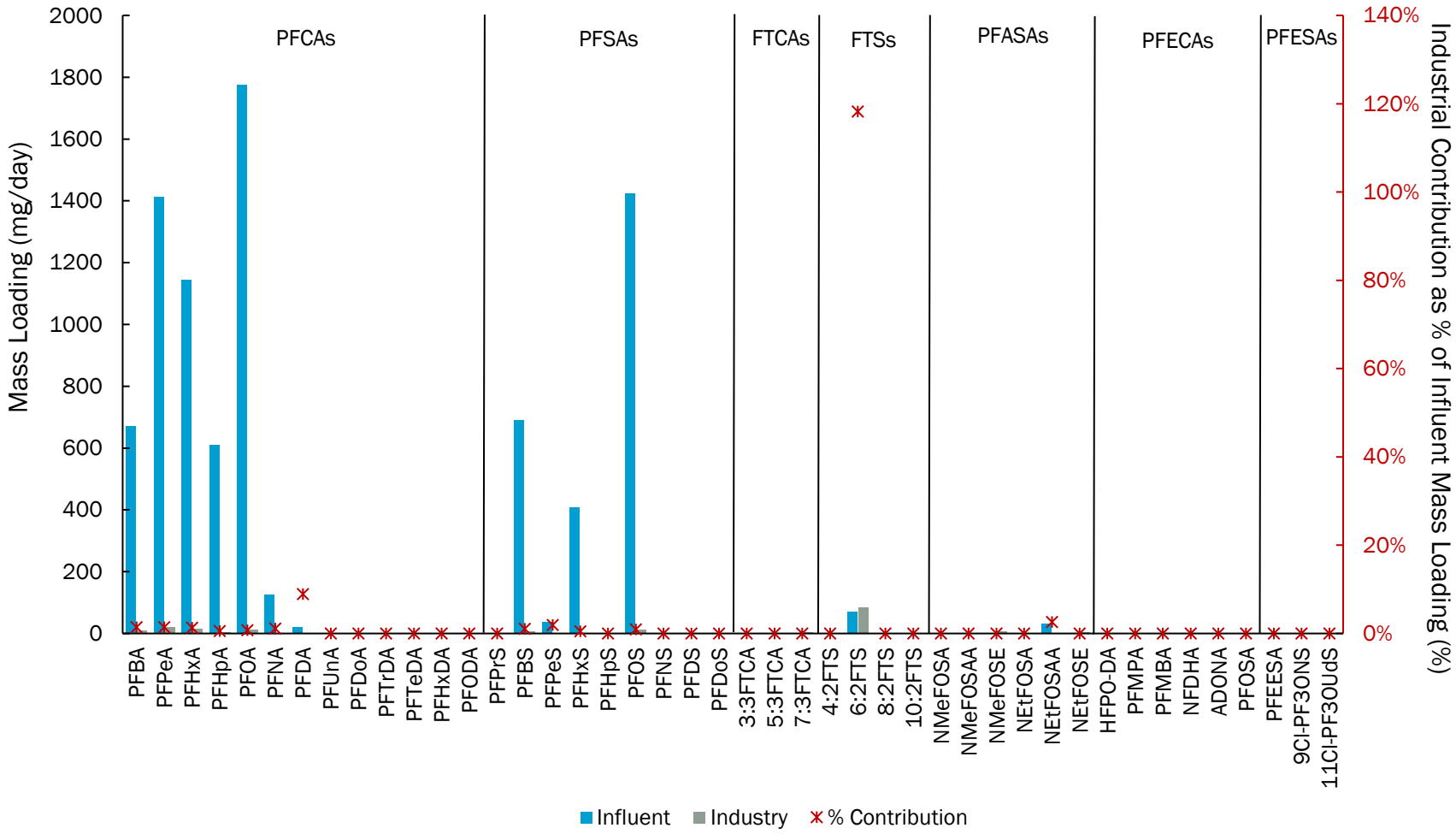


Figure 4-37. Identified Industrial and Influent Mass Loading to POTW A Presented with the Percent Contribution from Industrial Sources to the Facility Influent

POTW B

POTW B provided data from POTW influent and effluent samples. POTW B does not have an IPP, so no industrial data were collected. The influent and effluent samples were collected quarterly for two years starting in 2023.

Figure 4-38 illustrates the influent and effluent mass loadings of the fourteen PFAS species that were detected at POTW B. The difference in mass loading between the influent and effluent may indicate transformation within the POTW but warrants further study. The total average influent and effluent load of PFAS appears comparable (211 mg/day influent, 270 mg/day effluent), although data are insufficient for statistical comparison. This likely conservation of mass within the liquid stream implies that species transformation may have occurred. Some species (PFHxA, PFNA, PFOA, and PFPeA) had calculated effluent loads higher than influent loads, while some species (PFBA, PFBS, PFHxS, and PFOS) had calculated effluent loads lower than the influent loads. The PFCA group tended to have higher effluent than influent concentrations, whereas the PFSA group tended to have higher influent than effluent concentrations. Further study is required to understand these differences. There is a possibility that these species degrade into other forms of PFAS; however, PFSAs and PFCAs are both considered terminal species.

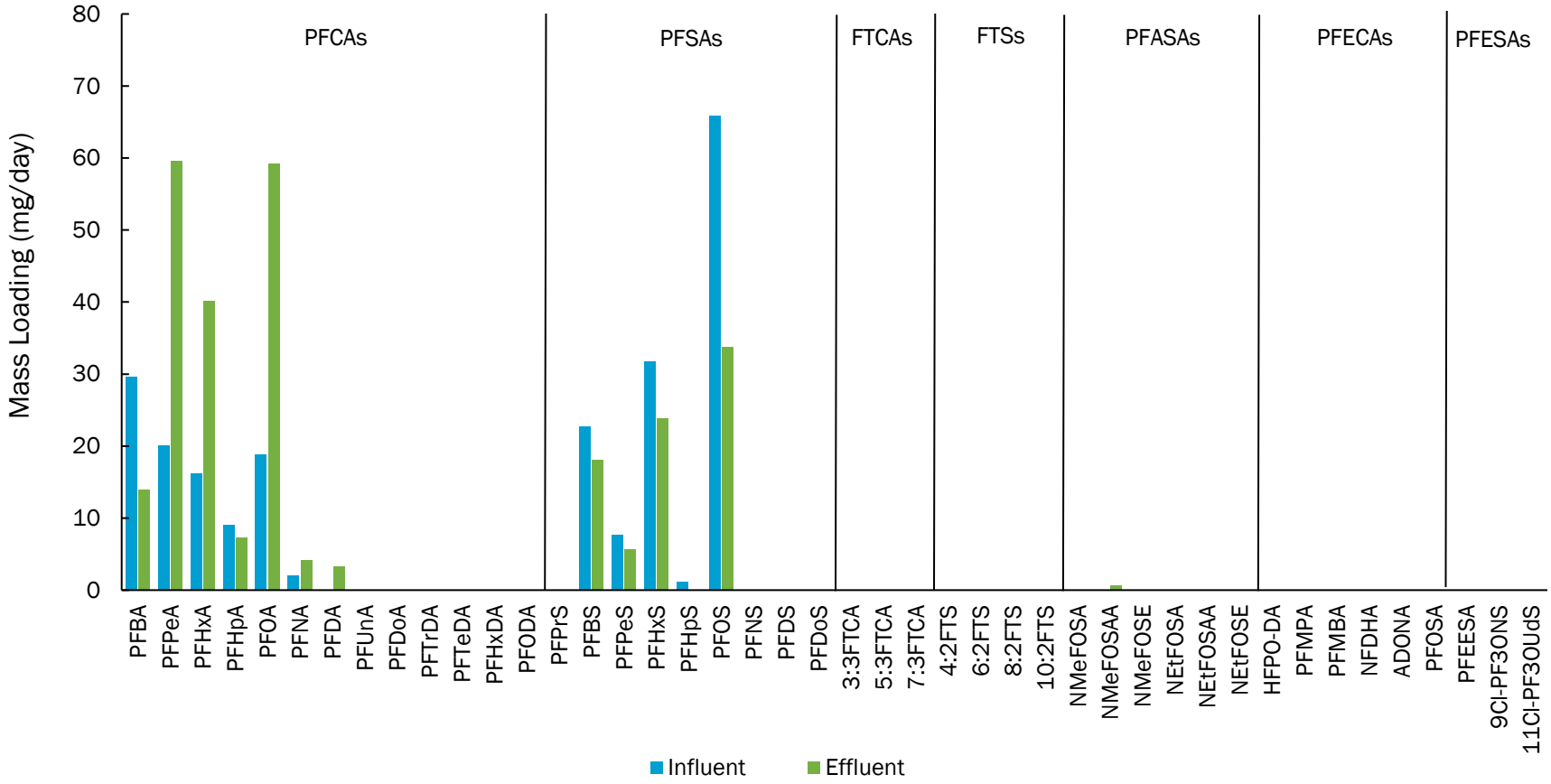


Figure 4-38. Influent and Effluent PFAS Mass Loading for POTW B

POTW C

POTW C provided data from POTW samples that were collected from influent, effluent, and the 21 industrial dischargers covered under the facility's IPP. The influent samples were taken three times over three years, and the three industrial samples were taken over two years. Effluent samples were collected once.

Figure 4-39 illustrates the influent and effluent mass loadings of the nine PFAS detected at POTW C. Apart from PFPeA and PFOS, the influent and effluent loads of PFAS are similar, implying that the treatment process had little impact on these species. The PFPeA and PFOS data may indicate removal of these species within the POTW. Removal of PFOS may be due to partitioning and subsequent removal of sludge. Some species (PFBA, PFBS and PFOA) have calculated effluent loads higher than influent loads. Because these species are considered terminal, they might be formed as other forms of PFAS are degraded.

Figure 4-40 shows the mass loadings PFAS species detected from industrial dischargers within POTW C's collection system. These data represent several individual dischargers and include the following industrial classifications: landfill leachate, drinking water treatment residuals, tanneries and leather/fabric/carpet treaters, platers/metal finishers, medical/pharmaceuticals, food, laundering, and power utilities. These data show four species with mass loadings greater than 50 mg/day. PFBS loading is almost double that of PFOA, the species with the second highest load.

The data presented in Figure 4-41 show the mass loading of PFAS species to POTW C from industrial sources compared to the mass loading for the entire plant influent. The percent contributions of industrial dischargers to the entire plant influent were calculated. Industrial contributions makeup a sizeable portion of several compounds, PFHxS (39%), PFBS (37%) and PFNA (35%). The contributions for each of these compounds is due mostly to a small number of industrial users and could benefit from pretreatment. However, the total industrial mass load (982 mg/day) up 19% of the total influent mass load (5,240 mg/day) for all PFAS measured. Eight species in total (PFHxS, PFBS, PFBA, PFHpA, PFHxA, PFNA, PFOA, and PFOS) have percent industrial contributions above 10%, which correspond to eight of the nine species that comprise the influent and effluent PFAS illustrated in Figure 4-39.

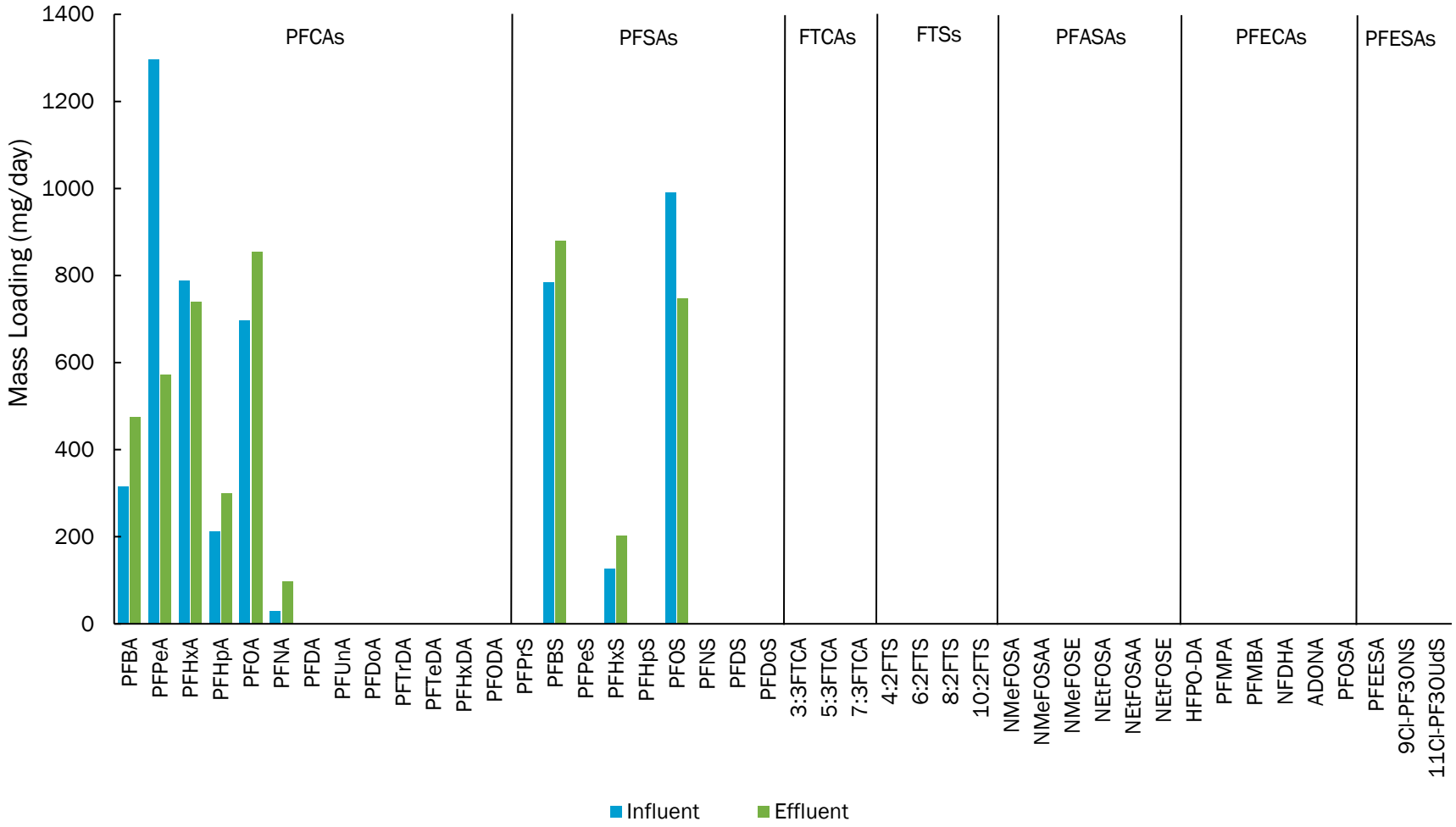


Figure 4-39. Influent And Effluent PFAS Mass Loading for POTW C

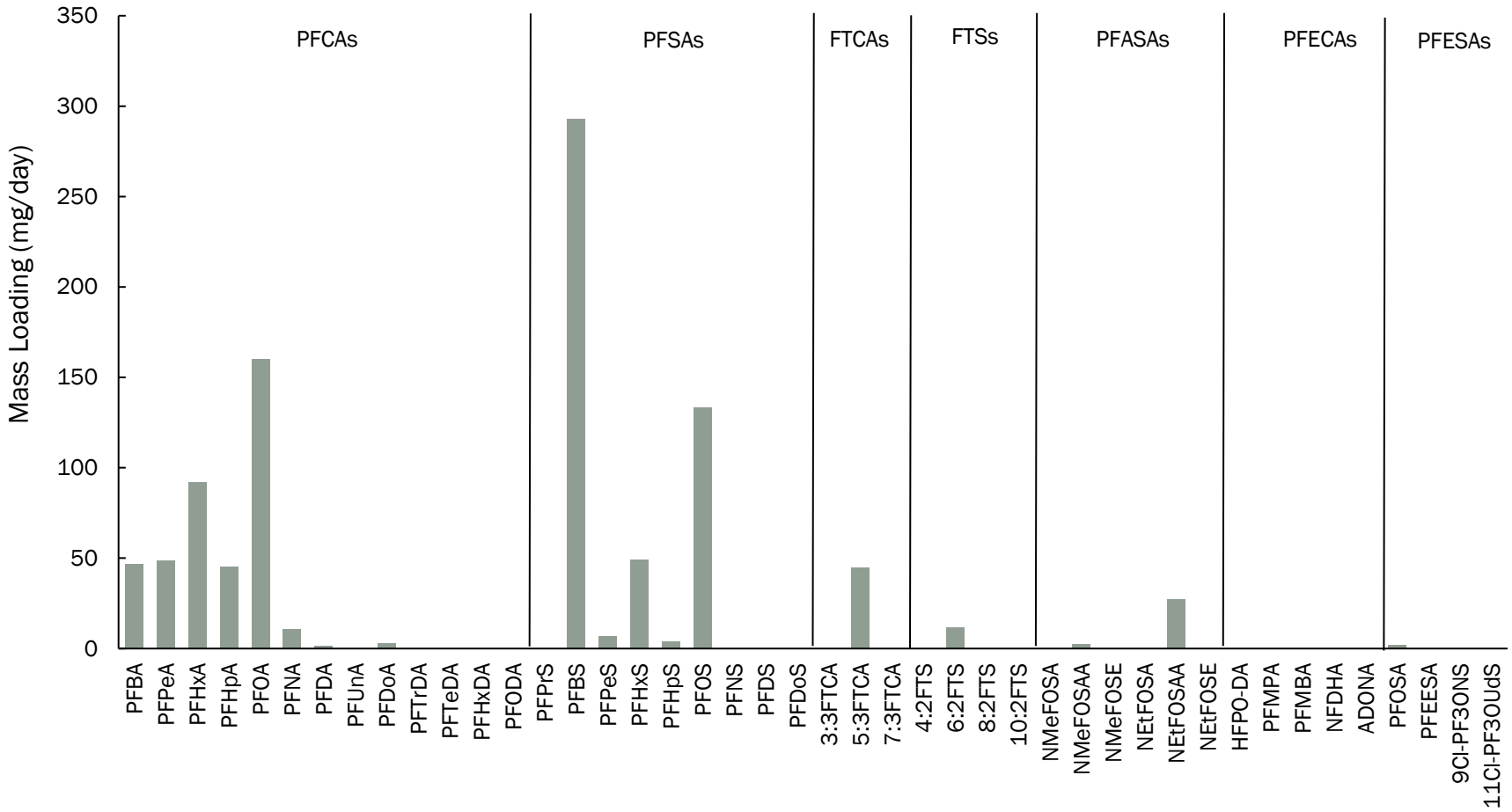


Figure 4-40. Mass loading of PFAS from industrial sources for POTW C's sewershed

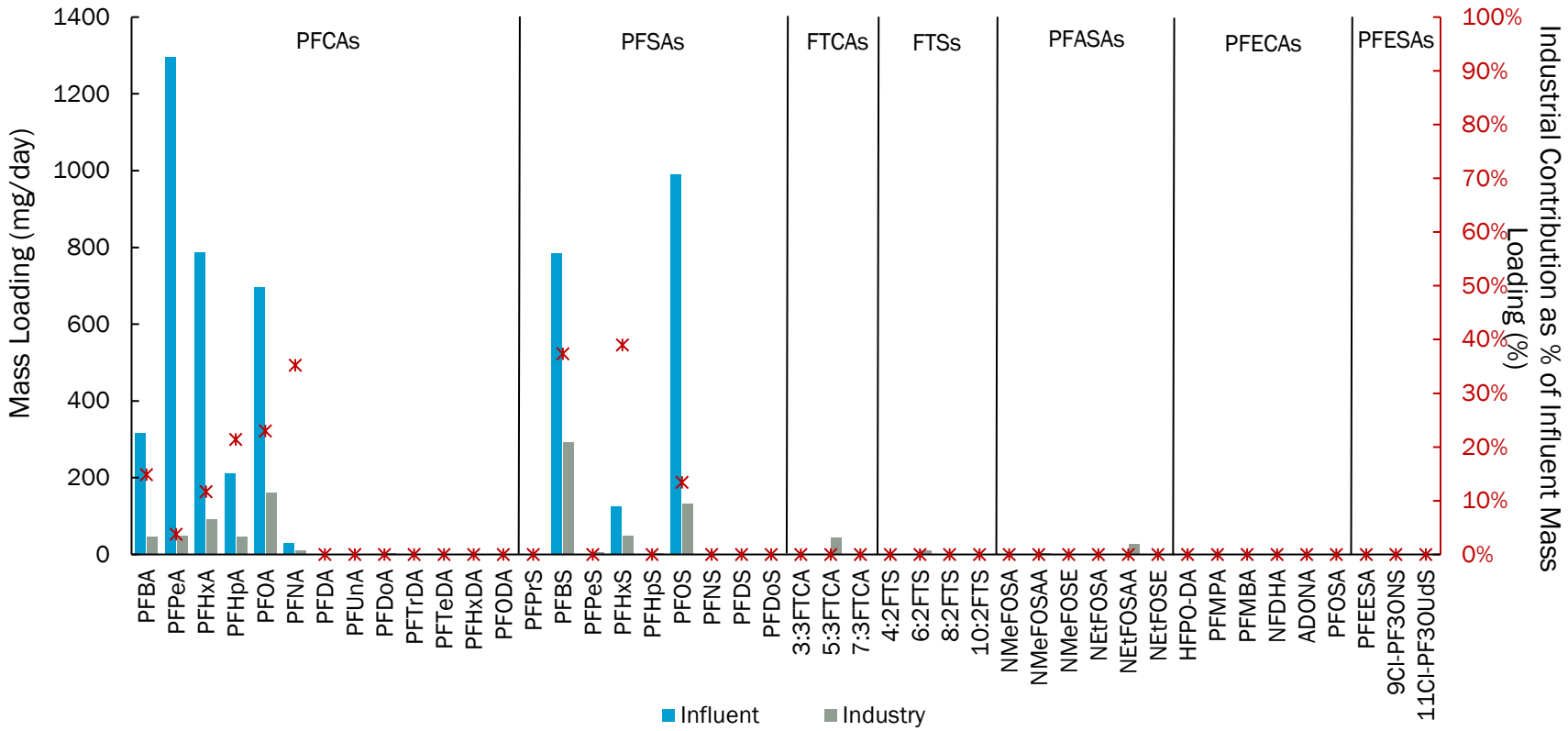


Figure 4-41. Industrial And Influent Mass Loading to POTW C Presented with the Percent Contribution from Industrial Sources to the Facility Influent

POTW D

POTW D provided data from samples that were collected from influent and effluent. POTW D does not have an IPP, so no industrial data were collected. Only a single set of influent/effluent samples were collected on one occasion in 2023. Readers must recognize that the observations made below are extremely limited and must be considered in the context of other case studies.

Figure 4-42 illustrates the influent and effluent mass loadings of the ten PFAS that were detected at POTW D. Two species (PFBA, and PFPeA) had calculated influent loads higher than effluent loads. However, these short-chain perfluoro carboxylic acids (PFCAs) are typically considered "terminal" species that do not typically degrade into other, smaller compounds, indicating that transformation is not the likely source of the difference between influent and effluent compound mass loading. It is more likely that the limited dataset (just one influent and one effluent sample) fails to capture sources of variability among the data, which prevents conclusion about the fate of any given species, so further exploration is warranted as more data become available. For example, PFHxA had calculated effluent loads higher than calculated influent loads, attributable to the non-representative nature of the dataset or the possibility that these species are being formed from other species.

The PFAS mass loading at POTW D appears comparable to or lower than POTWs A and C, both of which have an IPP. The higher mass loading observed for POTWs with IPPs in general is more likely to be due to the higher industrial flows at POTWs with IPPs rather than higher concentrations. The influent flow to POTW D is approximately one-eighth of the influent flow to POTWs A & C. Additionally, POTW D's measured concentrations of PFBA and PFPeA are 80 – 90 ng/L, while POTWs with IPPs have concentrations around 5 –15 ng/L. This shows that PFAS mass loading should not be used as the sole criteria to compare PFAS contamination in POTWs.

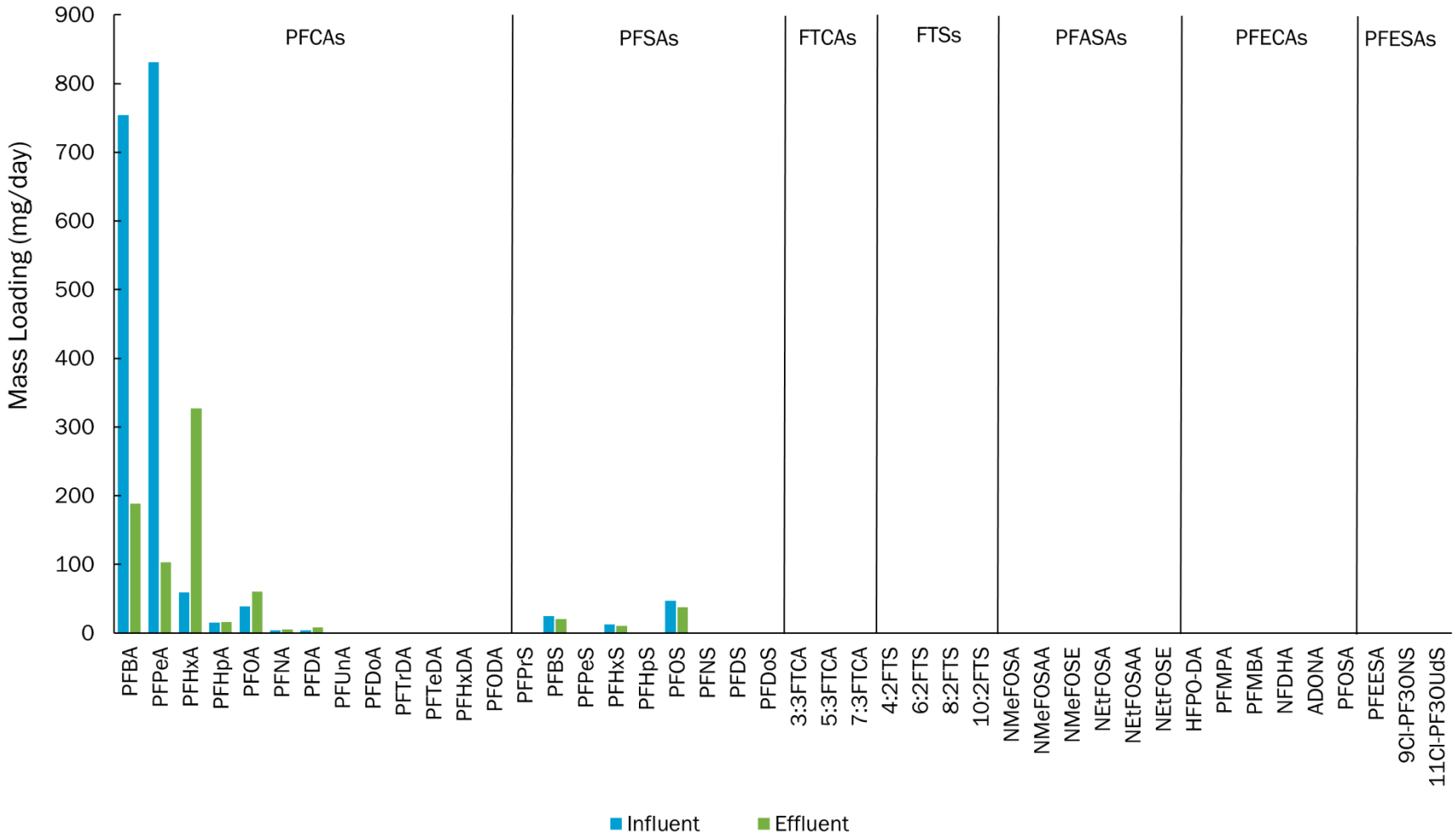


Figure 4-42. Influent and Effluent PFAS Mass Loading for POTW D

POTW E

POTW E provided data from influent and effluent samples collected four times in two years beginning in 2023. POTW E does not have an IPP, so no industrial data were collected.

Figure 4-43 illustrates the influent and effluent mass loadings of the thirteen PFAS that were detected at POTW E. Some species (6:2FTS, PFHxA, PFHxS, PFOA, and PFPeA) had calculated effluent loads significantly higher than influent, whereas some species (PFBA and PFOS) had calculated effluent loads lower than the influent loads. 6:2FTS is considered a precursor compound that can degrade into shorter chain compounds such as PFBA and PFOA; however, this is opposite to what was found during sampling. No 6:2FTS was measured in the influent, but a high concentration was measured in the effluent. This may be due to the limited number of samples taken which is susceptible to normal variations. The high effluent loading may be an error (only a single sample of the five effluent samples measured 6:2FTS, the other four were all non-detect) or this may be due to a "slug load" where a high concentration of the compound passed through the POTW. The other PFAAs and PFCAs with higher effluent loads than influent could be a result of transformations of other species. PFOA effluent concentrations could be a result of partitioning and removal of sludge through the treatment process.

The total average effluent load of PFAS is twice the influent load (667 mg/day effluent, 320 mg/day influent). This difference is predominantly attributed to the 275 mg/day 6:2FTS measured in the effluent because none was detected in the influent. This indicates that the high 6:2FTS loading may be due to an outlier measurement or a "slug load," a volume of influent wastewater which is not well-mixed and therefore has a higher concentration of pollutants than typical influent and which may be associated with industrial loading.

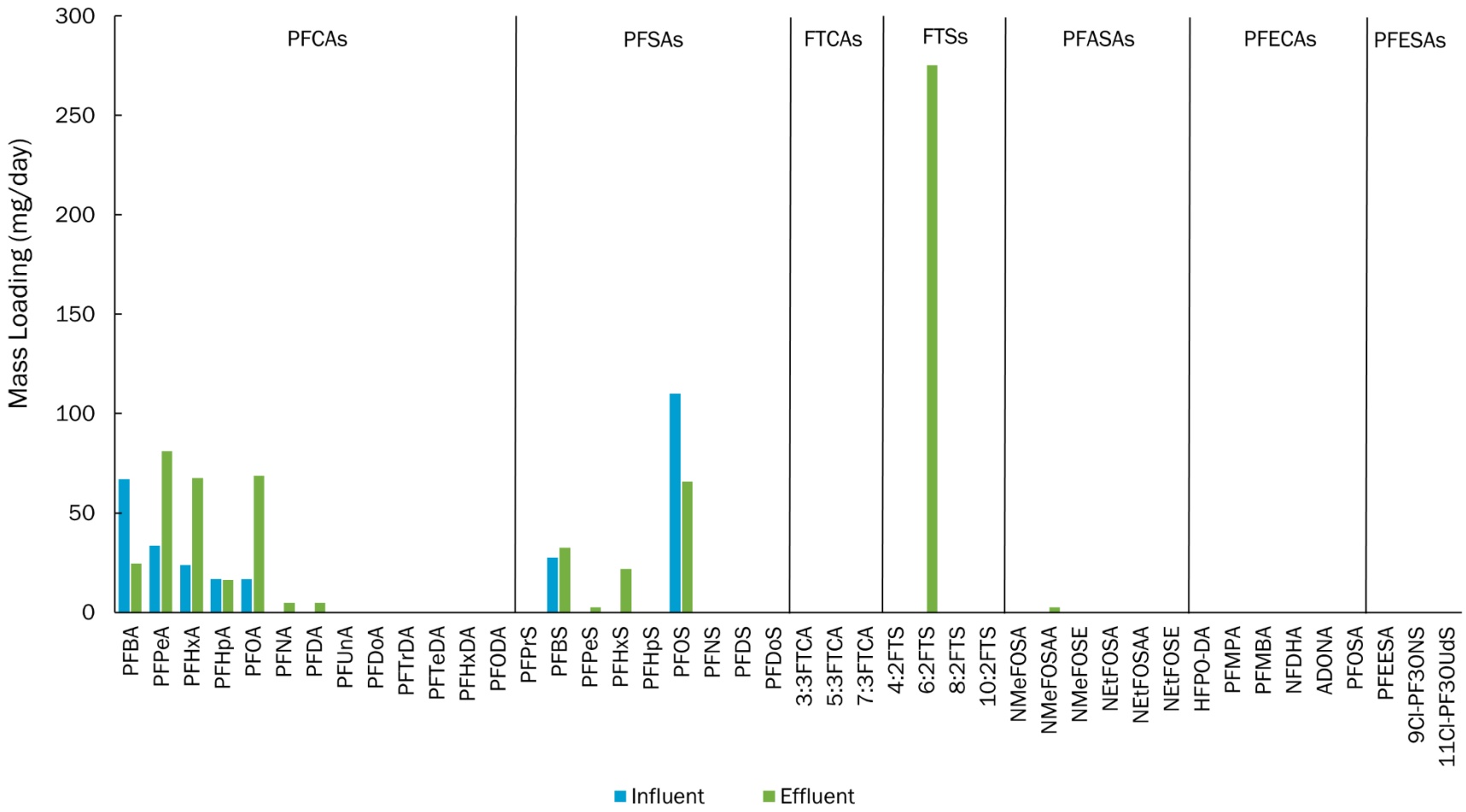


Figure 4-43. Influent and Effluent PFAS Mass Loading for POTW E

POTW F

POTW F provided data from POTW samples that were collected from influent, effluent and some of the 13 industrial dischargers covered under the facility's IPP. The influent and effluent samples were collected quarterly using Modified Method 537.1. Three influent samples were collected in 2023 and eight effluent samples were collected starting in 2022. The industrial samples were collected throughout 2023.

Figure 4-44 illustrates the influent and effluent mass loadings of the six PFAS species that were measured at POTW F. PFOA had calculated effluent loads higher than calculated influent loads, which may be attributed to transformation from precursor species. Some species (PFHpA and PFOS) had calculated effluent loads lower than the influent loads, potentially due to partitioning and removal in sludge. The total average influent mass load is 27% higher than the total average effluent mass load of PFAS (345 mg/day influent, 270 mg/day effluent). This may be due to the fact that only the six species listed below were sampled. It is possible PFBS and PFBA and other terminal PFAS species may make up the difference between influent and effluent loads

Industrial loading could not be calculated for POTW F due to the lack of industrial flow rate data, so Figure 4-45 illustrates the comparison among influent, effluent, and industrial concentrations. The extent of this analysis is to show the differing speciation in the three sublocations. All six PFAS measured are present in all three sublocations. Of these six species, PFHxS, PFHpA, and PFOA industrial concentrations are over four times the influent concentrations. This does not necessarily suggest that the industrial contributions to the POTW's influent are significant, but it does suggest that these compounds may contribute large industrial loads. Industrial flow rate data are required to quantify the industrial contributions to POTW F.

Figure 4-46 illustrates the concentration of PFAS species in the sludge. Of the six PFAS species measured, PFOS comprises the largest fraction of PFAS measured in the sludge. This suggests that PFOS partitions into the sludge and is present in smaller quantities in the POTW F effluent, as seen in Figure 4-44 and Figure 4-45.

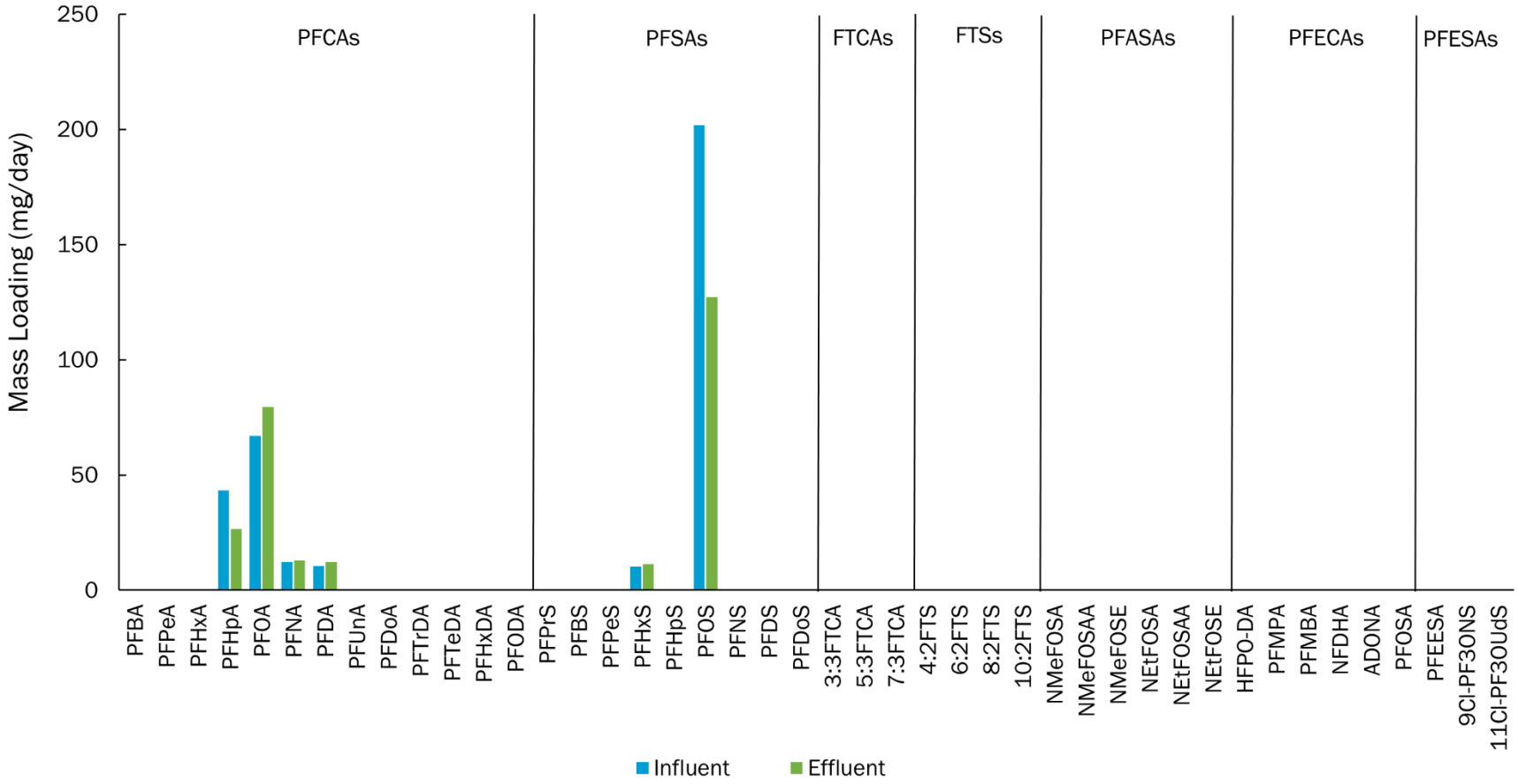


Figure 4-44. Influent and Effluent PFAS Mass Loading for POTW F

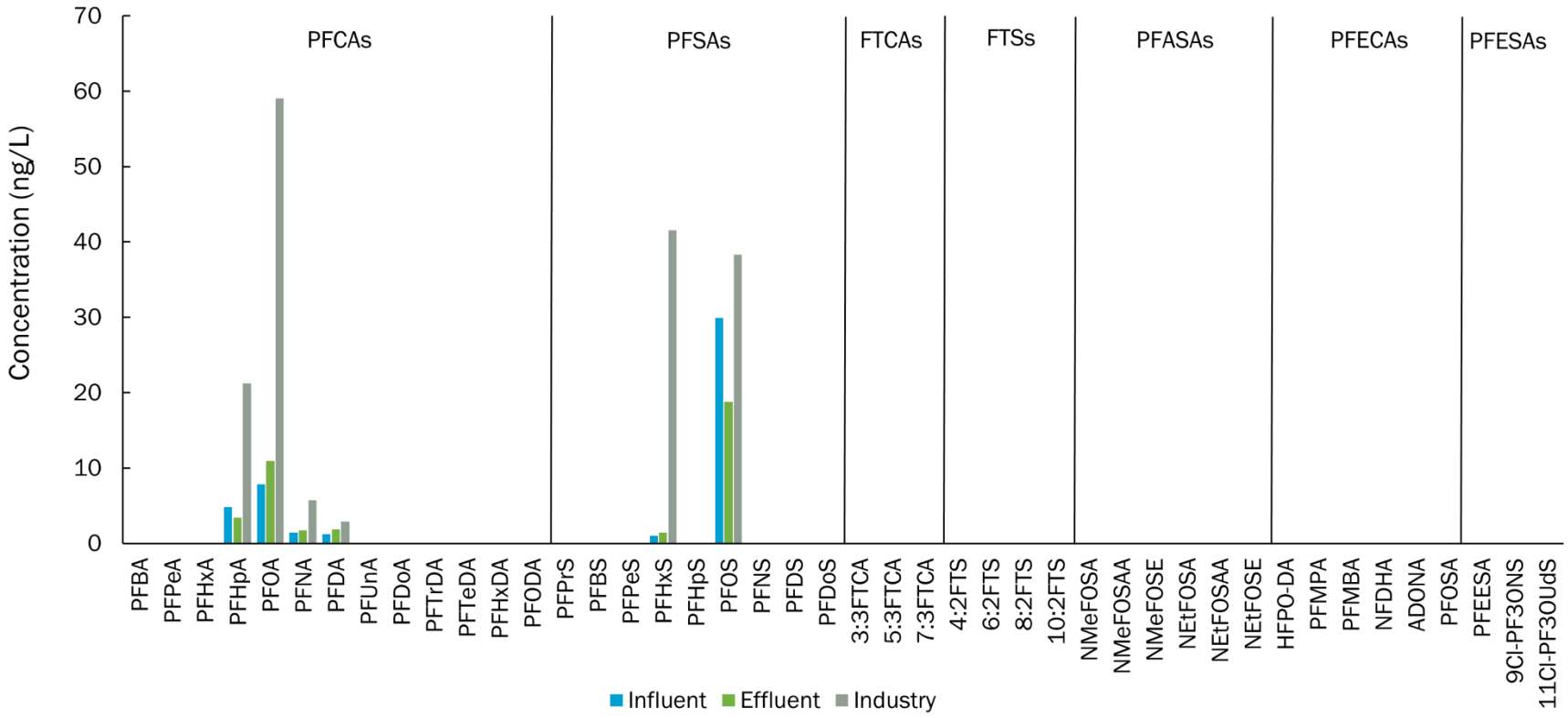


Figure 4-45. Influent, Effluent, and Industrial PFAS Concentrations for POTW F

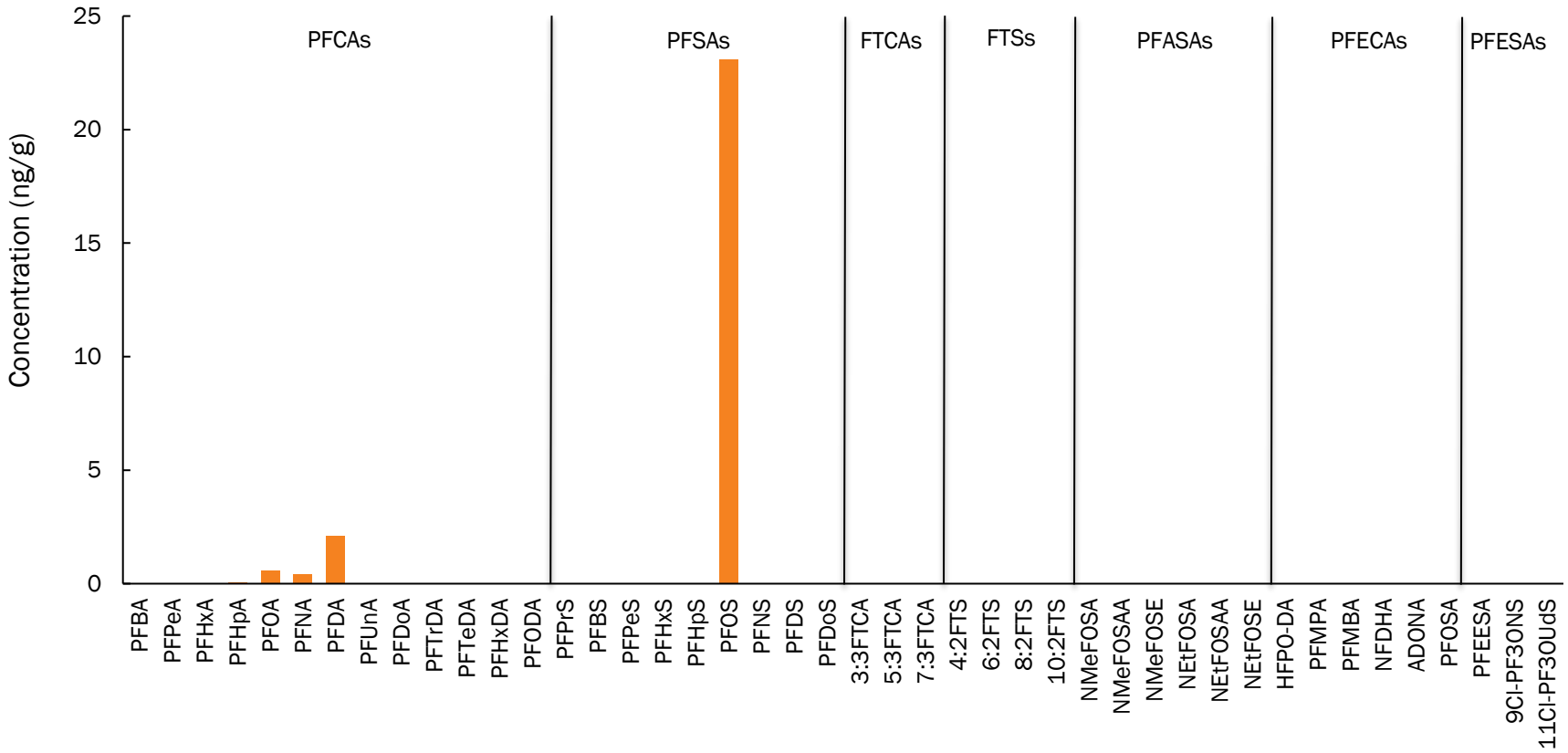


Figure 4-46. Sludge PFAS Concentrations for POTW F

POTW G

POTW G provided data from POTW samples that were collected from influent and effluent. POTW G does not have an IPP, so no industrial data were collected. The influent and effluent samples were collected quarterly, three times in two years, starting in quarter four of 2023.

Figure 4-47 illustrates the influent and effluent mass loadings of the thirteen PFAS species that were detected at POTW G. Some species (PFHxA and PFPeA) had calculated effluent loads higher than influent loads, which may be attributed to either partitioning into the liquid phase or a possibility that these species were formed from the degradation of other PFAS. No species had calculated effluent loads lower than the influent loads, and most were comparable. The total average influent mass load is less than half the effluent load of PFAS (344 mg/day influent 826 mg/day effluent) because some species (5:3FTCA, NMeFOSAA, PFDA, and PFPeS) were present only in the effluent and not in influent samples. This may be attributed to the non-representative nature of grab samples or differences in concentrations present around the limit of detection.

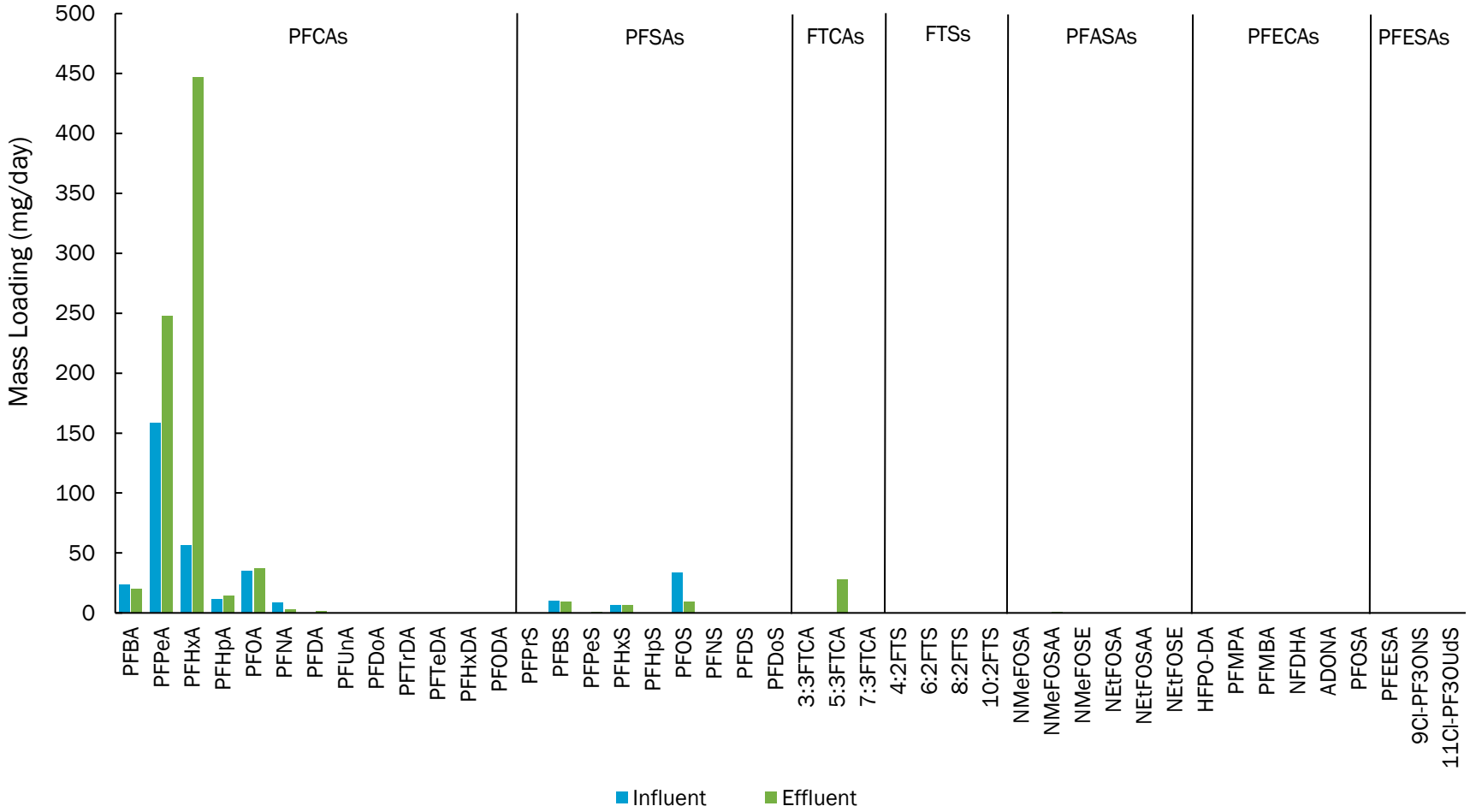


Figure 4-47. Influent and Effluent PFAS Mass Loading for POTW G

POTW H

POTW H provided data from POTW samples that were collected from influent and some of the 37 industries covered under the facility's IPP. No effluent data were reported. The influent samples were collected three times in 2022, and no samples from 2023 or 2024 were provided in the data set. The industrial samples were collected over a period of two years from 2022 to 2023.

Figure 4-48 illustrates the influent mass loadings of the eleven PFAS that were detected at POTW H. PFOS is the dominant influent species, contributing more than 2.5 times the mass load of the next highest species, PFPeA.

Figure 4-49 shows the mass loadings of PFAS detected from industries that are located within the collection system of POTW H. These data represent several individual dischargers within the following broad classifications: ceramics and plastics, electronics, platers/metal finishers, food, and laundering facilities. These data show eight species with mass loadings greater than 20 mg/day. PFOA loading is almost 60% higher than the loading of PFPeA, the species with the second highest mass loading. Several of the PFAS species have similar mass loadings, which suggests there may not be a single industrial user or category that discharge a particular "indicator" species, and it is more likely that several industries are discharging varying PFAS loads.

The data presented in Figure 4-50 show the mass loading of PFAS to POTW H from industrial sources compared to the mass loading for the entire plant influent in mg/day. The percent contribution of the entire plant influent mass loading from individual industrial users was calculated. The highest percentage is 28% for PFHxS followed by PFHpA and PFOA at 10%. The low percent contributions of industrial users for the remaining species indicates that their pretreatment would result in only a small decrease in influent PFAS. The data show instead that PFAS are likely contributed at moderate-to-low concentrations from a large number of sources, affirming that PFAS are ubiquitous among all sewer uses, or at very high concentrations from another individual source that has yet to be identified.

It should be noted that four industrial data points were excluded from the analysis because the measured concentrations far exceeded laboratory-established quality control limits of measurement. Values were recorded and reported by the laboratory, but the accuracy of the results is unknown. It is clear that a high level of the PFAS compound was detected, but the actual concentration present is unknown. The maximum level detection could not be used in place of the recorded value because the maximum level of detection was not included in the laboratory reports. The excluded data were from two separate industrial users, both platers/metal finishers, which typically have high concentrations of particular PFAS, as discussed in Section 4.3.2. The four excluded data were two PFOS measurements of 576 and 6,950 ng/L, a PFHxA measurement of 608 ng/L, and a 6:2FTS measurement of 3,470 ng/L. Had these data been included in the previous analysis, the industrial contribution to influent load for PFHxA would be 20%, PFOS would be 73%, and 6:2FTS would be 635%. These results would change the conclusion for PTOW H that targeted pretreatment for specific industrial users may be useful in reducing specific compound PFAS loading. However, due to the uncertainty associated with these relatively few data points, we can only conclude that the analysis described in the previous paragraph and Figure 4-50 underestimate the actual industrial mass loading of PFHxA, PFOS, and 6:2FTS. Additionally, it is suggested that a policy is implemented requiring laboratories to dilute and retest samples in which PFAS are measured above maximum measurable limits to accurately report the concentration of all PFAS.

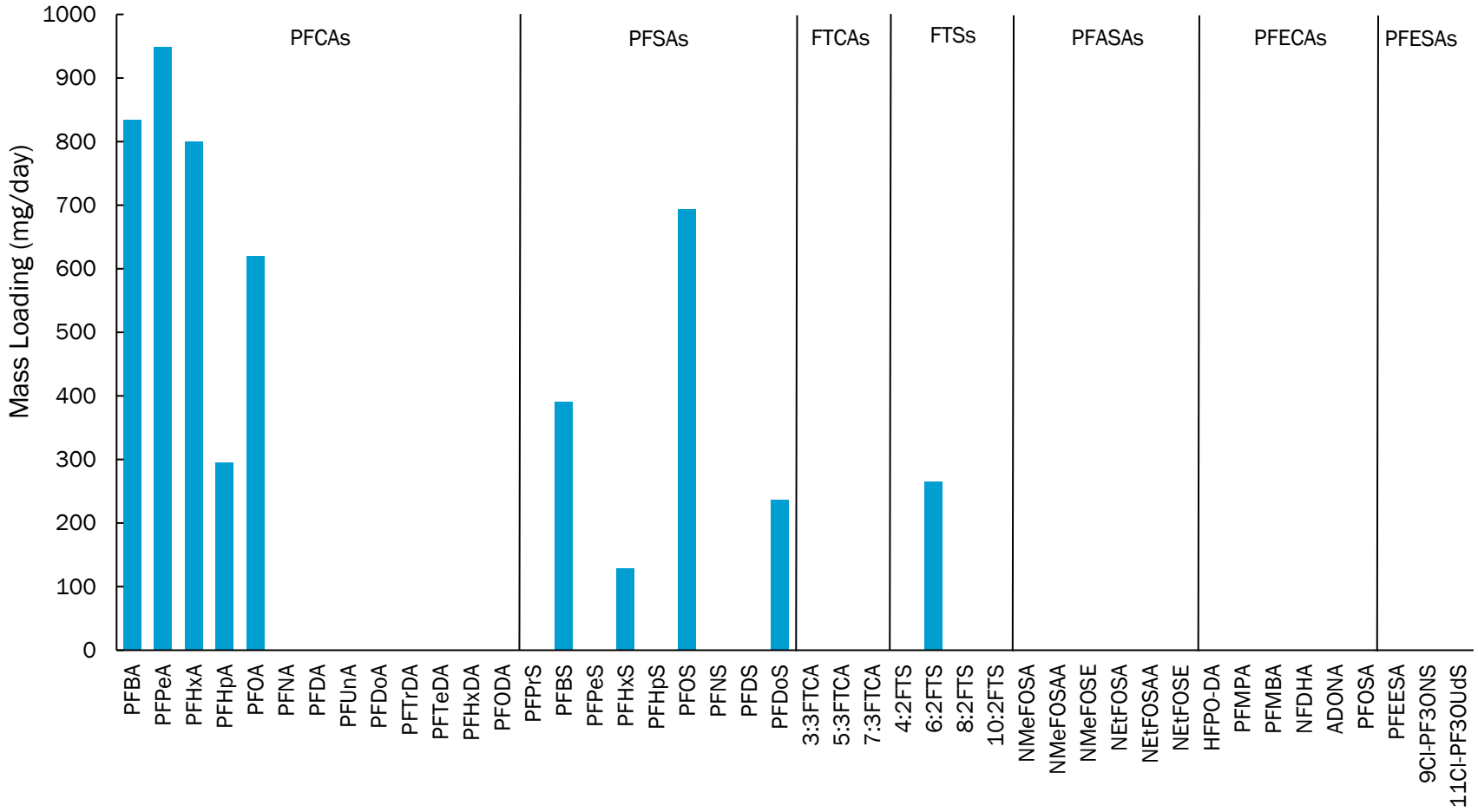


Figure 4-48. Influent PFAS Mass Loading for POTW H

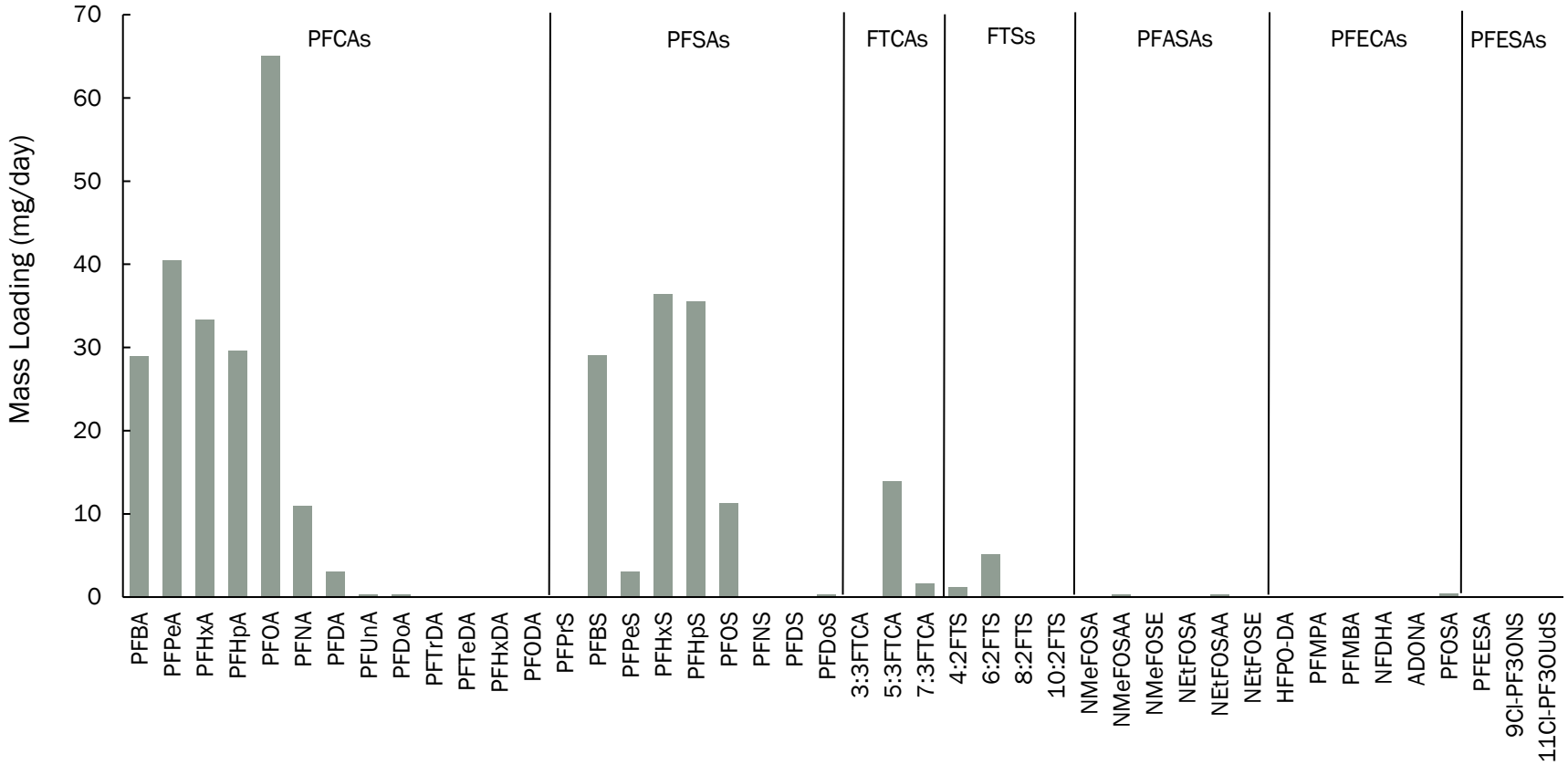


Figure 4-49. Mass Loading of PFAS from Industrial Sources for POTW H's Sewershed

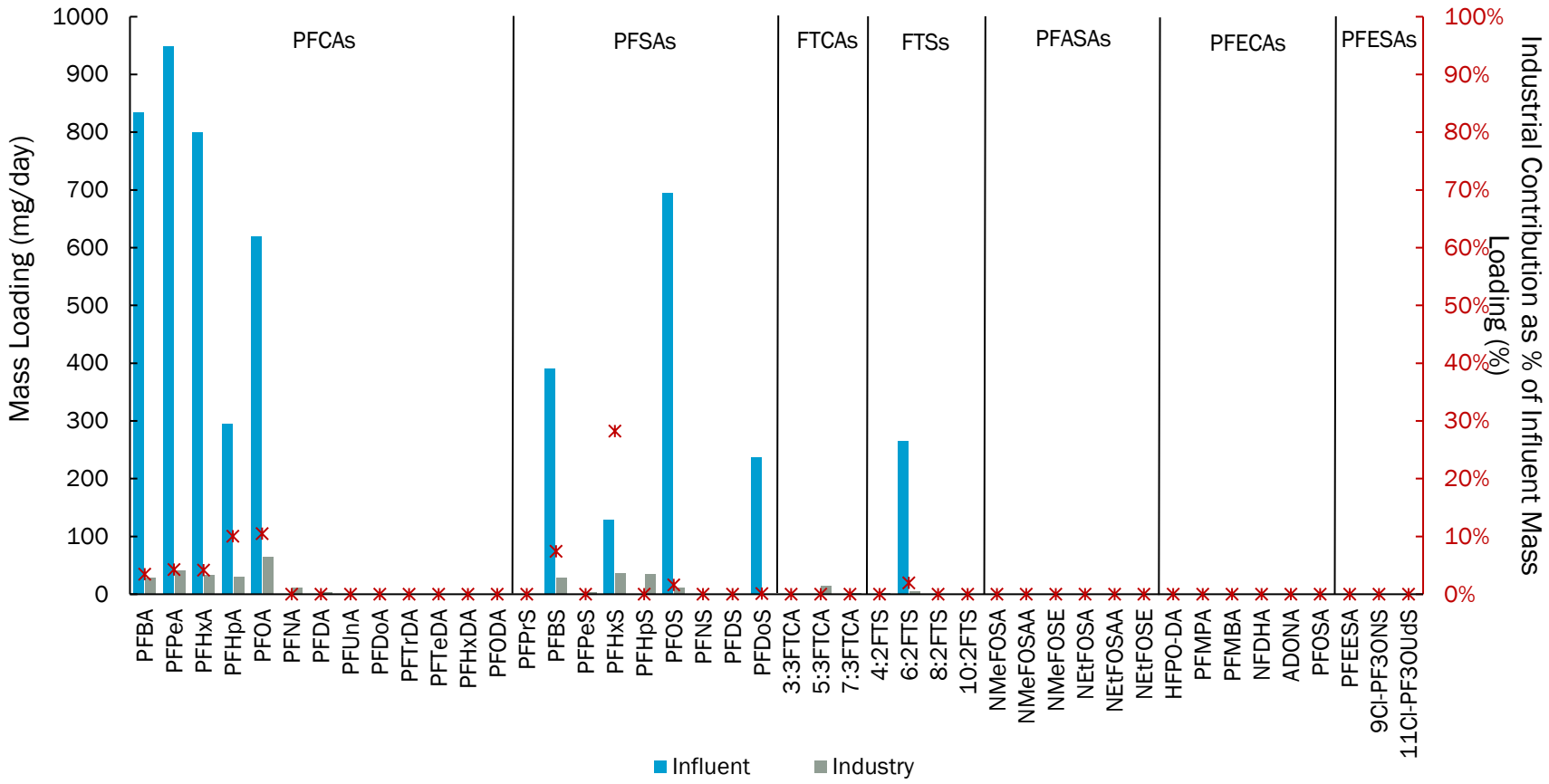


Figure 4-50. Industrial and Influent Mass Loading to POTW H Presented with the Percent Contribution from Industrial Sources to the Facility Influent

POTW I

POTW I provided data from POTW samples that were collected from influent and effluent. POTW I has an IPP but did not provide PFAS measurements or flow data for their industrial users. The influent and effluent samples were collected quarterly, five times in three years, once in 2022, thrice in 2023, and once in 2024.

Figure 4-51 illustrates the influent and effluent mass loadings of the twelve PFAS that were detected at POTW I. Some species (PFHpA, PFHxA, PFHxS, PFOA, and PFPeA) had calculated effluent loads higher than influent loads. Some species (PFBA, PFBS, and PFOS) had calculated effluent loads lower than the influent loads. The total average influent and effluent load of PFAS is comparable (1,590 mg/day influent, 1,775 mg/day effluent). The difference between influent and effluent loading may be attributable to either partitioning into the liquid phase in the case of PFPeA, PFHpA, PFHxA, and PFHxS, or the possibility that these species are being formed from other forms of PFAS as they degrade. It is unlikely that PFBA, PFBS or PFOS, typically considered terminal compounds, are being transformed into other compounds. PFOS could be partitioning into the sludge, but it is unlikely for PFBA or PFBS to do so with such short chain lengths.

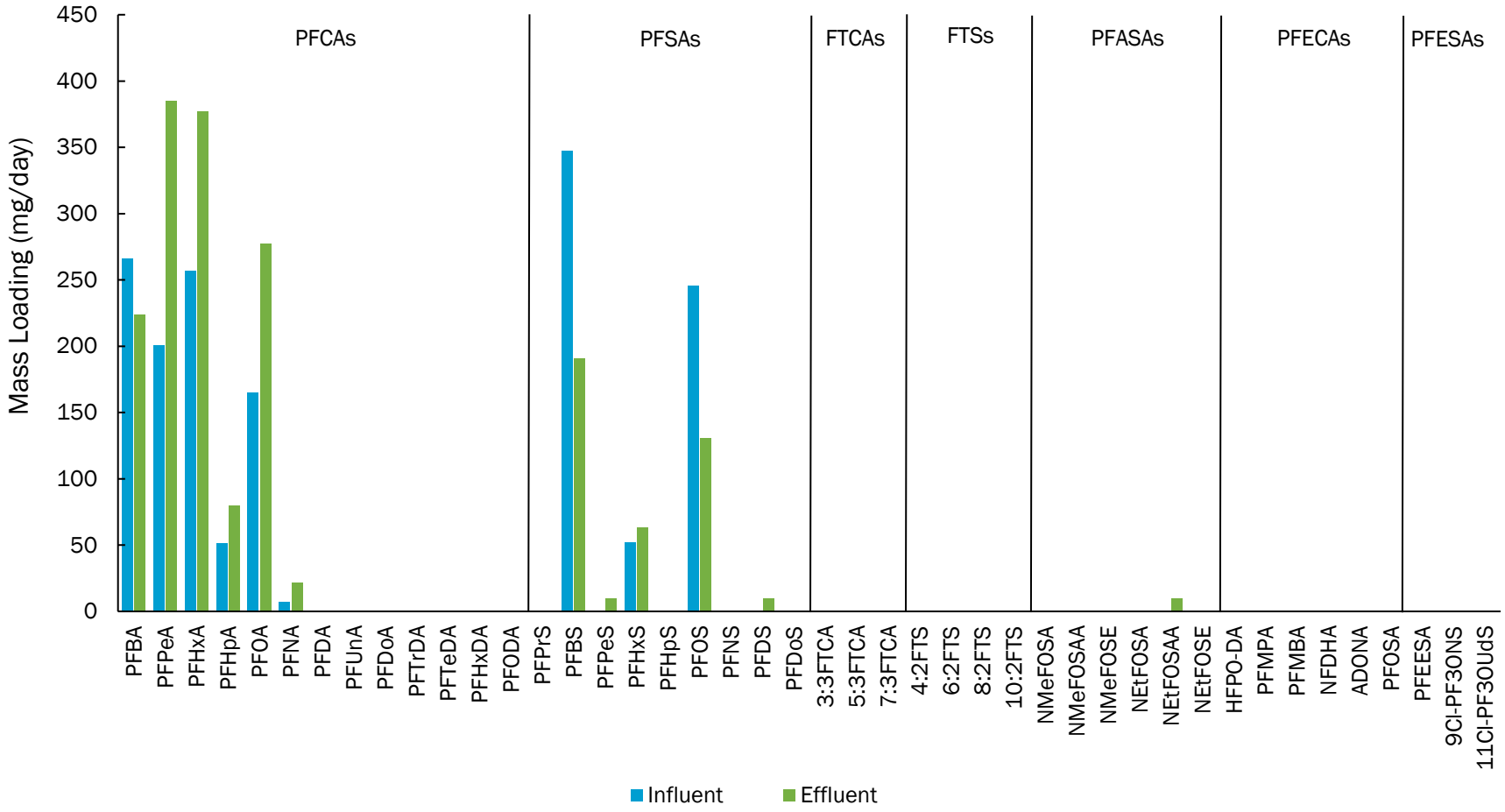


Figure 4-51. Influent and Effluent PFAS Mass Loading for POTW I

POTW J

POTW J provided data from POTW samples that were collected from influent and effluent. POTW J does not have an IPP, so no industrial data were collected. The influent and effluent samples were collected quarterly, three times in two years, starting in mid-2023 through quarter one 2024.

Figure 4-52 illustrates the influent and effluent mass loadings of the thirteen PFAS species that were detected at POTW J. Some species (PFBA, PFHxS, PFNA, PFOA, PFOS, and PFPeA) had calculated effluent loads higher than influent loads possibly attributable to these species are being formed from other PFAS compounds as they degrade, or shorter chain molecules (PFBA, PFHxS, and PFPeA) Some species (PFBS, PFHpA, PFHxA, and PFPeS) had calculated effluent loads lower than the influent loads, which may indicate they transform during the treatment process; however, these compounds are typically understood to be terminal and do not transform.

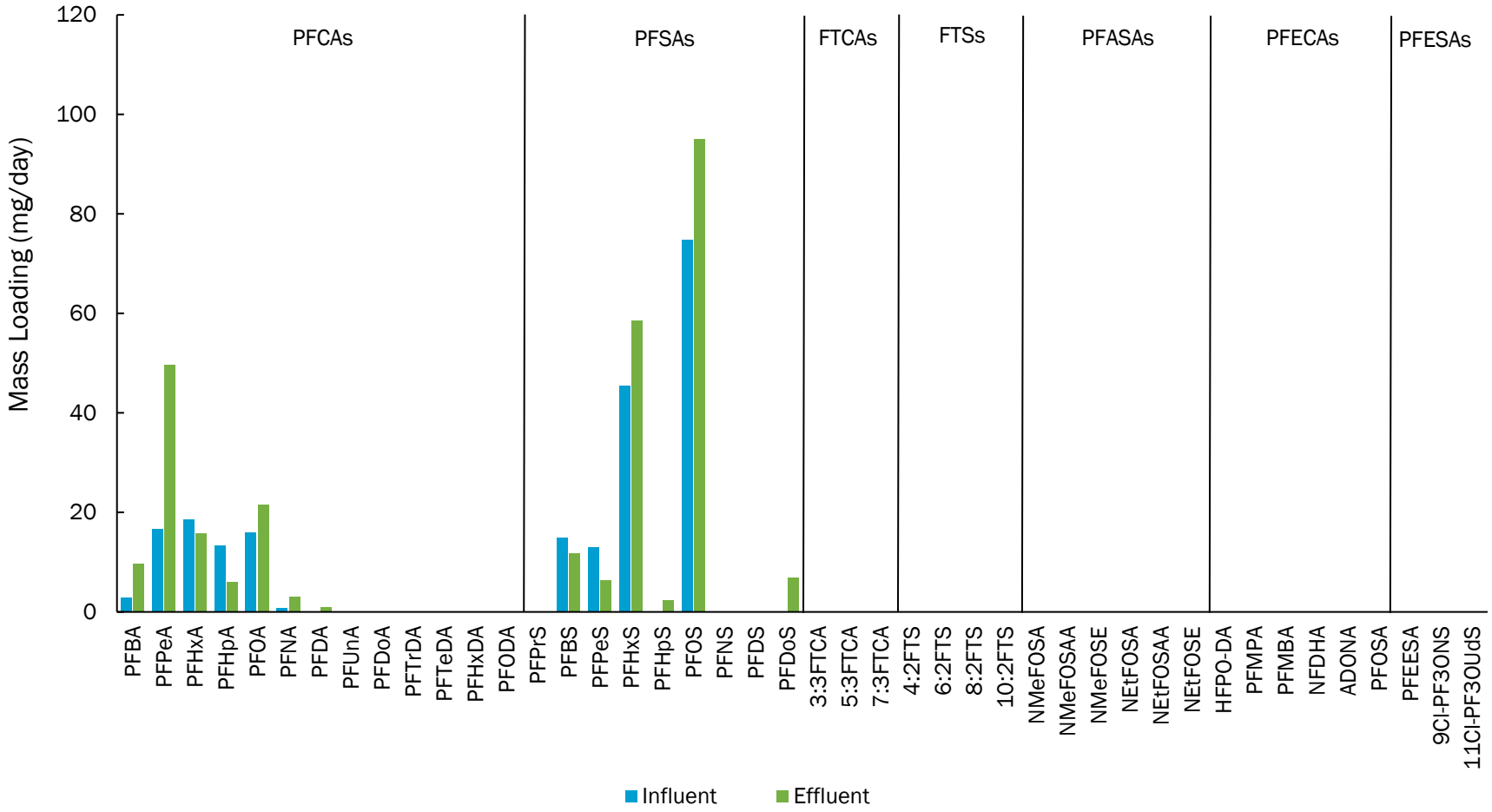


Figure 4-52. Influent and Effluent PFAS Mass Loading for POTW J

POTW K

POTW K provided data from POTW samples that were collected from influent and effluent. POTW K has one industry in the facility's IPP, but no data from the industrial user were provided. The influent and effluent samples were collected semiannually over two years starting in 2023.

Figure 4-53 illustrates the influent and effluent mass loadings of the thirteen PFAS species that were detected at POTW K. PFAS measurement was conducted for only six species, of which only one was present in the influent and three were present in the effluent. The three PFAS species detected in the effluent (PFOA, PFPeS, and PFHpS) are considered terminal species, so these may have been formed from species that are not analyzed by EPA Method 1633. The low mass loading in comparison to other POTWs appears low due to the low flows into the POTW (<1 mgd), although concentrations are comparable to other POTWs' influent concentrations.

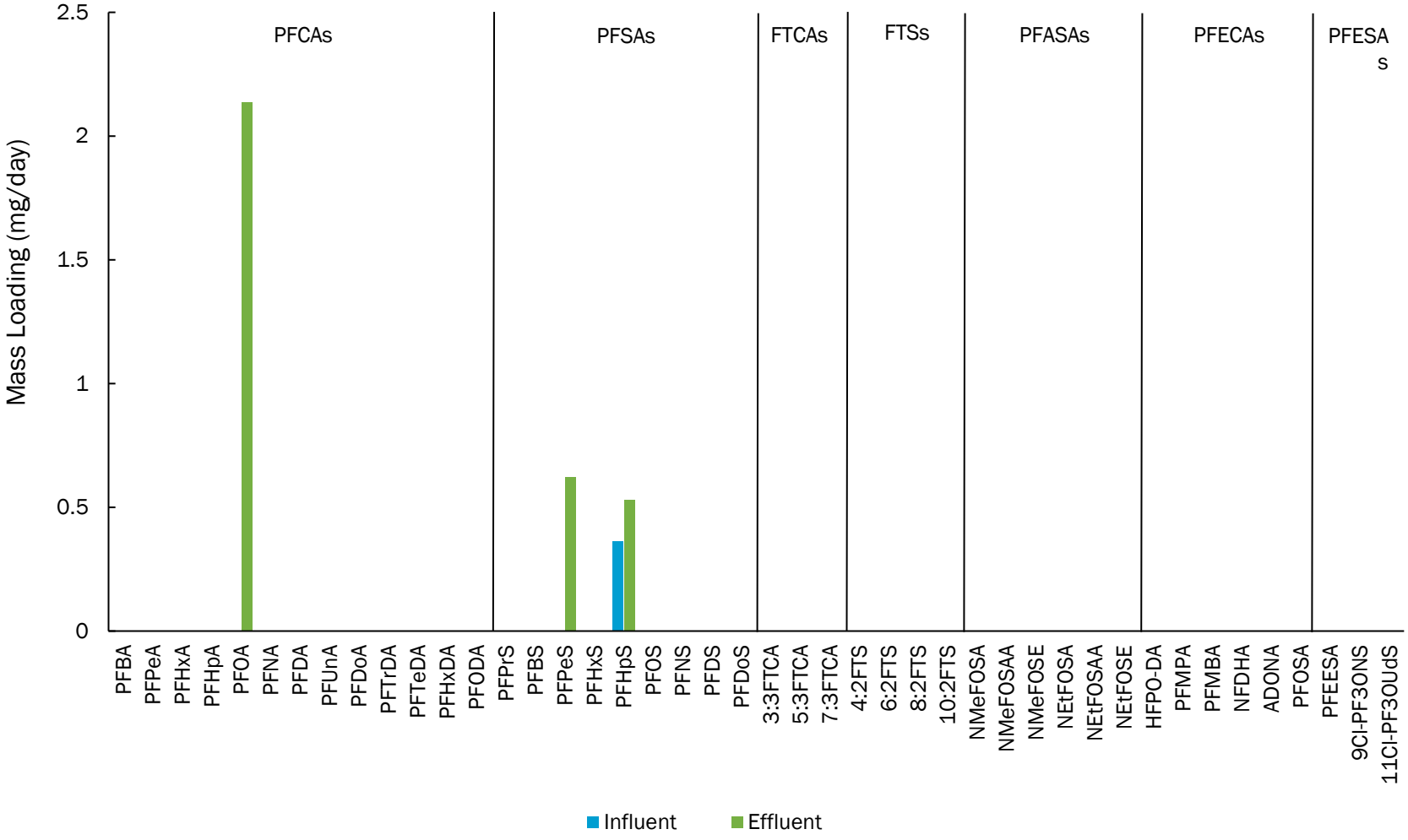


Figure 4-53. Influent and Effluent PFAS Mass Loading for POTW K

POTW L

POTW L provided data from POTW influent and effluent samples that were collected quarterly, three times in two years, starting in 2023. POTW L serves one large industrial user and a few residences.

Figure 4-54 illustrates the influent and effluent mass loadings of the thirteen PFAS species that were detected- at POTW L. PFAS testing was conducted for sixteen species, of which none were present in the influent, and eight were present in the effluent. This discrepancy may be attributed to either the non-representative nature of occasional grab samples or the possibility that these species are being formed from other forms of PFAS as they degrade from species not measured by the analytical method used. The limited data set (three influent and effluent samples) prevents definitive conclusions about the fate of any given species, but it does suggest possible implications that may warrant further exploration as more data become available.

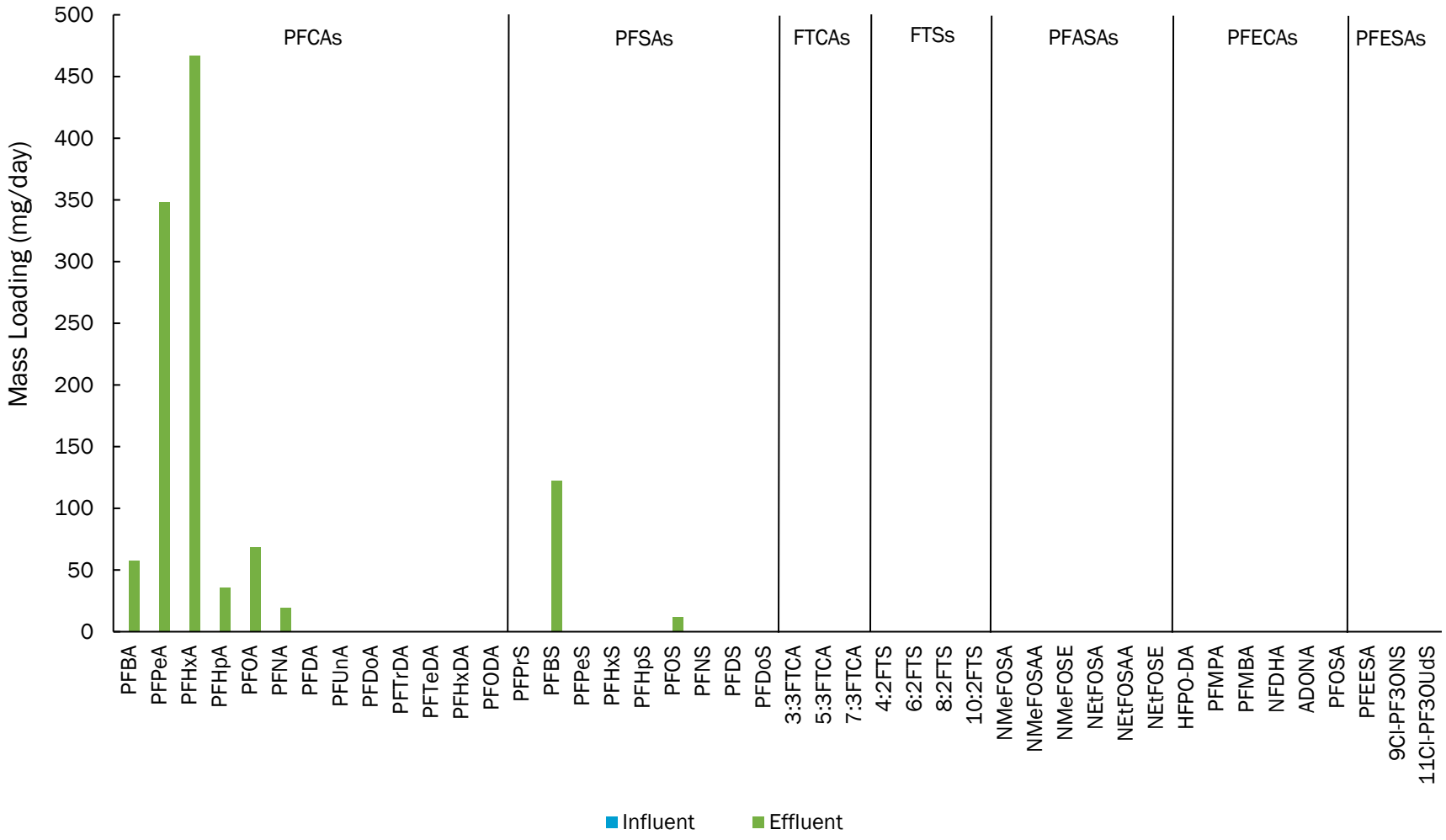


Figure 4-54. Influent and Effluent PFAS Mass Loading for POTW L

POTW M

POTW M provided data from POTW samples that were collected from influent, effluent, and one industrial source, although POTW M does not have an IPP. The influent and effluent samples were collected quarterly, three times in two years, starting in 2023, while the industrial user was sampled once in 2023.

Figure 4-55 illustrates the influent and effluent mass loadings of the three PFAS species that were detected at POTW M. PFHpA had calculated effluent load significantly higher than influent load, which is potentially due to transformations from other species into PFHpA. PFOS had calculated effluent loads lower than the influent loads, which can likely be attributed to partitioning into the solid phase. The total average influent and effluent load of PFAS is comparable (232 mg/day influent, 275 mg/day effluent).

Industrial loading is not available for POTW M due to lack of industrial flow data, so Figure 4-56 illustrates the comparison between influent, effluent, and industrial discharge concentrations. The extent of this analysis is to show the differing speciation between the three media. Industrial PFAS concentrations are higher than POTW influent concentrations for all species except for PFHpA. In particular, the industrial PFOS concentration is approximately 150 times higher than the average influent concentration, which may indicate high industrial contribution to POTW M. However, this cannot be verified without flow data for the industrial discharger. Additionally, this figure shows that several species in the industrial discharge are not present in either the influent or effluent sampling, which suggests that those species may be present at concentrations below the limit of detection in the influent and effluent.

The limited data set (three influent samples, three effluent samples, and one industrial sample) prevents definitive conclusions about the fate of any given species, but it suggests that further exploration is warranted as more data become available.

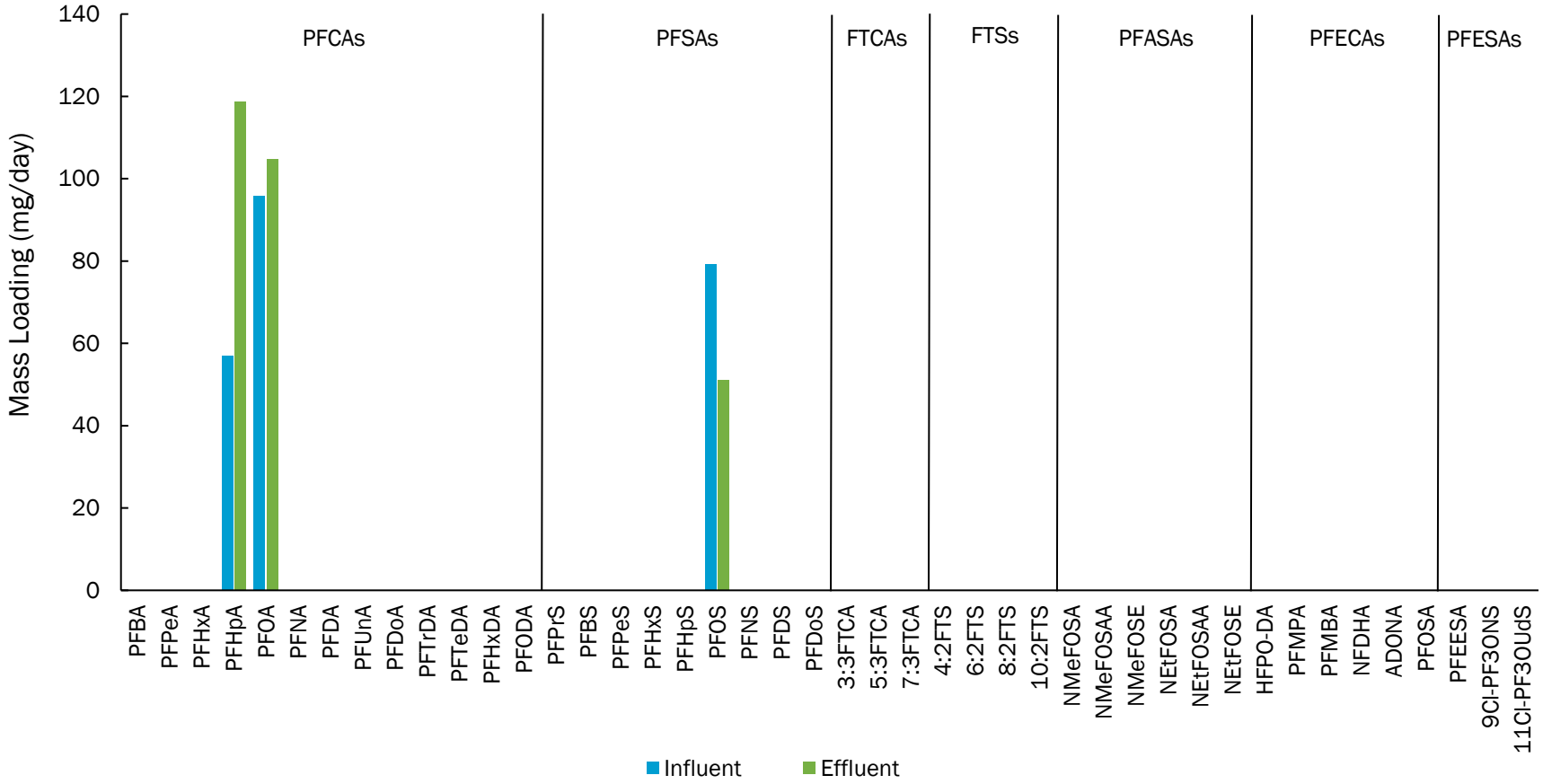


Figure 4-55. Influent and Effluent PFAS Mass Loading for POTW M

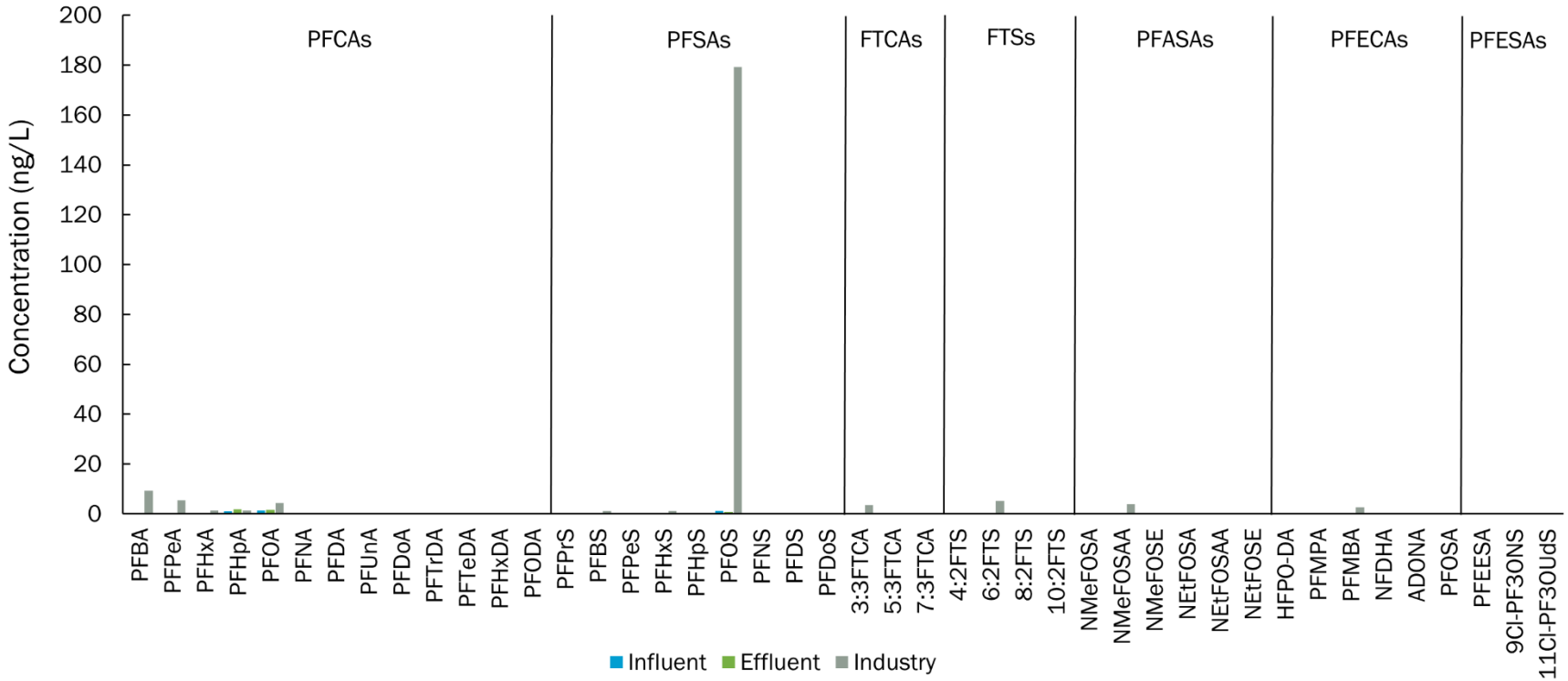


Figure 4-56. Influent, Effluent, and Industrial PFAS Concentrations for POTW M

Case Study Conclusions

Broad, definitive conclusions into the fate, transport, and transformation of PFAS from the investigation into the case studies of these 13 POTWs are not possible. Each POTW must be viewed on a case-by-case basis taking into account POTW specific factors such as influent streams from septage and industrial users, sludge treatment configurations, treatment technologies, and sampling locations.

A robust mass balance of PFAS around a POTW between influent, effluent, and sludge from the data collected is difficult due to several factors including the small order of magnitude of PFAS being measured in the sampling, the limited number of samples collected for each POTW and sublocation, and the nature of grab sampling which can only capture a moment in time when the sample was taken. These factors mean there is potentially high variability in the sampling and can be greatly impacted by any errors in the data and sampling, limiting the confidence that the average values reported are “real." A single particularly high sample amongst only a handful may bias the average away from the “actual” value. Therefore, more sampling should be conducted to include in the data set to have a larger sample size which can provide more confidence in individual POTW findings.

In some cases, specific industries or industrial categories can be the primary or significant contributor of particular PFAS compounds found in POTW influent. In these instances, an IPP or collaboration between the POTW and the industries of interest may reduce specific PFAS compound loading to the POTW. POTWs that have an IPP in place but have not sampled industrial users for PFAS, may find that an industrial user may be a significant contributor to specific PFAS compound loading.

4.4 Potential Source Control Opportunities

4.4.1 Product Replacement

Replacement of PFAS-containing products in industrial processes with non-PFAS alternatives has been successfully utilized in some cases to reduce industrial PFAS source contributions to POTWs. The Office of Technical Assistance (OTA) is a resource for POTWs, and along with the Massachusetts Toxics Use Reduction Institute (TURI), offers one such case study in which a Massachusetts manufacturer of materials for the electronics industry replaced their use of PFAS with a safer alternative. By replacing a PFAS-containing surfactant with one that does not contain PFAS in their etching process, this company produces safer products, has improved workplace safety, and has reduced ongoing surfactant unit costs by about 97%.

PFAS are also widely used in the textile and leather industries as waterproof membranes and surface treatments for products as well as processing agents to aid in deposition of dyes and bleaches or reduce foaming in treatment baths and as emulsifying agents. Textile manufacturing has contributed to Massachusetts’ economy since the Industrial Revolution, especially throughout the eastern region of the state. Discharge of textile manufacturing process water to POTWs can also contribute PFAS to POTWs, although product replacement and process substitution can reduce PFAS loading. For example, there are several PFAS-free alternatives for waterproofing in use today, such as wax-based treatments, and several textile and leather manufacturers claim not to use PFAS in their products at all that commonly contain PFAS, such as outerwear.

Product replacement at smaller scales can also substantially reduce PFAS contamination. In fact, customer interest in safer alternatives to PFAS drove the Massachusetts electronics components manufacturer to seek TURI and OTA’s assistance in identifying and implementing alternatives, and consumer demand for environmentally sustainable products can influence product and process

design. Following the detection of PFAS in drinking water supplies in Colorado, Maine, and Utah that were connected to widespread use of PFAS-containing ski and snowboard waxes, municipalities, winter sports equipment retailers, and at least one wax manufacturer have implemented ongoing take-back, buy-back, or trade-in programs. While the long-term effects of these programs remain to be seen, public participation in pollution prevention as exemplified by these programs is promising.

4.4.2 Contaminated Equipment Remediation or Replacement

Assessing Remediation or Replacement Need

Prior work suggests that historic PFAS contamination can contribute to ongoing PFAS loading. For example, Michigan EGLE's 2020 study on Targeted and Nontargeted Analysis of PFAS in Fume Suppressant Products in Chrome Plating Facilities found that PFOS was detected in facilities' wastewater discharges despite the fact that PFOS was not detected in fume suppressants used at the time of sample collection. The effluent PFOS was attributed to these facilities' past use of PFOS-containing fume suppressant products (EGLE, 2020c).

PFAS's surfactant qualities means that it can sorb, or physically or chemically attach itself, to the surfaces of any container that it is in. This includes any equipment that PFAS is in physical contact with during manufacturing or transport, including tanks, pipes, valves, pumps, and any other process equipment.

In effort to reduce their PFOS discharge, two chrome platers that participated in Michigan EGLE's 2020 study on Targeted and Nontargeted Analysis of PFAS in Fume Suppressant Products in Chrome Plating Facilities undertook extensive cleaning of equipment associated with their plating lines. Although cleaning efforts resulted in some PFOS reduction, wastewater pretreatment remained necessary for both chrome plating facilities (EGLE, 2020c). As discussed in Michigan EGLE's (2020) report, "Identified Industrial Sources of PFOS to Municipal Wastewater Treatment Plants," remediation efforts may be cost-prohibitive or logistically infeasible at industrial facilities because of the potential for widespread contamination among etch, plating, and rinse tanks, secondary containment pits, parts racks, air pollution control equipment, pipes, ducts, and valves (EGLE, 2020a). Remediation may be more feasible when PFAS contamination remains localized.

Identification of equipment that should be replaced can be done in a series of steps. First, industries should identify if any of the products they use or have used in the past include PFAS. If such products are found, then a sample should be taken of the fluid moving through the process equipment. If PFAS contamination is found, then continue the investigation to determine if the PFAS comes from the current process or from historic contamination of pipes and equipment.

Pipe Replacement and Rehabilitation Costs

This study has not identified instances in Massachusetts where PFAS has been determined to emanate from contaminated sewer piping, although the possibility is a concern. If targeted source identification studies by POTWs identify legacy PFAS contamination within their collection systems, pipe replacement or rehabilitation (lining) may be warranted. Estimated pipe replacement costs range from $300/LF of 6-in PVC to $500/LF for 24-inch PVC, as shown in Table 4-14. These estimates are based on several assumptions: that bypass pumping will be required to prevent facility shutdowns during replacement, that pipes to be replaced will be less than 10 feet deep, that a four-inch-thick, seven-foot-wide asphalt pavement patch will be restored as part of the pipe replacement, that all replacement pipes will be SDR-35 PVC, and that groundwater management, soil replacement, and sewer structure replacement will not be required. Importantly, costs associated with the disposal of the contaminated pipes have not been included in these estimates.

Table 4-14. Pipe Replacement Costs		
Pipe Size (inches)	Material	Cost ($/Linear Foot)
6	PVC	300
8	PVC	350
12	PVC	400
24	PVC	500

As an alternative to pipe replacement, pipe rehabilitation in the form of cured in place pipe lining (CIPPL) may be a way to encapsulate potential legacy PFAS contamination in sewer pipes. Estimated CIPPL costs range from $100/LF for 6-in piping to $300/LF for 24-in piping, as shown in Table 4-14 CIPPL costs are largely driven by mobilization of specialized equipment used during the lining process. As such, the estimated costs per linear foot will vary depending on the length of CIPPL required at each location. These estimated costs assume 100 linear feet of pipe lining per location.

Table 4-15. Pipe Rehabilitation Costs	
Pipe Size (inches)	Cost ($/Linear Foot)
6	100
8	150
12	200
24	300

4.4.3 Pretreatment Technology

In MI EGLE's study, approximately two thirds of chrome plating facilities included were discharging PFOS to wastewater treatment plants, despite not currently using PFOS-containing surfactants. After installing GAC pretreatment technologies, PFOS concentrations in effluent wastewater were reduced by orders of magnitude, and solid waste concentrations PFAS concentrations also decreased.

Technologies that are applicable for pretreatment in Massachusetts will depend greatly on the characteristics of the waste stream to be treated. Several of the technologies reviewed for liquid stream treatment in Section 2 are potentially applicable for use in pretreatment applications, including carbon or other media adsorption, ion exchange, reverse osmosis and foam fractionation. Selection of specific technology must consider the specific PFAS to be removed and the presence or absence of co-contaminants. Adsorption and ion exchange technologies are most suitable for relatively clean wastewater where PFAS faces little competition for adsorption or exchange sites and particulate matter is not present that could hinder flow through the media.

Foam fractionation and reverse osmosis offer more promise for wastewater that contains many contaminants, such as landfill leachate. Section 2.1.6 specifically addresses the use of these technologies to treat landfill leachate and presents cost curves for their application.

The decisions on whether to require pretreatment and, if so, which technologies to implement will be made on the local POTW and local industry/landfill level based onsite specific wastewater characteristics.

4.4.4 Pretreatment of Hauled-in Wastes

As discussed in Section 4.3.2, there is some evidence that hauled-in wastes typically processed by POTWs may have elevated PFAS concentrations and significantly affect overall PFAS loading at POTWs. Landfill leachate and domestic septage are two such hauled-in wastes. Pretreatment of hauled-in wastes high in PFAS have reduce PFAS loading to POTWs. For example, Renewable Water Resources (ReWa), a POTW in Greenville, SC, has observed success in pretreatment of landfill leachate.

Brown and Caldwell recommended in their memorandum for Maine DEP entitled "Study for Sustainable Management of Wastewater Solids, Septage & Leachate in the State of Maine" (Brown and Caldwell, 2023) a multiple stage pretreatment system for septage before further treatment at the POTW. The first step is screening and dewatering to separate the liquid and solid phase before further treatment. Their recommendations only include destructive processes for the resulting solids, which would represent significant capital and operational costs. The liquid phase could either go to a separative process or destructive process. If a separative process is selected, the highly concentrated stream could then move to a destructive process, or it would need to be hauled away. The remaining clean water from a separative process could then enter the headworks of the facility. Further discussion of separative and destructive processes can be found in Section 3.1.

Section 5

Analysis of Potential Sludge Management Scenarios

5.1 Scenario Introduction

The landscape for sludge and biosolids management in the Northeast U.S. is uncertain, both currently and as projected into the future (see Part 1 report of this study). Through development and consideration of ten hypothetical scenarios, this section explores the possible impacts of developments that could further restrict the system (e.g., future regulations in Massachusetts, neighboring states and federally; aging infrastructure; and facility closures), as well as opportunities like advances in technology and the development of regional facilities that could help alleviate the situation. For each scenario, driving factors, resulting impacts, and possible responses are discussed. These include reasonable predictions of possible future conditions and management options through 2044 and later. The intent of these scenarios is not to exhaustively detail each potential combination of factors, impacts, and responses, but to illustrate possible future outcomes. This analysis will help MassDEP, Massachusetts POTWs, and other decision-makers understand what the future may hold and begin to develop adaptation strategies. It will also illuminate regulatory and technical support needed to advance possible solutions or mitigate problematic conditions, as well as financial impacts. The focus of this chapter is analyzing hypothetical sludge management scenarios related to sludge capacity, solids handling technologies, and PFAS. There are other factors that may influence sludge management that are outside of the scope of this report.

This work builds upon the previous sections of this report, which evaluate treatment technologies for PFAS in wastewater and sludge, sludge volume reduction technologies, PFAS loading and potential source reduction options, and the impact of PFAS on sludge management. It also helps lay some of the groundwork for the options suggested for consideration in the following section.

5.2 Scenario Overview and Assumptions

Ten scenarios were explored and determined in collaboration between the Consultant and MassDEP. These cover a range of situations involving restrictions for land application, landfill, or incineration, whether inside Massachusetts, regionally, or nationally. Scenarios also included innovative approaches, and legislative and funding solutions.

Baseline conditions used for this analysis were drawn from the Part 1 study (Tighe & Bond and Brown and Caldwell, 2024a). This includes factors such as:

- 6.2% escalation rate for sludge hauling costs.
- 4.7% escalation rate for all other costs.
- 2.2% discount rate for bringing future costs back to 2024 dollars.
- 0.5% annual population growth rate corresponding to a proportional increase in sludge production.

Inflation and other factors would also impact costs but were outside the scope for this study. The principal source of information specific to POTWs was the survey results gathered in Part 1. These

include the location of each POTW in Massachusetts and the quantity and type (e.g., liquid, dewatered cake, dried) of sludge produced, as well as the location where each POTW transports the sludge produced.

When evaluating the impact of each scenario, focus was placed on evaluating the net *change* that would result. Due to effects of population growth and escalation, for instance, quantities of sludge, hauling prices, and overall management costs are expected to increase. Simply describing the overall cost of a given scenario was deemed less valuable than articulating the change (i.e., increase or decrease in costs) that a scenario was likely to generate. For instance, closing a landfill would result in increased prices for the facilities hauling solids there, as they would need to find alternative outlets. Calculating the increase in cost allows for easier comparison among different scenarios and their relative impact, rather than the total cost.

Additionally, it was assumed that the scale of impact was relative to the total amount of dry tons directly affected (see Table 5-1), and that there would be price increases to both POTWs that are directly impacted and all others with contracted management of liquid or dewatered sludge (i.e., those that are in the sludge management market). For example, a restriction on landfilling sludge in Massachusetts would have a *direct* impact on those POTWs currently sending sludge to landfills in Massachusetts. It would also *indirectly* impact the sludge management costs for all other POTWs contracting their sludge management, since there would be a resulting increase in demand as the POTWs currently landfilling in Massachusetts look for other outlets (e.g., landfills in other states, or incinerator facilities in Massachusetts or elsewhere).

The percent price increases used in Table 5-1 are based on increases seen after other disruptions to the market in the region (e.g., the land application ban in Maine or outages at incineration facilities) but ultimately are speculative. The actual impacts if any of these scenarios were to occur would likely be much more nuanced (e.g., impacting different regions of the state differently) and would unfold over a period of many years, but this analysis is meant to give a high-level approximation of the relative magnitude of the different scenarios. As an example of interpreting Table 5-1, if a given scenario is estimated to directly impact 5,000 dry tons per year (dtpy), then each plant directly affected would see price increases of 15%, and all plants indirectly affected would see price increases of 7.5%. Table 5-1 also includes, for ease of reference, the range of impacted tonnage that each scenario falls into, and as a result, the corresponding price increases. The calculations detailing the tonnage impacted for each scenario will be demonstrated under the specific section pertaining to that scenario.

Table 5-1. Schedule of Estimated Direct and Indirect Impacts to Sludge Management Costs

Dry Tons Directly Impacted	Direct Impact (% Price Increase)	Indirect Impact (% Price Increase)	Scenarios Impacted
0 - 10,000	15%	7.5%	Scenario 3
>10,000 - 15,000	30%	15%	Scenarios 2 and 4
>15,000 - 20,000	45%	22.5%	Scenarios 1 and 5
>20,000	60%	30%	Scenario 6

These price increases are implemented in this analysis by evaluating the current costs a plant is incurring in sludge management, applying the price increase, and evaluating the change in costs. Since a plant will have to continue handling its solids regardless of external forces, only the change in costs is reflected in this report. For example, a plant may be paying $100/wet ton (wt) currently to

handle its solids. With a 15% price increase, that rate now goes up to $115/wt. The difference or net increase in costs is $115 - $100 = $15/wt. In the tables that follow, only anticipated changes in costs are represented. For each scenario where percent increases came into play, price increases were applied individually to each individual solids load for each plant and summed.

There are some plants which, if not directly affected in a scenario, were assumed to not have an indirect cost impact in that scenario since they are not reliant on contracted management of liquid or dewatered sludge and so are less sensitive to fluctuations in this market. These facilities, which are assumed to continue to pay the sludge management cost they are currently paying in scenarios where they are not directly impacted, are:

- GLSD and the MWRA Deer Island WWTP, as it is assumed these facilities would continue drying operations for their own sludge in scenarios where drying and land application are not directly impacted.
- All facilities with their own incinerator (UBCW and Lynn) or landfill (see Section 4.3 of Part 1 for a list), as they would continue utilizing these facilities for their own sludge in scenarios where these outlets are not directly impacted.
- Erving #2 POTW, as the paper mill is the source of most of the sludge, outlets are available for the sludge from this facility that are not open to most POTWs (such as the co-generation facility in Quebec currently receiving their sludge).

These twelve plants are listed in Appendix H, Table H-0.

This analysis reviews POTWs across the state. The characteristic of the plant influent (such as the proportion of flows comprising inflow and infiltration, combined sewer collection systems, and the nature and proportion of industrial flows) are assumed to not directly affect the results of the analysis.

This section introduces the ten different scenarios analyzed, which are explored more thoroughly in the following sections. It is important to note that many of these scenarios are not mutually exclusive and could occur simultaneously, with compounding effects in the form of price increases. However, as presented, these scenarios are completely independent of one another. See Table 5-2 for a summary.

1. Scenario 1 considers land application restrictions in Massachusetts, resulting in POTWs that are currently delivering sludge to compost or dryer facilities to find alternative facilities further away. These are the only two types of facilities currently processing sludge for land application in Massachusetts.
2. Scenario 2 considers land application restrictions in neighboring states, specifically in New Hampshire, Vermont, and Connecticut. Federal restrictions could also lead to fewer land application outlets in neighboring states.
3. Scenario 3 considers landfill restrictions in Massachusetts. In this scenario, landfills that currently accept sludge from outside the community where the landfill is located will reduce the amount of sludge accepted by a significant portion (assumed to be 50% in these calculations).
4. Scenario 4 considers landfill restrictions in neighboring states. Here, Vermont and New Hampshire stop accepting Massachusetts sludge at their landfills, and New York landfills only accepts 50% of what is accepted currently. Federal restrictions could also lead to fewer landfill outlets in neighboring states.
5. Scenario 5 considers incineration restrictions in Massachusetts. The Upper Blackstone Clean Water (UBCW) incinerator is assumed to reach the end of its useful life and become unable to accept any outside sludge.

6. Scenario 6 considers incineration restrictions in neighboring states. In this analysis, it is assumed that all sewage sludge incinerators (SSIs) in Rhode Island close or stop accepting sludge from Massachusetts. Federal restrictions could also lead to fewer SSI outlets in neighboring states.
7. Scenario 7 explores the impacts of additional disposal capacity becoming available, specifically due to rehabilitation of five mothballed incinerators in the state.
8. Scenario 8 explores the impacts of additional sludge reduction capacity becoming available, such as opening a large regional drying or anaerobic digestion facility.
9. Scenario 9 explores development of new PFAS treatment capacity, such as the construction of a large regional pyrolysis facility.
10. Scenario 10 explores source reduction of PFAS going to POTWs.

The estimated impact of each scenario is broken out by size and region of the Commonwealth of the facilities impacted. For reference, a map of MassDEP regions is provided in Figure 5-1.



Figure 5-1. Map of Massachusetts Department of Environmental Protection Regions

Map provided by MassDEP

Table 5-2. Sludge Management Scenarios (through 2044 and beyond)

Scenario

Scenario Category	Land Application		Landfill		Incineration		New capacity, innovation, legislative & funding solutions			
Scenario Number	1	2	3	4	5	6	7	8	9	10
Scenario Description	Land application restrictions in Massachusetts	Regional/national land application restrictions with regional impact	Landfill restrictions in Massachusetts	Regional/national landfill restrictions with regional impact	Incineration capacity reduction in Massachusetts	Regional/national incineration restrictions with regional impact	Additional sludge disposal capacity becomes available	Additional sludge reduction capacity becomes available	New sludge PFAS treatment capacity becomes available	Source reduction to reduce PFAS at POTWs
Modeled Driving Factor	Legislation banning/restricting land application in Massachusetts	Legislation or regulation in neighboring states takes effect	PFAS regulations governing landfills are implemented Landfill operators limit "wet wastes" – typically defined as less than 60% TS	Legislation or regulation in neighboring states takes effect	Sewage Sludge Incinerators (SSIs) at Upper Blackstone Clean Water (UBCW) reach the end of their useful life (anticipated within the next 10-15 yrs)	Legislation or regulation takes effect in neighboring states	Rehabilitation of five existing mothballed incinerator facilities	Large regional drying facility opens	Large regional pyrolysis, gasification, SCWO or other facility opens	Pretreatment and source reduction efforts successfully bring down PFAS concentrations to acceptable levels
Modeled Resulting Impact	Land application in Massachusetts goes to zero Dried biosolids, compost to landfill or hauled further away	New Hampshire, Vermont, and Connecticut stop accepting biosolids from Massachusetts for the purpose of land application	Landfills in Massachusetts take 50% less sludge from non-local sources Increase in management costs to haul to out-of-state landfills	Vermont and New Hampshire stop accepting biosolids to landfills; New York takes 50% less sludge Increase in management costs to haul to more distant locations	UBCW SSI closes; must find outlet for large amount of dewatered cake Smaller plants bringing solids to UBCW send to other facilities accepting liquid or forced to put in dewatering	All incinerators in Rhode Island close down Smaller plants bringing liquid sludge to Rhode Island send to facilities accepting liquid or forced to put in dewatering Plants currently hauling cake to Rhode Island must find alternate outlets	Partially stabilizes management cost increases	Additional capacity may avoid disposal cost fluctuations	PFAS treatment technology leaves the opportunity to land apply low-PFAS biochar, even if land application of biosolids is banned Additional capacity may avoid management cost fluctuations	Requires additional oversight by POTW IPP coordinators
Modeled Solution	POTWs haul further away	POTWs haul further away	POTWs haul further away	POTWs haul further away	POTWs haul further away Dewatering or drying installed to enable easier transport or increased acceptance at landfills	POTWs haul further away Dewatering to enable easier transport or increased acceptability at incineration facilities	State funding incentivizes new disposal capacity	State funding incentivizes new sludge reduction capacity	States promote development of new technologies through funding of siting studies / pilot testing / new development	Increased enforcement of industrial discharge reduces PFAS flows to POTWs

5.2.1 Scenario 1 – Land Application Restrictions in Massachusetts

This scenario examines the possible impacts of a land application ban or restrictions taking effect in Massachusetts, whether due to legislation or other causes. The prospective impact is that all land application in Massachusetts is eliminated. Biosolids dryer facilities (MWRA and GLSD) and biosolids compost facilities (Bridgewater, Dartmouth, Hoosac, Ipswich and Southbridge), as well as POTWs bringing material to those facilities, would be directly affected. In addition, a land application ban in Massachusetts would require operational adjustments at the Hawk Ridge biosolids compost facility in Maine, as most of its compost is land applied in Massachusetts. While the exact impact is uncertain, for the purposes of this analysis, it was assumed that all plants sending material to Hawk Ridge would have to find another outlet. In addition, smaller composting facilities may be faced with a need to fully shut down composting operations, as their compost is mostly locally applied. As a result, it may not be practical or economically feasible to haul finished compost long distances across state lines for distribution.

Among the Massachusetts POTWs sending sludge to compost or drying facilities in Massachusetts, five (Acton, Concord, Maynard, Merrimac and Monroe) haul liquid sludge to processing facilities for land application (to GLSD, Ipswich, and Hoosac). If a land application ban is enacted and compost and/or drying facilities restrict the amount of sludge accepted from other POTWs, these five facilities producing liquid sludge will have few other outlets. For reference, the facilities that accepted liquid sludge from Massachusetts POTWs is shown in Table 5-3. (Note: The Erving #1 POTW accepts liquid sludge, but only from other Erving facilities.)

Table 5-3. Facilities Accepting Liquid Sludges from Massachusetts POTWs (2023)

Facility Type	Facility Name	State
Incinerators	Upper Blackstone Clean Water	MA
	Cranston WPCF Incinerator	RI
	MDC Hartford Connecticut Incinerator	CT
Drying/Composting Facilities	Greater Lawrence Sanitary District	MA
	Ipswich Compost Facility	MA
	Hoosac WQD	MA
Other POTWs	Lowell Regional WW Utility	MA
	Westfield WPCP	MA
	New Bedford WWTP	MA
	Montague WPCF	MA

Cost and Operation Impacts

To determine the extent of the impact under this scenario, Table 5-3 from Part 1 was re-visited. This data was organized to highlight how many dry tons would be affected by a ban on land application in Massachusetts (Table 5-4). For instance, while MWRA sends a total of 32,524 dry tons for land application, only 2,739 dry tons is applied in Massachusetts.

Table 5-4. Land-Applied Solids sent to MA from MA Plants								
	Sending Plant							
	Bridgewater	Ipswich Composting Facility	MWRA	Hawk Ridge Compost Facility	GLSD	Dartmouth	HWQD	Southbridge
Dry Tons Sent to MA	345	1,623	2,739	6,647	2,626	992	265	737
Dry Tons Sent Elsewhere	0	85	29,785	3,571	3,926	0	14	0
Total Dry Tons Sent	345	1,708	32,524	10,218	6,552	992	279	737
% Sent to MA	100%	95%	8%	65%	40%	100%	95%	100%

By adding up the dry tons sent to Massachusetts in this table, it was determined that 15,974 dtpy of sludge would be affected in this scenario. This is equivalent to 9% of dry solids produced in the state, or roughly 2,000 tractor trailers of material. This quantity of solids can be further divided into cake (i.e., sludge that has been dewatered), or dried biosolids (i.e., sludge that has been dried). There are 10,609 dry tons (equivalent to 46,530 wt of cake) that would need to be hauled further away and may see higher tip fees, and 5,365 dry tons (equivalent to 5,831 wt of dried biosolids) that would also require hauling to another outlet, potentially with higher tip fees. Combined, this amounts of 52,361 wt of cake and biosolids. The most likely solution was assumed to be hauling sludge further away (out of state). Since the dry tonnage of sludge directly impacted is between 15,000 and 20,000 dry tons, Table 5-1 indicates that directly affected plants would see price increases of 45%, and indirectly affected plants would see price increases of 22.5%. Plants already hauling their sludge to other dryers or compost facilities would therefore see a cost increase of 45%. As noted in Section 5.2, change in overall costs was considered the most pertinent outcome, and is the focus of this and future sections discussing cost impacts. A list of facilities directly impacted is included in Table H-1A.

Compost facilities deserve special consideration in this scenario, as they are somewhat sheltered from the broader sludge management market. This is because composting their own sludge enables them to be largely self-sufficient. To quantify this, a current sludge management cost for compost facilities that process their own sludge (Bridgewater, Dartmouth, Hoosac, Ipswich, and Southbridge) was assumed at $50/wt. Collectively, these five plants compost roughly 2,609 dt or 6,000 wt of compost. As a result of the land application restrictions explored in this scenario, these five facilities would need to haul their sludge elsewhere, since they could no longer find outlets for the compost they produce. The average cost of current sludge management, as determined in Part 1, Section 3.8, is $156/wt (Tighe & Bond and Brown and Caldwell, 2024a); thus, $156/wt is the base price that these plants could expect to pay as a result of entering the broader sludge market, prior to any disruption. A theoretical price increase of $20/wt to the base price of $156/wt for sludge management was also assumed, representing disruptions to the current sludge market brought about by effects considered in this scenario. As a result, these five facilities (Bridgewater, Dartmouth, Hoosac, Ipswich, and Southbridge), would now pay $176/wt ($156 + $20 = $176). Relative to the original assumed management cost of $50, the overall increase in sludge management pricing would be $126/wt ($156 + $20 - $50 = $126), or an increase of about 250% ($126/$50 = 250%). Cost increases for compost facilities that process their own sludge to ship outside of Massachusetts totals over $750,000 ($756,000) per year. See Table H-1B in Appendix H for detailed calculations.

The remainder of directly impacted plants account for 13,365 dt, or 64,059 wt. From their current wet ton management cost, they would each see a 45% increase (based on the assumptions presented in Table 5-1). For instance, for a plant that paid the average rate of $156/wt, they would now pay $226/wt ($156 * 145% = $226), or an increase of $70/wt ($226 - $156 = $70). The total cost increases for the directly affected plants (excluding those which apply compost and were discussed above) amounts to roughly $3,417,000 ($3.4M) per year. Detailed calculations are in Table H-1C.

Of the plants sending sludge for land application in Massachusetts, only five send all or nearly all of their product to Massachusetts (the five composting facilities – Bridgewater, Dartmouth, Hoosac, Ipswich, and Southbridge). The remainder (MWRA, Hawk Ridge, and GLSD) only send a portion of their sludge for land application in Massachusetts. Thus, the plants which send their sludge to MWRA, Hawk Ridge, and GLSD, would see an equal proportion of the sludge they send to the receiving plant affected by direct price increases. As an example, MWRA land applies a total of 32,524 dry tons, with 2,739 being applied in Massachusetts. This comes out to 8% (2,739/32,524 = 8%), so 8% of their sludge would be directly impacted by price increases, resulting in a 45% increase to their costs. The remaining 92% would be affected by indirect price increases (22.5% increases to their costs). Indirect price impacts to these directly affected plants amounts to $3,489,000 ($3.5M). Detailed calculations for these indirect impacts are also in Table H-1C.

Included with the 15,974 dry tons directly impacted, 789 dry tons are handled by compost and drying facilities as liquid sludge. It was assumed that, for the purposes of this analysis, any liquid sludge already accepted at a dryer or composting facility would continue to be accepted at the facility or be diverted to another location that accepts liquid sludge at no additional cost.

These additional charges for directly impacted facilities (listed in Table H-1A), both for facilities bringing solids to compost or drying facilities, as well as compost facilities managing their own solids, resulted in an annual cost increase of approximately $4.2M ($3,417,000 + $756,000 = $4,173,000 or $4.2M), affecting 15,974 dtpy, across 20 different plants. This does not include the $3.5M that represents the indirect impacts on plants which send at least a portion of their sludge for land application in Massachusetts. The majority of plants considered were in the northeast region of the state and a plurality were considered to be medium size. These results are summarized in Table 5-5. Several potential outlets for sludge management were discussed in Section 4.7 and 7.3 in Part 1 (Tighe & Bond and Brown and Caldwell, 2024a). These include municipal solid waste landfill facilities, such as:

- Tunnel Hill Reclamation Landfill, New Lexington, OH
- Rumpke Sanitary Landfill, Cincinnati, OH
- Keystone Sanitary Landfill, Dunmore, PA
- Alliance Landfill, Taylor, PA
- Taylor County Landfill, Mauk, GA

Sites in Alabama, Kentucky, Ohio, Pennsylvania, and Virginia are developing sludge outlets in the form of mine reclamation, composting, lime stabilization, landfills, and deep well injection. It is important to note that long-distance hauling would involve numerous logistical and financial challenges, and is unlikely to become a sustainable long-term strategy.

Of the original 127 plants, 20 plants are directly impacted. Another six are not affected due to one or more of the reasons discussed in Section 5.2 (e.g., Lynn and Upper Blackstone can continue incinerating their sludge as usual. All plants that are unaffected by indirect impacts are listed in Table H-0. This leaves 101 (127 – 20 – 6 = 101) plants which would be indirectly impacted. To determine the cost of indirect impacts, the current sludge hauling costs each plant spends in a year

was multiplied by 22.5% (this corresponds to the scale of dry tonnage affected in this scenario, per Table 5-1).

As mentioned above, plants indirectly impacted would see price increases of 22.5%. These cost increases include both augmented hauling fees as well as access to more expensive outlets (that is, an overall management cost). The combined cost of indirect impacts was calculated by multiplying the current sludge hauling costs by 22.5% for each plant, and summing these figures. This resulted in indirect impacts of $10,374,000 ($10.4M) per year (see Table H-1D for detailed calculations). The total amount of indirect impacts amounts to $13,863,000 ($13.9M), including indirect impacts on plants sending sludge for land application in Massachusetts ($3.5M), and effects on plants which are indirectly impacted ($10.4M). While this and all remaining scenarios discuss financial impacts in aggregate, Section 3.5 reviewed impacts of sewer rate increases due to installation of new facilities, and demonstrated that these impacts are significantly more difficult to finance for smaller utilities.

Operational impacts may take the form, for larger utilities, of increased truck traffic, especially if there are limited facilities for loading and unloading of sludge at these plants. Facilities located farther from the border would have to haul their material farther.

Section 7.1.2 in Part 1 notes that the capacity of smaller composting facilities in Massachusetts is expected to decrease even without a land application ban. This is anticipated due to the difficulty in finding outlets for their product, as well as potential legislative or regulatory impacts. Decreases in capacity in this scenario are in addition to those explored in Part 1.

Table 5-5. Scenario 1 Summary: Land Application Restrictions in Massachusetts		
Parameter	Value	
# of Plants Directly Impacted	20	
# of Plants not Impacted	6	
# of Plants Indirectly Impacted	101	
Dry Tons Directly Affected per Year	15,974	
Wet Tons of Dewatered Cake Directly Affected per Year	46,531	
Wet Tons of Dried Biosolids Directly Affected per Year	5,832	
Direct Price Increase	45%	
Indirect Price Increase	22.5%	
Cost of Direct Impacts	$4.2M	
Cost of Indirect Impacts	$13.9M	
Annual Total Cost Increase	$18.1M (15% of current $118.8M annual cost)	
Breakdown of Directly Impacted Plants by MassDEP Region		
Region	Count of POTWs	Percentage of Total Number of Directly Impacted Plants
Central	3	15%
Northeast	12	60%
Southeast	3	15%
West	2	10%
Total	20	100%
Breakdown of Directly Impacted Plants by Size		
Size	Count of POTWs	Percentage of Total Number of Directly Impacted Plants
Small (<1 mgd)	4	20%
Medium (1 to 5 mgd)	9	45%
Large (>5 mgd)	7	35%
Total	20	100%

Potential Mitigation Measures

The analysis focused on cost impacts from disruptions to previous strategies for managing biosolids. Some alternative solutions to this scenario include:

- Implementing PFAS treatment technologies to allow for land application of low or no detectable-PFAS product (assuming that a land application ban would not affect PFAS-treated solids).
- Reducing PFAS at the source.
- Dewatering liquid sludges to enable easier transport and acceptance at additional outlets, such as incineration facilities or landfills. It's important to note that smaller plants may be

less well-equipped to incorporate this additional equipment and workflow. As a result, it may be more advantageous for them to truck their liquid sludge to a larger plant or regional dewatering facility.

Implementing PFAS treatment technology or source reduction could allow for continued land application. Research and development to support advances in technology would benefit significantly from state or federal funding, as well as from legislative measures to facilitate their evolution. There is a myriad of developing technologies that exist for treatment of PFAS, but only incineration is an established, commercial-scale technology. Among the developing technologies, there exist only a few commercial-scale installations (pyrolysis and gasification) that have been operating for a few months to a few years. Costs for installing new technology would need to be considered if this approach were pursued, as well as the hauling costs that would continue to be borne until the installation is fully operational.

PFAS source reduction is another potential solution. Such reduction could be enacted through legislation, or limiting the use of PFAS products, although there would be significant lag before the benefits of this approach would be realized. As an alternative to or in conjunction with legal efforts, source reduction may take place by treatment of influent upstream of solids handling. Potential pretreatment technologies and approaches are as discussed in Section 3.1. In this case, treatment may be either distributed and coordinated with a utility's industrial pretreatment program (e.g. treatment located at each industry discharging PFAS) or centralized (located at the receiving plant). In either case, this would require a significant effort in identifying and characterizing different sources and developing appropriate technologies for reduction and ultimate means of disposal.

5.2.2 Scenario 2 – Land Application Restrictions Regionally or Nationally

Scenario 2 evaluates the effects of land application restrictions or bans in other states. This could be the result of numerous causes, such as:

- Legislation or regulation in neighboring states takes effect.
- Canada restricts importation of biosolids from the United States.
- The designation of PFAS-containing sludge as a hazardous substance under Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) has a dramatic effect, limiting land application.
- Public concern about PFAS and other contaminants of emerging concern.
- Based on the recently published Sewage Sludge Risk Assessment for PFOA and PFOS, the EPA sets low limits for PFOS and/or PFOA in land applied biosolids.

When EPA's 503 regulations were initially published in the Federal Register in 1993, they were accompanied by a preamble outlining the implications the regulations will have for other federal acts. CERCLA was specifically addressed; since the "normal application of fertilizer" is exempt from liability under CERCLA, the preamble explains that utilizing biosolids in a manner that is considered a "normal application of fertilizer," is exempt from CERCLA liability. An important distinction is that fertilizers are not categorically exempt; if a fertilizer was dumped into a stream, there could be CERCLA liability. What remains unclear is whether the new CERCLA designation of PFOA and PFOS continues to provide protections from CERCLA liability if a site receiving biosolids and utilizing them as a "normal application of fertilizer" becomes contaminated with PFAS.

While the EPA does not plan on pursuing enforcement actions for entities such as farmers, municipal landfills, water utilities, municipal airports, and local fire departments, this does not prevent these entities from being sued under CERCLA by others, for which the CERCLA exemption described in the preamble to 40 CFR 503 would be tested. Another important consideration with respect to CERCLA is that only PFOA and PFOS have been listed as hazardous substances; both have been banned from

manufacture for over a decade, leading to a substantial decline in environmental levels. As of now, the EPA has not announced plans to add additional PFAS substances, which would require substantial research and time prior to inclusion.

For this analysis, it was assumed that legislation in neighboring states was the most likely driver of change. This was considered probable as Maine and, more recently, Connecticut have banned land application of biosolids. Since the ban in Connecticut is very recent (having gone into effect in October 2024), it was deemed worth exploring the potential effects of this ban, as well as possible restrictions in New Hampshire and Vermont. Vermont and New Hampshire were chosen for the following reasons:

- Vermont has set very low PFAS limits in biosolids (Vermont Residuals Management Group, 2024).
- New Hampshire is in the process of developing soil screening standards, which are anticipated to be below the levels of PFAS currently in many POTW sludges (RFQ DES 2025-01, 2024).

Note that neither Scenario 1 nor Scenario 2 represent worst-cast scenarios. For example, New England states often mimic aspects of regulations in other New England states, so it is possible that a land application ban in Massachusetts could eventually trigger land application bans in neighboring states, or vice versa. In addition, far greater amounts of sludge from Massachusetts are land applied in New York (18,270 dtpy) and Canada (10,386 dtpy) than these states, so restrictions in these jurisdictions would have a more significant impact (Part 1, Table 7-1). (The recently passed regulations in New York and Canada will allow the continued land application of biosolids without elevated levels of PFAS for the foreseeable future; therefore, bans on land application in New York and Canada were not included in this analysis.)

Cost and Operation Impacts

To determine the extent of the impact under this scenario, Table 5-3 from Part 1 was re-evaluated. This data was organized to highlight how many dry tons would be affected by a ban on land application in Connecticut, New Hampshire, and Vermont (Table 5-6). For instance, while GLSD sends a total of 6,552 dry tons for land application, only 1,520 dry tons are applied in Connecticut, New Hampshire, or Vermont.

Table 5-6. Land-Applied Solids sent to CT, NH or VT from MA Plants

Region	Ipswich Composting Facility	MWRA	Hawk Ridge Compost Facility	GLSD	HWQD
Dry Tons Sent to CT, NH, or VT	85	5,741	3,571	1,520	14
Dry Tons Sent Elsewhere	1,623	26,783	6,647	5,032	265
Total Dry Tons Sent	1,708	32,524	10,218	6,552	279
% Sent to CT, NH, or VT	5%	18%	35%	23%	5%

By adding up the dry tons sent to Connecticut, New Hampshire, or Vermont, it was calculated that 10,931 dtpy would be affected in this situation. In this hypothetical scenario, New Hampshire (3,571 dry-tons of Massachusetts sludge land applied in 2023) and Vermont (1,556 dry-tons) both stop accepting sludge from Massachusetts for the purpose of land application. This is combined with the anticipated effects of Connecticut's recently-enacted ban (5,804 dry-tons). As a result, 10,931 dtpy would be affected (3,571 + 1,556 + 5,804 = 10,931), representing contributions by 17 plants (see

Table H-2A in Appendix for a complete list). This amounts to 6% of all dry solids produced in Massachusetts, and would be enough to fill over 1,500 tractor trailers and 900 liquid tankers. Sludge hauled to those states would incur a surcharge representing the additional cost of finding alternate locations to manage the sludge, including economic effects of increased demand on already-strained resources, additional driving distance, fuel usage, and labor, and higher tip fees. This equates to a 30% increase for directly affected plants (referencing Table 5-1 between 10,000 and 15,000 dtpy are affected, corresponding to direct impacts of 30%, and indirect impacts of 15%).

Five plants send sludge for land application in Connecticut, New Hampshire, or Vermont (Ipswich, MWRA, Hawk Ridge, GLSD, and HWQD, see Table 5-6). The amount of their total sludge production they send to Connecticut, New Hampshire, or Vermont varies by plant – for instance, Ipswich only sends about 5% of its sludge to Connecticut, New Hampshire, or Vermont (85/1708 = 5%). Thus, the plants which send their sludge to these five plants would see an equal proportion of the sludge they send to the receiving plant affected by direct price increases. For those sending sludge to Ipswich, for example, 5% of their sludge would see direct price impacts of 30%. The remaining 95% of sludge would be affected by indirect price increases (15% increase to their costs per Table 5-1). Some plants send some sludge for land application in Connecticut, New Hampshire, or Vermont, and some of their sludge to a different destination that would not be directly impacted (Concord, for example, sends a portion to a landfill in Vermont). As a result of direct impact price increases, an annual increase in costs to these 17 plants of $1,369,000, or $1.4M, was calculated (see Table H-2B in Appendix for detailed calculations). Indirect price impacts to these directly affected plants amounts to $2,850,000, or $2.8M. Detailed calculations for these indirect impacts are also in Table H-2B.

Of the total 127 plants in the state, 17 plants were directly impacted, and additional nine saw no impacts. This leaves 101 (127 – 17 – 9 = 101) plants which would see indirect impacts of 15%. Multiplying current sludge hauling costs for each plant by 15% results in indirect cost increases of $6,916,000, or $6.9M per year (see Table H-2C in Appendix H). This is in addition to the indirect impacts to plants which send a portion of their sludge to be land applied in Connecticut, New Hampshire, or Vermont of $2.8M. The total indirect impacts, therefore, amount to $9.8M.

Of the 10,931 dry tons considered in this analysis, approximately 800 dry tons are in the form of liquid sludge, comprising a volume of roughly 5.2 MG. It was assumed that, for purposes of this analysis, any liquid sludge already accepted at a dryer or composting facility would be diverted to another location that accepts liquid sludge at no additional cost. Most plants were in the northeast region of the state, and over 80% were either large- or medium-sized POTWs. These data are summarized in Table 5-7.

Table 5-7. Scenario 2 Summary: Regional/National Land Application Restrictions with Regional Impact on Massachusetts POTWs		
Parameter		**Value**
# of Plants Directly Impacted		17
# of Plants not Impacted		9
# of Plants Indirectly Impacted		101
Dry Tons Directly Affected per Year		10,931
Wet Tons of Dewatered Cake Directly Affected per Year		47,943
Direct Price Increase		30%
Indirect Price Increase		15%
Cost of Direct Impacts		$1.4M
Cost of Indirect Impacts		$9.8M
Annual Total Cost Increase		$11.1M (9% of current $118.8M annual cost)
Breakdown of Directly Impacted Plants by MassDEP Region		
Region	Count of POTWs	Percent of Total Number of Directly Impacted Plants
Central	2	12
Northeast	12	71
Southeast	1	6
West	2	12
Total	17	100
Breakdown of Directly Impacted Plants by Size		
Size	Count of POTWs	Percent of Total Number of Directly Impacted Plants
Small (<1 mgd)	4	24
Medium (1 to 5 mgd)	6	35
Large (>5 mgd)	7	41
Total	17	100

Potential Mitigation Measures

Some avenues for mitigating the impacts explored above, in addition to hauling sludge to more distant locations, include:

- Development and implementation of PFAS treatment technologies.
- Source reduction of PFAS, for example, by industrial pretreatment programs.
- Expansion of dewatering for liquid sludges, thereby enabling easier transport and acceptance at additional outlets, such as incineration facilities or landfills.

Advantages of dewatering and even drying would be very evident in this scenario, due to decreasing the volume of solids requiring transport. A more detailed analysis would be required to evaluate the

relative costs and benefits of implementing these technologies, compared to the price increase for the diverted solids.

Similar to Scenario 1, PFAS reduction techniques, such as industrial pretreatment or source control, or the advancement of destructive technologies, could have a significant beneficial impact on sludge management.

5.2.3 Scenario 3 – Landfill Restrictions in Massachusetts

This scenario explored the potential for landfill restrictions in Massachusetts. This could be the result of several factors:

- Organics landfill diversion is expanded beyond food waste.
- PFAS regulations governing landfills are implemented.
- Landfill operators limit "wet wastes" – typically defined as less than 60% total solids.

Landfill restrictions explored here are in addition to the anticipated landfill closures discussed in Part 1 (Tighe & Bond and Brown and Caldwell, 2024a).

In this scenario, sludge that is disposed in a landfill that is not owned by the local municipality would be reduced. The impact was assumed to be reflected in a 50% reduction in sludge being sent to the Resource Control, Inc., Fitchburg Landfill, as they are the only privately-owned landfill accepting sludge. Eleven municipalities in Massachusetts operate landfills or sludge monofills that only accept sludge or incinerator ash from the local POTW. It was assumed that these municipalities would be shielded from broader restrictions and would continue to place sludge or ash in their local landfill at no additional cost.

Cost and Operation Impacts

This would only affect one plant, the Fitchburg East Wastewater Treatment Plant (WWTP). Fitchburg currently sends 1,837 dry tons to the Resource Control, Inc, landfill (noted in Table H-3A). Under this scenario, 919 dtpy (half of the 1,837 dt currently being sent) would be affected (less than 1% of total dry solids produced in the Commonwealth annually, and equivalent to roughly 150 tractor trailers). This change would incur a 15% price increase, representing the difficulty that the Fitchburg WWTP would have in finding a new landfill, and increased driving distances, if Resource Control, Inc. reduced how much sludge they would accept from Fitchburg WWTP (Table 5-1) indicates that scenarios where less than 10,000 dtpy are affected result in 15% direct increases, and 7.5% indirect increases). The overall direct cost increase annually would be roughly $25,000 (compared to the annual operating budget of $4.9M). The remaining half of the sludge that Fitchburg can still send to the RCI landfill would be subject to indirect impacts, totaling $12,000. See Table H-3B for detailed calculations.

Of the total 127 plants, one is directly impacted, and a further eleven are not affected. This results in indirect impacts to 115 (127 – 1 – 11 = 115) plants, increasing prices by 7.5%, and resulting in an annual cost increase of $4,601,000, or $4.6M. This is in addition to the indirect costs that Fitchburg would see ($12,000). See Table H-3C for detailed calculations. This analysis is summarized in Table 5-8.

Table 5-8. Scenario 3 Summary: Landfill Restrictions in Massachusetts	
Parameter	**Value**
# of Plants Directly Impacted	1
# of Plants not Impacted	11
# of Plants Indirectly Impacted	115
Dry Tons Affected per Year	919
Wet Tons of Dewatered Cake Affected per Year	4647
Direct Price Increase	15%
Indirect Price Increase	7.5%
Cost of Direct Impacts	$25,000
Cost of Indirect Impacts	$4.61M
Annual Total Cost Increase	$4.64M (4% of current $118.8M annual cost)

Potential Mitigation Measures

While increasing hauling distances was explored in some detail as a possible response, other mitigation measures include:

- Implementing PFAS treatment technology to allow for land application or landfilling of low-PFAS product.
- Source reduction of PFAS, including landfill leachate treatment.
- Drying to enable easier transport or increases in incineration.
- New landfill capacity.
- Anaerobic digestion can also be implemented to supply energy and reduce the volume of material to be managed.

PFAS reduction options and considerations are similar to those explored in Scenario 1. Provided PFAS levels are reduced to an acceptable degree, this may enable continued usage of the Fitchburg Landfill. Development of drying facilities, or increased incinerator usage, should be compared against the price increases for finding alternative locations for sludge.

Expansion of landfill capacity may be a contentious issue among voters and local municipalities, but could be a short-term solution while, for example, research and development continue.

5.2.4 Scenario 4 – Landfill Restrictions Regionally or Nationally

Scenario 4 examined the impacts of landfill restrictions regionally or nationally. Possible contributing factors for this change include:

- Legislation or regulation in neighboring states or federally takes effect.
- Landfill operators limit “wet wastes” – typically defined as less than 60% total solids.
- Planned landfill expansions do not proceed. Table 4-5 in Part 1 notes four potential landfill expansions totaling approximately 5.3 million cubic yards. However, over 80% of this capacity has not yet been permitted, and should be considered tentative (Tighe & Bond and Brown and Caldwell, 2024a).
- Climate regulations restricting organics disposal (including sludge) in landfills are enacted in neighboring states.
- Federal PFAS regulations for landfill leachate are implemented.

Climate regulations are worth anticipating for several reasons. The EPA is expected to update rules governing landfill air emissions in 2025. Most states and landfills currently calculate greenhouse gas (GHG) emissions with EPA models instead of measurements; however, recent studies have shown that onsite measurements typically exceed modeled emissions by a significant margin (Peters, 2024). Such a discrepancy, as it becomes better understood and publicized, will only increase public pressure on officials to enact climate regulations.

Legislation in neighboring states was considered most likely and proposed to have the following impacts. These impacts are theoretical and intended to represent possible situations:

- Vermont and New Hampshire stop accepting sludge for landfills completely.
- New York landfills reduce sludge acceptance from Massachusetts by 50% (i.e., a decrease by 50% in the sludge that can be sent to New York landfills).

Cost and Operation Impacts

Evaluating the impacts under this scenario required revisiting Figure 7-1 from Part 1 (Tighe & Bond and Brown and Caldwell, 2024a). According to that figure, 6,841 dry tons are landfilled in Vermont, 2,823 dtpy are landfilled in New Hampshire, and 3,416 dtpy are landfilled in New York. Since only half of the sludge landfilled in New York would be affected, the contribution affected by a potential New York ban is 1,708 dtpy. Totaling up the combined tonnage that would be affected results in 11,372 dtpy (6,841 + 2,823 + 1,708 = 11,372), representing about 6% of all dried solids produced annually. Ten plants would be impacted by these developments, representing roughly 47,500 wtpy (enough to fill approximately 1,700 tractor trailers). See Table H-4A in Appendix H for a listing of these plants. Owing to the magnitude of the disruption (between 10,000 and 15,000 dtpy) a price increase of 30% was determined for plants directly impacted by referencing Table 5-1 resulting in an annual cost increase of approximately $2,327,000, or $2.3M, reflecting their need to find more distant outlets and the likelihood of paying higher tip fees (see Table H-4B in Appendix for detailed calculations). Plants affected by this change tended to be located in the central or northeast regions. A majority of plants were large POTWs, with the remaining plants considered medium-sized.

Since many of these ten plants send their sludge to multiple locations, some solids loads would be directly impacted (100% of those going to landfills in NH or VT, and 50% of those going to landfills in NY). The remainder of solids at these plants, however, would be subject to indirect impacts. Table 5-1 indicates that indirect impacts for this scenario are 15%. This price increase was incorporated into current biosolids hauling costs. Indirect impacts for these ten plants amounts to $1,795,000, or $1.8M (see Table H4-B).

A similar approach for the plants only experiencing indirect impacts was followed. Current sludge hauling costs were multiplied by 15% to determine the anticipated cost increases for plants indirectly impacted (i.e., none of the sludge they produced was sent to landfills in NH, NY, or VT). Indirect impacts resulted in a price increase of 15% for 106 plants, totaling $6,294,000, or $6.3M per year. Indirect costs for all plants (considering both the ten plants send some sludge to affected landfills, as well as the 106 plants indirectly impacted) totals $8.1M ($6.3M + $1.8M = $8.1M). The total annual cost for both direct and indirect impacts was $10.4M ($2.3M + $1.8M + $6.3M = $10.4M). This data is summarized in Table 5-9.

Table 5-9. Scenario 4 Summary: Regional/National Landfill Restrictions with Regional Impact on Massachusetts POTWs

Table 5-9. Scenario 4 Summary: Regional/National Landfill Restrictions with Regional Impact on Massachusetts POTWs		
Parameter	**Value**	
# of Plants Directly Impacted	10	
# of Plants not Impacted	11	
# of Plants Indirectly Impacted	106	
Dry Tons Directly Affected per Year	11,372	
Wet Tons of Dewatered Cake Directly Affected per Year	49,877	
Direct Price Increase	30%	
Indirect Price Increase	15%	
Cost of Direct Impacts	$2.3M	
Cost of Indirect Impacts	$8.1M	
Annual Total Cost Increase	$10.4M (9% of current $118.8M annual cost)	
Breakdown of Directly Impacted Plants by MassDEP Region		
Region	Count of POTWs	Percentage of Total Number of Directly Impacted Plants
Central	4	40%
Northeast	4	40%
Southeast	0	0%
West	2	20%
Total	10	100%
Breakdown of Directly Impacted Plants by Size		
Size	Count of POTWs	Percentage of Total Number of Directly Impacted Plants
Small (<1 mgd)	0	0%
Medium (1 to 5 mgd)	4	40%
Large (>5 mgd)	6	60%
Total	10	100%

Potential Mitigation Measures

Alternative methods to adapt to this change in landfill access include:

- Implementing PFAS treatment technology to allow for land application or landfilling of low-PFAS product.
- Source reduction of PFAS, including landfill leachate treatment.
- Drying to enable easier transport or increased acceptance at incineration facilities.
- New landfill capacity, or access to more distant landfill capacity.
- Anaerobic digestion can also be implemented to supply energy and reduce the volume of material to be managed.

PFAS reduction options for this scenario are comparable to those in Scenario 1. Climate regulations that would lead to landfill restrictions may also affect operation of incinerators, limiting that as a possible solution. Landfill leachate restrictions would have impacts both upstream and downstream: landfills may restrict POTWs depositing sludge with suspected PFAS, and POTWs may require landfills

to treat their leachate before discharging to the plant (since it would eventually end up in the sludge to some degree). As in Scenario 3, increases in landfill capacity could be thwarted by pressure or resistance from environmental groups, residents, and municipalities.

5.2.5 Scenario 5 – Incineration Capacity Reduction in Massachusetts

Scenario 5 explored impacts of incineration capacity reductions. Such a change in incineration capacity in Massachusetts could be sparked by several factors:

- The sewage sludge incinerators (SSIs) at UBCW reach the end of their useful life (anticipated within the next 10-15 yrs). The remaining useful life of the incinerator at Lynn Regional WWTP is one year at existing conditions, with planned rehabilitation expected to increase this by 20 years.
- State PFAS regulations concerning air emissions are implemented.
- Sewage sludge incinerator rehabilitation meets the 50 % threshold requiring the facility to meet newer, more stringent Clean Air Act regulations for sewage sludge incinerators, which can be cost prohibitive (CFR Title 40, Chapter I, Subchapter C, Part 60, subpart LLLL).

As was reported on the Part 1 survey, "UBCW is in the planning stages for a New England Regional Biosolids facility. If this facility is not built, UBCW will need to replace its incinerator." The estimated replacement cost for such a facility is $650M, per the survey response received from UBCW for Part 1 if this study – a significant cost for any utility to bear. If the regional biosolids facility does not come to fruition, and funding is not available for a new incinerator, this will represent a major decrease in incinerator capacity in the state.

The most likely scenario was considered to be the closure of the SSIs at UBCW, as UBCW is the larger of two SSIs in the state. UBCW processes about three times as much material as the other incinerator, located at Lynn Regional WPCF, so it would have a much greater impact if capacity there were eliminated and not replaced by a new facility.

Cost and Operation Impacts

This has several potential impacts. Overall, ten plants send a total of 17,988 dtpy to UBCW annually and would thus be affected (approximately 11% of all dry solids in the state, or 2,000 tractor trailers and over 5,000 liquid tankers). These ten plants are listed in Table H-5A. Approximately 31 MG of sludge, which originally was hauled to UBCW from other plants, would either be hauled or fed to new dewatering facilities. The cake produced by UBCW alone and incinerated there amounted to 52,035 wtpy (11,864 dtpy). In Table 5-1, impacts between 15,000 and 20,000 dtpy correspond to 45% increases for direct impacts, and 22.5% increases for indirect impacts.

The cake produced by UBCW and currently being incinerated at UBCW would need to find a new outlet. The average cake management price of $156/wt (determined in Part 1) was, for this analysis, assumed to increase by $20, resulting in $176/wt ($156 + $20 = $176) being charged for dewatered cake produced by UBCW and currently incinerated there. This increase considers additional driving distance and higher tip fees. The current cost for ash disposal being incurred by UBCW was assumed negligible in this analysis. An engineering economics analysis was applied to determine the net present value of these costs over 20 years, using a 2.2% discount rate, and then converted to an equivalent annual cost using a 4.7% escalation factor. The costs associated with operating the incinerator were not included but are likely to be considerable. Detailed calculations can be found in Table H-5B.

In addition, nine POTWs haul to UBCW. It was assumed that these plants would either accept increased sludge management costs or construct dewatering facilities to avoid this. They were

randomly divided into two groups – 4 plants that haul to UBCW were assumed to see an immediate increase in liquid sludge management costs. The remaining 5 plants would install dewatering facilities, to avoid increasing management costs. Table H-5A lays out which plants affected in this scenario were assumed to continue hauling or to install dewatering units.

As noted in the Executive Summary of the Part 1 study, sludge management costs have increased by 35% from 2018 to 2023. This is an average increase of 6.2 % per year and was applied only to sludge management (hauling plus tip fees) price increases. A standard escalation factor of 4.7 % was applied to other costs.

When calculating cost increases for those plants which would continue to haul and therefore see increases to management costs, an immediate 45% price increase was assumed per Table 5-1 (taking place in 2024). This increase was assumed to take place due to the restriction of available outlets for sludge. 45% is comparable to, or in some cases less than, price increases that have occurred in similar situations elsewhere. It is expected that such a large shift in the solids management landscape would result in immediate price impacts. Prices were assumed to continue to escalate at a rate of 6.2 % per year, and solids quantities also increased at a rate of 0.5 % per year, matching population growth. An engineering economics analysis was applied to determine the net present value of these costs over 20 years, using a 2.2% discount rate, and then converted to an equivalent annual cost using a 4.7% escalation factor. Detailed calculations for those plants that continued hauling are found in Table H-5C.

In determining the cost for facilities that would install dewatering, solids production was projected out to 2044, using 0.5% population growth. Centrifuge and screw press facility prices were calculated for each plant based on their 2044 loadings, utilizing equations developed in Section 3 of Part 2. The average of these figures was calculated, accounting for the uncertainty in selection of screw presses or centrifuges among plants.

Next, operations and maintenance (O&M) costs were also calculated for each year, according to the solids production at each facility, for both centrifuge and screw press facilities (these O&M costs were also calculated using equations developed in Section 3 of this report). Costs were escalated at a rate of 4.7% per year for 20 years, brought back to net present value using a discount rate of 2.2%, and then converted back to an annual cost using 4.7%.

The cost of liquid sludge management that POTWs installing dewatering would avoid (based on removing water from the solids) was also calculated, assuming an immediate 45% increase to their base prices, and an increase of 6.2% per year thereafter (as for the plants that continue hauling). This was converted to an average annual cost, and subtracted from the total cost of dewatering. However, these facilities would still have to haul the cake they produce, so this was calculated as an additional cost to provide the net change in costs POTWs installing dewatering would incur. Cake hauling costs included the 45% initial increase and 6.2% subsequent increase for consistency with other calculations. Calculations for the plants that opted for dewatering are in Table H-5D.

Indirect impacts would affect 107 additional plants with a price increase of 22.5%. In addition, several of the ten plants directly affected also have sludge that would be indirectly affected. These cost increases for both groups of plants would total $12,913,000, or $12.9M per year (see Table H-5E for detailed calculations).

The cost of management for UBCW-generated cake was determined to be $25,638,000, or $25.6M. Costs for management would increase for the four plants that continued hauling, by $1,909,000, or $1.9M per year. Costs for dewatering installation (including the annualized capital cost of the facilities and operating costs, the savings from no longer paying for liquid sludge management, and including costs of cake management) came out to $14,946,000, or $14.9M per year. The capital cost of installing dewatering facilities at these plants is approximately $77,814,000, or $77.8M.

Altogether, an estimated direct impact of approximately $42.5M ($25.6M + $1.9M + $14.9M = $42.5M) per year was calculated (Table H-5F summarizes direct and indirect costs to plants), which includes amortized capital costs.

Most plants directly affected in this scenario are located in the central region of the state, the same region where UBCW is located. 80% of plants were either medium or large-sized POTWs. Plants needing to manage liquid sludge as a result of incinerator capacity reductions can explore options in Table 5-3. Data for this scenario is summarized in Table 5-10.

Table 5-10. Scenario 5 Summary: Incineration Capacity Reduction in Massachusetts	
Parameter	**Value**
# of Plants Directly Impacted	10
# of Plants not Impacted	10
# of Plants Indirectly Impacted	107
Dry Tons Directly Affected per Year	17,988
Wet Tons from UBCW that are Re-directed per Year	52,035 (11,900 dtpy)
Gallons of Liquid Sludge Hauled to a new Location per Year	8,837,721
Gallons of Liquid Sludge Served by New Dewatering Facilities per Year	22,651,000
Price Increase for Wet Tons from UBCW, $/wt	$176
Direct Price Increase for Liquid Sludge	45% immediate increase over base price, with 6.2% escalation per year thereafter
Dewatering Facilities	Average of Centrifuge and Screw Press, sized per plant, 20-year useful life
Indirect Price Increase	22.5%
Annual cost increase of managing wet tons produced at UBCW	$25.6M
Annual cost increase of managing liquid sludge	$1.9M
Annual cost of dewatering and hauling cake	$14.9M
Estimated annualized capital cost of dewatering facilities	$6.1M
Estimated annualized O&M costs of dewatering facilities	$10.4M
Cost of Direct Impacts	$42.5M
Cost of Indirect Impacts	$12.9M
Total Annual Cost Increase	$55.5M (47% of current $118.8M annual cost)

Breakdown of Directly Impacted Plants by MassDEP Region

Region	Count of POTWs	Percentage of Total Number of Directly Impacted Plants
Central	6	60%
Northeast	1	10%
Southeast	2	20%
West	1	10%
Total	10	100%

Breakdown of Directly Impacted Plants by Size

Size	Count of POTWs	Percentage of Total Number of Directly Impacted Plants
Small (<1 mgd)	2	20%
Medium (1 to 5 mgd)	4	40%
Large (>5 mgd)	4	40%
Total	10	100%

Potential Mitigation Measures

The preceding analysis looked at cost increases due to management costs and dewatering facility installation. Other mitigation measures include:

- Implement PFAS treatment technology to allow for landfilling or land application of low-PFAS product.
- Source reduction of PFAS.
- New incinerator capacity.
- Drying to enable easier transport or increased acceptance at landfills.
- New landfill capacity, or access to more distant landfill capacity. This capacity would likely be subject to restrictions that have been seen elsewhere; for example, where a landfill limits wet waste and charges a premium to manage sludge. Decisions by local authorities would govern whether sludge containing PFAS would be accepted.
- Anaerobic digestion can also be implemented to supply energy and reduce the volume of material to be managed.

With the elimination of UBCW as an option for incineration, interest would likely increase around pyrolysis/gasification and other promising technologies. Advancement in this space would benefit greatly from investment at the state or national level, as well as legislation to support these efforts.

If UBCW shuts down their incineration process, it's most likely that they would replace it with an alternative technology (such as an anaerobic digestion or thermal drying process), potentially as part of the New England Regional Biosolids project, or as a stand-alone venture by UBCW. That facility could also include additional PFAS and/or volume reduction technologies such as pyrolysis and gasification, or include space for addition of these processes in the future once the technologies are developed further. Finally, there is a reasonable chance that a new sludge management system at UBCW would include spare capacity to receive some merchant sludge. However, that is not guaranteed, so this scenario analysis assumes that plants currently hauling to UBCW would need to find other outlets.

Development of new incinerator capacity, while possible, seems unlikely, especially considering the prospect of climate-related and air pollution regulations.

5.2.6 Scenario 6 – Incineration Capacity Reduction Regionally or Nationally

Similar to Scenario 5, Scenario 6 investigates impacts on Massachusetts solids handling as a result of reduced incinerator capacity in neighboring states. This could be the result of any of the following:

- Legislation or regulations, specifically targeting incinerators, are taking effect in neighboring states.
- The EPA implements federal restrictions governing PFAS in air emissions.
- Climate regulations are enacted in neighboring states or at a federal level, with an indirect effect on incinerators (see Section 5.2.4).
- SSI rehabilitation meets the 50% threshold requiring the facility to meet newer, more stringent Clean Air Act regulations for sewage sludge incinerators, which can be cost prohibitive (CFR Title 40, Chapter I, Subchapter C, Part 60, subpart LLLL).

The tangible impact of these factors was assumed to be Rhode Island incinerators shutting down, preventing any sludge from Massachusetts from being delivered and processed there.

Cost and Operation Impacts

A total of 44 plants would be directly impacted, collectively managing 23,370 dtpy (14% of annual solids production, or 350 tractor trailers and over 20,000 liquid tankers). These plants are listed in Table H-6A. Seven of these plants haul cake, and would need to find new outlets for their sludge. The remaining 37 plants all haul liquid sludge. Since Scenario 6 affects more than 20,000 dtpy, according to Table 5-1, directly impacted plants would see price increases of 60%, and indirectly affected plants would see price increases of 30%. Similar to Scenario 5, it was assumed that 50% of plants that currently haul liquid sludge would continue hauling and see their management costs increase by 60%, representing the additional distance needed to find a suitable location and the higher tip fees likely to be charged at other facilities. The other 50% of plants that currently haul liquid sludge to Rhode Island incinerators would build dewatering facilities. Plants were randomly assigned to each category in the analysis. Table H-6A indicates which plants haul cake, which would continue hauling liquid, and which would install dewatering. Price increases for the plants which continue hauling liquid and those which install dewatering followed the same logic as laid out in Scenario 5, with the main difference being that the price increase is 60% here, rather than 45%, due to the increased amount of sludge impacted.

For the plants which continue hauling, their hauling prices were assumed to increase 60% due to direct impacts on locations available for receiving sludge. Prices were assumed to continue to escalate at a rate of 6.2 % per year, and solids quantities also increased at a rate of 0.5 % per year, matching population growth. An engineering economics analysis was applied to determine the net present value of these costs over 20 years, using a 2.2% discount rate, and then converted to an equivalent annual cost using a 4.7% escalation factor. Detailed calculations for those plants that continued hauling are found in Table H-6B.

In determining the cost for facilities that would install dewatering, solids production was projected out to 2044, using 0.5% population growth. Centrifuge and screw press facility prices were calculated for each plant based on their 2044 loadings, utilizing equations developed in Section 3.4.4 of Part 2. The average of these figures was calculated, accounting for the uncertainty in selection of screw presses or centrifuges among plants.

Next, operations and maintenance (O&M) costs were also calculated for each year, according to the solids production at each facility in that year, for both centrifuge and screw press facilities (these O&M costs were also calculated using equations developed in Section 3.4.4 of this report). Costs were escalated at a rate of 4.7% per year for 20 years, brought back to net present value using a discount rate of 2.2%, and then converted back to an annual cost using 4.7%.

The cost of liquid sludge management that POTWs installing dewatering would avoid (based on removing water from the solids) was also calculated, assuming an immediate 60% increase to their base prices, and an increase of 6.2% per year thereafter (as for the plants that continue hauling). This was converted to an average annual cost, and subtracted from the total cost of dewatering. However, these facilities would still have to haul the cake they produce, so this was calculated as an additional cost to provide the net change in costs POTWs installing dewatering would incur. Cake hauling costs included the 60% initial increase and 6.2% subsequent increase for consistency with other calculations. Calculations for the plants that opted for dewatering are in Table H-6C.

A third group of plants would be affected, those that currently haul cake to Rhode Island for incineration. These plants would see an increase of 60% immediately, escalated by 6.2% per year. 6.2% has been calculated previously, in Part 1, as the annual average percent increase in sludge management costs from 2018 to 2023. Calculations for these plants are in Table H-6D.

For the 18 POTWs which would continue to haul liquid sludge, management price increases would result in an additional $9,855,000 or $9.9M per year to manage roughly 63 MG of sludge. The 19

POTWs randomly assigned to the group that would construct dewatering facilities would spend about $42,268,000 or $42.3M per year to handle 58 MG of liquid sludge (as in Scenario 5, this includes the annualized capital cost of the facilities and operating costs, the savings of not having to haul liquid sludge, and the added cost of managing dewatered cake). The capital cost of installing dewatering facilities at the plants implementing dewatering is $273,213,000, or $273.2M. The remaining seven plants of the 44 directly impacted would see an increase of $2,535,000, or $2.5M per year for the 10,000 wt they manage, as they would need to identify new outlets to handle their cake. Altogether, the 44 directly impacted plants would see a total annual average cost increase of $54,658,000, or $54.7M ($9.9M + $42.3M + $2.5M = $54.7M). This includes amortized capital costs.

78 plants would be indirectly impacted owing to the additional pressures on remaining sludge outlets. 15 of the directly impacted plants would also see indirect price increases on the sludge loads not currently being sent to Rhode Island incinerators. As a result of a 30% price increase for indirect impacts, these plants would experience $13,624,000, or $13.6M, per year in additional costs. Table H-6E details these indirect cost impacts, and Table H-6F summarizes direct and indirect costs for all plants.

The largest proportion of plants are located in the central region, followed closely by plants from the southeast and west region, indicating the tremendous impact such a change could have. Roughly half of these plants were of a medium size. Plants needing alternative outlets to manage liquid sludge can explore options in Table 5-3. Data for this scenario is summarized in Table 5-11.

Table 5-11. Scenario 6 Summary: Regional/National Incinerator Capacity Reductions with Regional Impact on Massachusetts POTWs		
Parameter	**Value**	
# of Plants Directly Impacted	44	
# of Plants not Impacted	5	
# of Plants Indirectly Impacted	78	
Dry Tons Directly Affected per Year	23,730	
Gallons of Liquid Sludge Hauled to a new Location per Year	62,720,538	
Wet Tons of Dewatered Cake that are sent to a different Incinerator per Year	10,407	
Gallons of Liquid Sludge Served by New Dewatering Facilities per Year	57,929,471	
Price Increase for Liquid Sludge and Re-directed Wet Tons	60% immediate increase over base price, with 6.2% escalation per year thereafter	
Dewatering Facilities	Average of Centrifuge and Screw Press, sized per plant, 20-year useful life	
Indirect Price Increase	30%	
Annual cost increase of managing liquid sludge	$9.9M	
Annual cost of dewatering and hauling dewatered cake	$42.3M	
Estimated annualized capital cost of dewatering facilities	$21.4M	
Estimated annualized O&M costs of dewatering facilities	$33.3M	
Annual cost increase of managing redirected cake	$2.5M	
Cost of Direct Impacts	$54.7M	
Cost of Indirect Impacts	$13.6M	
Annual Total Cost Increase	$68.3M (57% of current $118.8M annual cost)	
Breakdown of Directly Impacted Plants by MassDEP Region		
Region	Count of POTWs	Percentage of Total Number of Directly Impacted Plants
Central	15	34%
Northeast	3	7%
Southeast	13	30%
West	13	30%
Total	44	100%
Breakdown of Directly Impacted Plants by Size		
Size	Count of POTWs	Percentage of Total Number of Directly Impacted Plants
Small (<1 mgd)	10	23%
Medium (1 to 5 mgd)	23	52%
Large (>5 mgd)	11	25%
Total	44	100%

Potential Mitigation Measures

While more distant hauling or dewatering implementation were explored as solutions to this problem, other mitigation measures may include:

- Implement PFAS treatment technology to allow for landfilling or land application of low-PFAS product.
- Source reduction of PFAS.
- New incinerator capacity.

Similar to Scenario 5, the addition of incinerator capacity seems unlikely given the current regulatory environment. This would add further pressure to implement destructive technologies like pyrolysis/gasification or explore less-established means such as supercritical water oxidation. The state or federal government could play a pivotal role in providing funding or otherwise accelerating these efforts. Source reduction is another avenue, assuming the primary driver behind incinerator shutdowns is PFAS-pollution related, and not climate related. In the latter case, source reduction would still be beneficial but would need to be coupled with other measures to provide the greatest benefit.

5.2.7 Scenario 7 – New Capacity Becomes Available

Scenario 7 instead looked at potential developments leading to increased sludge management capacity. These could take the form of any of the following:

- A large regional incineration or landfill facility opens and accepts sludge.
- State funding incentivizes new disposal or management capacity.
- Rehabilitation of 5 existing mothballed incinerator facilities.
- A rail facility opens with the purpose of transporting Massachusetts sludge further out of the northeast region, or additional POTWs begin using the rail spur in Marlborough operated by EPIC, a Synagro subsidiary, that is currently accepting sludge from the Fall River WWTF.

Rehabilitation of mothballed incineration facilities was considered to be the most likely development due to the existing infrastructure and familiarity with using incineration statewide. However, full condition assessments would need to be conducted to understand which of these incinerators could be upgraded most cost effectively. These condition assessments would also provide more clarity and accuracy for cost estimates relating to improvements. There is also the possibility that, as a result of the condition assessments, some facilities may be established as beyond repair.

Cost and Operation Impacts

As a result of this capacity increase, management costs are assumed to increase slower than they are currently. Furthermore, land application remains an outlet (assuming an outright national ban is not in effect). As noted in Part 1 of this study (Tighe & Bond and Brown and Caldwell, 2024a), sludge management costs have increased by 35% from 2018 to 2023. This is an average increase of 6.2% per year. However, if new capacity became available, sludge handling costs may increase more slowly than current rates. This scenario assumed the increase in costs is instead 3.1% per year, or half the status quo. Thus, the original price escalation of 6.2% per year would be reduced, and a lesser price escalation of 3.1% per year would instead take place. This decrease in price escalation is likely to result in significant cost savings.

Capital costs involved in rehabilitating all five of the incinerators were assumed to be the same as estimated for rehabilitation of the UBCW incinerator as indicated by the utility in the Part 1 survey response ($650M) and would increase incinerator capacity by about 25,000 dtpy in total –

equivalent to the capacity at UBCW. There may be additional costs to install thermal oxidizers or other control technologies to reduce PFAS; however, this was not included in this analysis, and would have to be established through field work. The overall O&M budget for UBCW in 2025 was approximately $21M (see Section 3.4.4); of this, it was assumed $7M was for operating and maintaining their incinerators. The $7M in O&M costs was escalated at 4.7% over 20 years and discounted at 2.2% to calculate an annualized O&M cost of $14.8M.

The 25,000 dtpy of capacity proposed is roughly equivalent to about 1140 tractor trailers, or 15% of annual solids production. However, the effects of relieving this pressure on the sludge management market would benefit everyone, as noted below. The annual equivalent cost of rehabilitating the incinerators, including amortized capital cost and annual O&M costs, and assuming as in prior scenarios an escalation rate of 4.7% over a 20-year period, is $65.6M (see Table H-7H for additional details).

Each of the 127 POTWs in the state would be impacted (by the slower rate at which sludge management costs would increase), with a total tonnage of 171,000 dtpy affected by the resulting price attenuation (enough to fill approximately 20,000 tractor trailers and 30,000 liquid tankers). (This scenario assumes a 25,000 dtpy increase in capacity, but the benefit of this added capacity would be felt by all POTWs.)

To calculate the net savings as a result of rehabilitating five incinerators, annual projected material quantities were first calculated. This involved applying a 0.5% yearly increase to each plant and sludge load, to determine projected quantities (in gallons or wet tons, depending on the plant) for each year from 2024 through 2044 (see Table H-7B for detailed calculations). Next, yearly unit prices were also calculated for each plant by applying 6.2% growth to the unit prices that each plant currently pays (see Table H-7C for detailed calculations).

Table H-7D demonstrates the annual solids handling cost per year and per plant, as a result of 0.5% annual solids quantity increases, as well as 6.2% price escalation. These quantities were calculated by multiplying the projected solids quantity in a given year for a given plant, by the projected unit price for the same plant and year. The sum of all solids handling costs across all plants for each year was first summed, then brought back to present-day dollars at a discount rate of 2.2%. The sum of this present worth, representing the theoretical cost that plants would see over 20 years assuming status quo conditions, was calculated as $4,095,145,000, or approximately $4B.

To compare status quo costs with those anticipated as a result of rehabilitating five incinerators, yearly unit prices were also calculated assuming 3.1% escalation (see Table H-7E). These prices were in turn multiplied by the solids quantities calculated in Table H-7B to determine annual solids hauling costs under 3.1% price escalation (see Table H-7F for detailed calculations). As in Table H-7D, handling costs for all plants in a given year were summed, then brought to present worth dollars using a 2.2% discount rate. These present costs were summed and came to $2,872,074,000, or roughly $2.9B. This represents the costs that all plants in the state would see, over a period of 20 years, given a 3.1% increase in sludge handling costs.

As demonstrated in Table H-7G, the difference in these two present costs amounted to $1,223,071,000, or approximately $1.2B. On an annual basis, this is $95,661,000, or $95.6M, representing the annual average savings realized by Massachusetts POTWs as a result of sludge prices increasing slower than at present (3.1% per year instead of 6.2% per year).

Subtracting the annual cost of rehabilitating, operating, and maintaining the incinerators ($65.6M per year) from the savings resulting from a decrease in price escalation ($95.6M per year) results in a net annual savings of $30M ($95.6M - $65.6M = $30M). Similar logic is applied to Scenarios 8 and 9.

The largest proportion of POTWs are located in the western region of the state, and medium-sized plants made up the largest group based on size. Data for Scenario 7 is summarized in Table 5-12.

Table 5-12. Scenario 7 Summary: Innovation / New Capacity / Legislative & Funding Solutions affecting all Massachusetts POTWs

Parameter	Value	
# of Plants Impacted	127	
Dry Tons Affected per Year	171,000	
Estimated Price Increase for Affected Sludge	3.1% escalation per year, instead of average 6.2% per year	
Estimated Annualized Capital Cost of Rehabilitation of Multiple Incinerators	$50.8M	
Estimated Annualized O&M Costs	$14.8M	
Annual Savings from a Stabilized Market	$95.6M	
Annual Net Savings	$30M (25% of current $118.8M annual cost)	
Breakdown of Directly Impacted Plants by MassDEP Region		
Region	Count of POTWs	Percentage of Total Number of Directly Impacted Plants
Central	35	28%
Northeast	18	14%
Southeast	31	24%
West	43	34%
Total	127	100%
Breakdown of Directly Impacted Plants by Size		
Size	Count of POTWs	Percentage of Total Number of Directly Impacted Plants
Small (<1 mgd)	44	35%
Medium (1 to 5 mgd)	52	41%
Large (>5 mgd)	31	24%
Total	127	100%

Potential Benefits

Sludge management options are more expansive in this scenario due to the addition of incinerator capacity. Public or private investment, or a combination of the two, could potentially have a dramatic mitigating impact on solids handling costs.

5.2.8 Scenario 8 – Additional Sludge Reduction Capacity Becomes Available

Scenario 8 investigated the potential outcomes of an increase in sludge reduction capacity. This could be the result of:

- State funding incentivizes new sludge reduction capacity.
- A large regional drying facility opens.
- A regional anaerobic digestion facility opens.

This may be the result of state funding incentivizing new sludge reduction capacity.

Cost and Operation Impacts

Potential cost impacts include:

- Additional processing may result in increased costs for the operator of the facility.
- Additional capacity may avoid disposal cost fluctuations.

For this scenario, impacts of a large regional drying facility opening was explored. Cost curves, developed in Section 3.4.4 for rotary drum dryers, were used to estimate capital and O&M expenditures for a 35,000 dtpy plant (comparable in scale to the proposed New England Regional Biosolids facility). 35,000 dtpy represents about 20% of all solids produced annually, and enough to fill about 1,600 tractor trailers. As a result, management costs increase slower than currently (as in Scenario 7), and land application remains an outlet (assuming a ban or significant restrictions are not in effect). While the facility only has a capacity of 35,000 dtpy, it is assumed that all plants in the state would benefit from the construction of such a facility. This is because the added reduction capacity would reduce strain on other sludge outlets, and allow sludge handling costs to rise more slowly than currently (that is, at 3.1% per year instead of 6.2% per year).

The approximate capital cost for such a facility based on the cost curves from Section 3.4.4 would be $1,358,321,000 (roughly $1.36B) in total, with an O&M cost in 2024 dollars of $34,207,000 or $34.2M per year (costs of a 3,600-dtpy drying facility were scaled to a 35,000-dtpy facility as a rough estimation). Applying the economics analysis in previous scenarios by using an escalation rate of 4.7% over 20 years, discounting it back to present day at a rate of 2.2%, and then converting it to an annual equivalent cost, results in a total of $178,553,000, or $178.5M (see Table H-8A). Factoring in the savings estimated by stabilized management costs (laid out in Section 5.2.7 and Tables H-7B through H-7F), the overall cost to the state is $82.9M ($178.5M - $95.6M = $82.9M). See Table 5-13. Regional and size breakdown for this scenario are not reproduced here, as they are identical to those in Table 5-12.

By comparison, the approximate capital cost for a mesophilic anaerobic digester of equal capacity would be roughly $870M in total. O&M costs would amount to $26.7M per year. Applying the economics analysis as in previous scenarios, and outlined in the previous paragraph, results in a total cost of $124.1M, and a net cost to the state of $28.5M.

Table 5-13. Scenario 8 Summary: Additional Sludge Volume Reduction Capacity Benefitting all Massachusetts POTWs

Parameter	Value
# of Plants Directly Impacted	127
Dry Tons Affected per Year	171,000
Estimated Annual Cost of a 35,000 dtpy Drying Facility	$178.5M
Estimated annualized capital cost of drying facility	$106.2M
Estimated annualized O&M costs of drying facility	$72.3M
Annual Savings from a Stabilized Market	$95.6M
Annual Net Cost	$82.9M (70% of current $118.8M annual cost)

Potential Benefits

As in Scenario 7, adding new sludge volume reduction capacity could take pressure off utilities. New facilities being constructed for drying or anaerobic digestion should contemplate accommodating

future inclusion of PFAS treatment technologies onsite if necessary. Investment from private or public entities could also mitigate increasing costs.

5.2.9 Scenario 9 – New PFAS Treatment Capacity Becomes Available

Scenario 9 investigated the potential outcomes of an increase in PFAS treatment/destruction capacity. This could be the result of:

- Biosolids PFAS treatment technologies mature.
- Large regional pyrolysis, gasification, SCWO-super critical water oxidation or other facility opens.
- Regulatory/legislative changes encourage development of new technologies.
- Volume reduction associated with digestion could reduce the sizing of downstream PFAS treatment technology. However, this would have to be evaluated against the effect on the energy balance as a result.
- States providing clarity on regulatory requirements for new technologies, removing a barrier to implementation.
- States promoting development of new technologies through funding of siting studies, pilot testing, or new development.

Cost and Operation Impacts

For this scenario, impacts of opening a large regional pyrolysis facility were explored. Pyrolysis was considered a representative project that would directly address PFAS. Incorporation into this analysis assumes that pyrolysis as a technology matures, and that perhaps funding mechanisms facilitate the evolution of such a project. Cost curves, developed in Section 3.4.4 for pyrolysis installations, were used to estimate capital and O&M expenditures for a 35,000 dtpy plant (comparable in scale to the proposed New England Regional Biosolids facility). As a result of this expanded ability to treat for PFAS, management costs increase less steeply than currently (as in Scenario 7). If a ban based on PFAS concentrations goes into effect, then material generated by pyrolysis may still be land applied (given reduction of PFAS as a result of pyrolysis). However, if a ban directed at biosolids is implemented, then the material would go to landfill.

Pyrolysis was explored as the representative technology in this scenario as it tends to be more easily permitted than incineration, is similar to gasification, and is more established than SCWO.

The approximate capital cost for such a facility based on the cost curves from Section 3.4.4 would be $1,257,072,000 (roughly $1.26B) in total, with an expected annual O&M cost of $13,504,000 ($13.5M) in 2024 dollars (costs of a 3,600-dtpy pyrolysis facility were scaled to a 35,000-dtpy facility as a rough estimation). Escalating annual costs by 4.7% over 20 years, including capital expenditure in 2024, discounting back to present cost, and converting to an average annual cost resulted in $126.9 M per year (see Table H-9A for detailed calculations). Factoring in the savings estimated by stabilized management costs (laid out in Section 5.2.7 and Tables H-7B through H-7F), the overall cost to the state is $31.2M ($126.9M - $95.6M = $31.2M – numbers are not exact due to rounding). See Table 5-14. Regional and size breakdown for this scenario are not repeated, as they are identical to those in Table 5-12.

Table 5-14. Scenario 9 Summary: New PFAS Treatment Capacity Benefitting all Massachusetts POTWs	
Parameter	**Value**
# of Plants Directly Impacted	127
Dry Tons Affected per Year	171,000
Estimated Annual Cost of a 35,000 dtpy Pyrolysis Facility	$126.9M
Estimated Annualized Capital Cost of Pyrolysis Facility	$98.5M
Estimated Annualized O&M Costs of Pyrolysis Facility	$28.5M
Annual Savings from a Stabilized Market	$95.6M
Annual Net Cost	$31.2M (26% of current $118.8M annual cost)

One unfavorable possibility would be that new technologies may result in increased costs to utilities. However, this is likely to be offset by reduced management cost increases.

Potential Benefits

Possible impacts include:

- PFAS treatment technology (pyrolysis in this case) leaves the opportunity to land apply low-PFAS biochar, even if bans based on PFAS concentrations are implemented.
- New technologies may result in increased costs.
- Additional capacity may avoid disposal cost fluctuations.

Production of low-PFAS biochar could be a very valuable addition for agricultural uses. It would provide a way for biosolids to continue to be land applied, generating carbon sequestration benefits, albeit as a result of extensive processing.

5.2.10 Scenario 10 – Source Reduction to Reduce PFAS at POTWs

Scenario 10 investigated the potential outcomes of PFAS source reduction. This could be the result of:

- Pretreatment and source reduction efforts successfully bring down PFAS concentrations to acceptable levels. Quantifying the financial costs associated with this was not explored, since it is too complex to characterize given the wide range of factors that are associated (such as PFAS concentrations, the industry discharging PFAS, potential methods for limiting PFAS discharge, operational changes to avoid discharging PFAS, the specific species in the effluent, available treatment technologies, background water parameters, and other factors). However, this scenario would have financial impacts, which would be worth exploring in a future phase if additional information were available. Additionally, determining specific pretreatment processes to implement would require increased understanding of several factors, like those mentioned above (concentration and species of PFAS, the industry discharging, background water parameters, etc.).
- Legislation/regulation significantly reduce PFAS usage.
- Treatment of landfill leachate.

Increased enforcement of industrial discharge reduces PFAS loads to POTWs. The primary negative impact for utilities that would result is the additional oversight required by the IPP coordinators for POTWs.

Cost and Operation Impacts

As a result of these developments, management costs increase less steeply than currently, and land application remains an outlet (assuming an outright ban is not in effect). The cost/benefit analysis assumes no capital cost is taken on by the state, as industries discharging PFAS pay for source reduction themselves. Industries that need to implement treatment are likely to pass these costs onto other entities. Calculations for annual savings from a stabilized market are laid out in Section 5.2.7 and Tables H-7B through H-7F. See Table 5-15.

Table 5-15. Scenario 10 Summary: PFAS Source Reduction Benefitting all Massachusetts POTWs

Parameter	Value
# of Plants Impacted	127
Dry Tons Affected per Year	171,000
Annual Savings from a Stabilized Market	$95.6M
Annual Net Savings	$95.6M (80% of current $118.8M annual cost)

Potential Benefits

With the reduction in PFAS by source controls, landfills, land application, and incineration could remain viable options. Depending on the level of source reduction, this may enable biosolids to continue being land-applied despite a ban, for instance. However, benefits are unlikely to be fully realized immediately, as pipes in the sewer system and POTWs will contain PFAS that will contribute to influent PFAS contamination for a significant period of time, unless a targeted cleaning campaign is undertaken.

This scenario is primarily concerned with source reduction. This may take the form of treatment at the originating industry (like a landfill or metal finisher), or centralized treatment at the plant. Extensive work would be involved in developing this, including inventorying PFAS sources, testing for different species of PFAS, and determining appropriate technologies for the different sources. As noted previously, the state can play a significant role here, especially in terms of technical support and assistance to utilities.

5.3 Review of Scenarios

Table 5-16 and Table 5-17 below summarize the findings from the different scenarios, as well as the considerations involved in developing them. A given scenario could involve a range of contributing factors and have a range of impacts, but for simplicity in this analysis, only one or two of each were selected to consider further. The specific driving factors, resulting impacts, and solutions that were modeled in each scenario are laid out. A majority of plants affected were located in either the Northeast or Central regions and were generally medium-sized plants.

Financial impacts were assessed in three ways. The annual impact of ongoing cost increases due to sludge management, the initial and annualized capital cost, and annualized O&M costs (where applicable) were considered. For Scenarios 1 through 6, the annual impact was presented as a percentage of the current estimated cost of sludge management in Massachusetts. The overall management cost was determined by incorporating estimated solids handling costs for Greater Lawrence Sanitary District and the Massachusetts Water Regional Authority, as provided in the Part

1 survey ($2.2M and $1.1M, respectively). Of the remaining sludge, hauling and tip fees for liquid sludge was estimated to cost $0.16/gal and cake was estimated to cost $156/wt, as established in Part 1. Ash management costs for UBCW and Lynn Regional WWTP were assumed to be negligible. This resulted in a total annual estimate of $119M.

Annual growth in statewide sludge management costs was assessed as the initial relative increase in statewide sludge management costs resulting from increases in hauling costs, resulting in a 'price spike.' Subsequent years were assumed to see increases of 6.2% per year, which has been noted as the average increase in sludge management prices over the last five years. Scenarios 5 and 6, as they included construction of dewatering facilities, also demonstrate the estimated total and annualized capital cost and annualized O&M costs for those facilities.

Initial price spikes seen for Scenarios 1 through 6 ranged from 4% to 19%, highlighting both the variable impacts, and compounding effects of changes to the sludge management landscape. As established at the beginning of this section, a key assumption in this analysis is that a scenario affecting a larger amount of sludge would have greater price impacts than scenarios affecting smaller amounts. Even Scenario 3, which only affects one plant directly, could have ramifications on almost every other plant in the state and increase sludge management costs by 4% initially. Scenarios 5 and 6 both have the only capital costs among Scenarios 1 through 6, and among the highest initial price spikes (which are calculated separately from capital costs and O&M costs). Since the plants in Scenarios 5 and 6 were randomly assigned to either more distant hauling, or installing dewatering, a more detailed analysis may be able to explore the relative costs and benefits of the two approaches for a given plant.

In Scenarios 7 through 10, each scenario is assumed to experience 3.1% growth in sludge management costs as explored previously. Capital costs for these scenarios represent the estimates for rehabilitation of five incinerators (Scenario 7), a regional drying facility (Scenario 8), or a regional pyrolysis facility (Scenario 9). The very high costs associated (ranging from $650M to $1.36B) must be balanced against the advantages in relieving pressure on the sludge management ecosystem and the attenuation of sludge management price increases. Annualized O&M costs are also provided in the table.

As noted previously, while these scenarios were developed and analyzed separately, in reality, multiple scenarios could take place at the same time. However, the effects would not be simply additive, as some impacts would compound. A few examples of combined scenarios are briefly explored here. One possible combination would be Scenario 1 and Scenario 2, representing land application restrictions both in Massachusetts and regionally. This would have the result of causing sludge to be hauled much further away, and potentially development of regional facilities or technologies to address the difficulty in managing solids. Alternatively, regional limitations on land application, landfilling, and incineration could happen at the same time, putting immense strain on the current sludge management market (Scenarios 2, 4, and 6). Source reduction could be developed in Massachusetts at the same time as landfill restrictions are enacted in the state, leading to a complex balance of advantages and disadvantages for sludge handling (Scenarios 3 and 10). Construction of a large regional drying facility, coupled with a new pyrolysis facility, would dramatically alleviate strain on solids handling in the state (Scenarios 8 and 9). This would be especially beneficial as drying is a pre-requisite to pyrolysis, and would enable significant portions of solids to be treated at a regional facility. Smaller municipalities specifically would benefit from the reduced stress on their facilities.

Table 5-16. Scenarios 1-6 Summary - Analysis Overview

Scenario						
Scenario Category	Land Application		Landfill		Incineration	
Scenario Number	1	2	3	4	5	6
Scenario Description	Land application restrictions in Massachusetts	Regional/national land application restrictions with regional impact	Landfill restrictions in Massachusetts	Regional/national landfill restrictions with regional impact	Incineration capacity reduction in Massachusetts	Regional/national incineration restrictions with regional impact
Modeled Driving Factor	Legislation banning/restricting land application in Massachusetts	Legislation or regulation in neighboring states takes effect	PFAS regulations governing landfills are implemented Landfill operators limit "wet wastes" – typically defined as less than 60% TS	Legislation or regulation in neighboring states takes effect	Sewage Sludge Incinerators (SSIs) at Upper Blackstone Clean Water (UBCW) reach the end of their useful life (anticipated within the next 10-15 yrs)	Legislation or regulation takes effect in neighboring states
Modeled Resulting Impact	Land application in Massachusetts goes to zero Dried biosolids, compost to landfill or hauled further away	New Hampshire, Vermont, and Connecticut stop accepting biosolids from Massachusetts for the purpose of land application	Landfills in Massachusetts take 50% less sludge from non-local sources Increase in management costs to haul to out-of-state landfills	Vermont and New Hampshire stop accepting biosolids to landfills; New York takes 50% less sludge Increase in management costs to haul to more distant locations	UBCW SSI closes; must find outlet for large amount of dewatered cake Smaller plants bringing solids to UBCW send to other facilities accepting liquid or forced to put in dewatering	All incinerators in Rhode Island close down Smaller plants bringing liquid sludge to Rhode Island send to facilities accepting liquid or forced to put in dewatering Plants currently hauling cake to Rhode Island must find alternate outlets
Modeled Solution	POTWs haul further away	POTWs haul further away	POTWs haul further away	POTWs haul further away	POTWs haul further away Dewatering or drying installed to enable easier transport or increased acceptance at landfills	POTWs haul further away Dewatering to enable easier transport or increased acceptability at incineration facilities
Plants Affected	20	17	1	10	10	44
Dry Tons Affected per Year	15,974	10,931	919	11,372	17,988	23,730
Annual Growth in Statewide Sludge Management Costs	+$18M initially (+15%) +6.2% thereafter	+$11M initially (+9%) +6.2% thereafter	+$4.6M initially (+4%) +6.2% thereafter	+$10M initially (+9%) +6.2% thereafter	$23M initially (+19%) +6.2% thereafter	$14M initially (+12%) +6.2% thereafter
Estimated Capital Cost	-	-	-	-	$6.1M/year annualized ($77.8M total)	$21M/year annualized ($273.2M total)
Estimated O&M Costs	-	-	-	-	$10M/year annualized	$33M/year annualized
Predominant DEP Region	Northeast	Northeast	Central	Central/Northeast	Central	Central
Predominant Plant Size	Medium	Large	Large	Large	Medium/Large	Medium

*Scenarios are not mutually exclusive.

Table 5-17. Scenarios 7-10 Analysis Overview

	Scenario			
Scenario Category	New capacity, innovation, legislative & funding solutions			
Scenario Number	7	8	9	10
Scenario Description	Additional sludge disposal capacity becomes available	Additional sludge reduction capacity becomes available	New sludge PFAS treatment capacity becomes available	Source reduction to reduce PFAS at POTWs
Modeled Driving Factor	Rehabilitation of five existing mothballed incinerator facilities	Large regional drying facility opens	Large regional pyrolysis, gasification, SCWO or other facility opens	Pretreatment and source reduction efforts successfully bring down PFAS concentrations to acceptable levels
Modeled Resulting Impact	Partially stabilizes management cost increases	Additional capacity may avoid disposal cost fluctuations	PFAS treatment technology leaves the opportunity to land apply low-PFAS biochar, even if land application of biosolids is banned Additional capacity may avoid management cost fluctuations	Requires additional oversight by POTW IPP coordinators
Modeled Solution	State funding incentivizes new disposal capacity	State funding incentivizes new sludge reduction capacity	States promote development of new technologies through funding of siting studies / pilot testing / new development	Increased enforcement of industrial discharge reduces PFAS flows to POTWs
Plants Affected	127			
Dry Tons Affected per Year	171,000			
Annual Sludge Management Cost Increase	3.1%	3.1%	3.1%	3.1%
Estimated Capital Cost	$51M/year annualized ($650M total)	$106M/year annualized ($1.36B total)	$99M/year annualized ($1.26B total)	-
Estimated O&M Costs	$15M/year	$72.M/year	$29M/year	-
Annual Net Cost**	-$30M (-25%) *Net savings*	+$83M (+70%)	+$31M (+26%)	-$96M (-80%) *Net savings*
Predominant DEP Region	West			
Predominant Plant Size	Medium			

*Scenarios are not mutually exclusive.
** Percentages listed in the table are out of current annual costs of $118.8M/year. Net costs consider $96M/year savings from a stabilized sludge market

Conclusions

Previous sections of this report have explored PFAS reduction and management technologies applicable to wastewater and sludge, quantified PFAS sources and potential source-reduction solutions, and the impact of PFAS on sludge management. This has informed the work conducted in Section 5 by ascertaining approximate costs of facilities (for instance, dewatering, as explored in Scenarios 5 and 6), evaluated the feasibility of source reduction for PFAS, and highlighted management challenges of sludge containing PFAS. In Section 5, several different scenarios, covering a range of different plant sizes, solids management techniques, and regions, were explored.

One major implication of this work is the urgency of creating new capacity and implementing IPP, while exploring ways to specifically target making incineration capacity in the region more robust. These efforts would be likely to cushion the impacts on POTWs, especially smaller ones. Technology advancement is another key component of this.

The insight provided by exploring these scenarios informed work in Section 6 to identify possible sludge management and PFAS reduction or elimination options.

Section 6

Conclusions and Options to Consider for Sludge Management

6.1 Introduction

Part 1 of this study documented current sludge generation and management in Massachusetts. It showed that POTWs in Massachusetts rely on land application, incineration and landfilling to manage their sludge at both in-state and out-of-state sites, with capacity for all of these outlets overextended and decreasing. Northeast landfill capacity is decreasing, particularly for unstable, "wet wastes" like dewatered sludge. Apart from an alkaline stabilization facility in northern New York and Canada, there are no facilities producing material for land application that report having additional available capacity in the northeast.

Additionally, there are no potential increases in incineration capacity in the region. Historically, it has proven difficult to obtain the necessary permits and public acceptance for new incinerators in Massachusetts. By 2028, annual sludge production is expected to grow to 172,200 dry-tons from approximately 165,700 dry-tons generated in 2023 (Tighe & Bond and Brown and Caldwell, 2024a, Section 3.7). Several outlets will reach capacity or be shut down by then, and very little additional capacity at existing facilities or capacity at new facilities will be available.

According to Part 1 of this study (Section 7.1.2), a minimum of 7% of the sludge generated in Massachusetts in 2028 (11,826 dry tons) will have no available outlet for reuse or disposal of any type under status quo conditions. In Part 2, Sections 1-4 examine how growing concern over PFAS in wastewater is impacting the sludge management landscape through evaluating PFAS treatment technologies, source control options, and regulatory and market considerations. Section 5 discusses various hypothetical scenarios and presents associated cost estimates from the resulting impacts (summarized in Table 6-1 and Table 6-2 below). Note that these scenarios are not mutually exclusive and it is likely that at least portions of multiple scenarios could come to fruition in the coming years.

Table 6-1. Scenarios 1-6 Analysis Overview

Scenario Category	Land Application		Landfill		Incineration	
Scenario Number	1	2	3	4	5	6
Scenario Description	Land application restrictions in Massachusetts	Regional/national land application restrictions with regional impact	Landfill restrictions in Massachusetts	Regional/national landfill restrictions with regional impact	Incineration capacity reduction in Massachusetts	Regional/national incineration restrictions with regional impact
Modeled Driving Factor	Legislation banning/restricting land application in Massachusetts	Legislation or regulation in neighboring states takes effect	PFAS regulations governing landfills are implemented Landfill operators limit "wet wastes" – typically defined as less than 60% TS	Legislation or regulation in neighboring states takes effect	Sewage Sludge Incinerators (SSIs) at Upper Blackstone Clean Water (UBCW) reach the end of their useful life (anticipated within the next 10-15 yrs)	Legislation or regulation takes effect in neighboring states
Modeled Resulting Impact	Land application in Massachusetts goes to zero Dried biosolids, compost to landfill or hauled further away	New Hampshire, Vermont, and Connecticut stop accepting biosolids from Massachusetts for the purpose of land application	Landfills in Massachusetts take 50% less sludge from non-local sources Increase in management costs to haul to out-of-state landfills	Vermont and New Hampshire stop accepting biosolids to landfills; New York takes 50% less sludge Increase in management costs to haul to more distant locations	UBCW SSI closes; must find outlet for large amount of dewatered cake Smaller plants bringing solids to UBCW send to other facilities accepting liquid or forced to put in dewatering	All incinerators in Rhode Island close down Smaller plants bringing liquid sludge to Rhode Island send to facilities accepting liquid or forced to put in dewatering Plants currently hauling cake to Rhode Island must find alternate outlets
Modeled Solution	POTWs haul further away	POTWs haul further away	POTWs haul further away	POTWs haul further away	POTWs haul further away Dewatering or drying installed to enable easier transport or increased acceptance at landfills	POTWs haul further away Dewatering to enable easier transport or increased acceptability at incineration facilities
Plants Affected	20	17	1	10	10	44
Dry Tons Affected per Year	15,974	10,931	919	11,372	17,988	23,730
Annual Growth in Statewide Sludge Management Costs	+$18M initially (+15%) +6.2% thereafter	+$11M initially (+9%) +6.2% thereafter	+$4.6M initially (+4%) +6.2% thereafter	+$10M initially (+9%) +6.2% thereafter	$23M initially (+19%) +6.2% thereafter	$14M initially (+12%) +6.2% thereafter
Estimated Capital Cost	-	-	-	-	$6.1M/year annualized ($77.8M total)	$21M/year annualized ($273.2M total)
Estimated O&M Costs	-	-	-	-	$10M/year annualized	$33M/year annualized
Predominant DEP Region	Northeast	Northeast	Central	Central/Northeast	Central	Central
Predominant Plant Size	Medium	Large	Large	Large	Medium/Large	Medium

*Scenarios are not mutually exclusive.

Table 6-2. Scenarios 7-10 Analysis Overview

	Scenario			
Scenario Category	New capacity, innovation, legislative & funding solutions			
Scenario Number	7	8	9	10
Scenario Description	Additional sludge disposal capacity becomes available	Additional sludge reduction capacity becomes available	New sludge PFAS treatment capacity becomes available	Source reduction to reduce PFAS at POTWs
Modeled Driving Factor	Rehabilitation of five existing mothballed incinerator facilities	Large regional drying facility opens	Large regional pyrolysis, gasification, SCWO or other facility opens	Pretreatment and source reduction efforts successfully bring down PFAS concentrations to acceptable levels
Modeled Resulting Impact	Partially stabilizes management cost increases	Additional capacity may avoid disposal cost fluctuations	PFAS treatment technology leaves the opportunity to land apply low-PFAS biochar, even if land application of biosolids is banned Additional capacity may avoid management cost fluctuations	Requires additional oversight by POTW IPP coordinators
Modeled Solution	State funding incentivizes new disposal capacity	State funding incentivizes new sludge reduction capacity	States promote development of new technologies through funding of siting studies / pilot testing / new development	Increased enforcement of industrial discharge reduces PFAS flows to POTWs
Plants Affected	127			
Dry Tons Affected per Year	171,000			
Annual Sludge Management Cost Increase	3.1%	3.1%	3.1%	3.1%
Estimated Capital Cost	$51M/year annualized ($650M total)	$106M/year annualized ($1.36B total)	$99M/year annualized ($1.26B total)	-
Estimated O&M Costs	$15M/year	$72.M/year	$29M/year	-
Annual Net Cost**	-$30M (-25%) *Net savings*	+$83M (+70%)	+$31M (+26%)	-$96M (-80%) *Net savings*
Predominant DEP Region	West			
Predominant Plant Size	Medium			

*Scenarios are not mutually exclusive.
** Percentages listed in the table are out of current annual costs of $118.8M/year. Net costs consider $96M/year savings from a stabilized sludge market

Finally, this section provides options for individual POTWs and for policymakers as well as for future study relating to PFAS and sludge management. Environmental advocates, regulators, legislators, researchers, and residents are invited to consider using some or all of these options in their work protecting human and environmental health.

An overview of the options to consider, which are detailed in the following sections, is provided in Figure 6-1.Options for POTWs, Legislators and Regulators to Improve Sludge Management. Options for consideration are made for wastewater utilities operating POTWs, as well as regulators and legislators. To help differentiate the options, they have been given ratings to give readers an idea of how quickly different changes could be enacted, the potential for each to increase sludge management capacity and reduce PFAS, and the relative cost.

	Options (Report Section)	Potential Timeline (Years)	Potential to Increase Sludge Management Options	Potential to Reduce PFAS	Relative Cost	Comments
POTWs	Undertake Local PFAS Source Reduction through Industrial Pretreatment Programs (6.2.3)	0-2		(Low-Med-or High)		Efficacy depends on proportion of PFAS load from industry
POTWs	Consider Pilot Testing Promising PFAS Reduction Technologies (6.2.4)	2-5				Pilots can help determine the treatment performance of new technologies
POTWs	Reduce Sludge Volume (6.2.1)	2-5				Producing less sludge with more potential outlets reduces market risks
POTWs	Consider Commitments to Regional Facilities (6.2.2)	5-10		(Low or High)		PFAS reduction depends on technology
Legislature & Regulators	Limit Biosolids Land Application (6.3.2)	0-2				Can build off the tiered approach of most other states. Compliance could be costly for some POTWs.
Legislature & Regulators	Promote PFAS Treatment Technologies (6.3.3)	0-2				PFAS treatment technology systems typically greatly reduce sludge volume, as well
Legislature & Regulators	Implement PFAS Source Control Measures-Consumer Products & Manufacturing Processes (6.3.1)	2-5	(Low or Med)	(Med or High)		Office of Technical Assistance can assist industries
Legislature & Regulators	Support Volume Reduction and PFAS Treatment Projects (6.3.4)	2-5				Funding needed for full-scale and pilot installations; regulatory certainty needed for pilots
Legislature & Regulators	Promote Regional Facilities (6.3.5)	5-10		(Low or High)		PFAS reduction depends on technology; regulatory certainty and funding needed

KEY

Low Medium High

Figure 6-1.Options for POTWs, Legislators and Regulators to Improve Sludge Management

6.2 Options to Consider for Massachusetts POTWs

Resolving PFAS contamination in the environment is a multi-faceted problem that cannot be solved by targeting a single sector or medium (e.g. air, water, land). Even within the municipal wastewater treatment sector, addressing PFAS contamination will require a multi-sector approach and an array of solutions. This report has focused in particular on sludge/biosolids management, and strategies through which utilities, industry, and regulators can work to break the PFAS cycle in the environment.

POTWs can act to improve the quality and quantity of their sludge and wastewater, the method in which their residuals are managed, and their resilience to disruptions in the sludge management market. Reducing the amount of sludge produced and/or the amount of PFAS in the sludge will expand POTWs' access to limited sludge management outlets.

6.2.1 Reduce Sludge Volume

This report and the report from Part 1 of this study have shown that the primary sludge management issue facing Massachusetts POTWs is that management capacity in Massachusetts and the region is barely sufficient now and continues to dwindle. As discussed in Section 3 of the Part 1 report, sludge management costs are rapidly increasing and seem likely to increase for the foreseeable future at a rate far above inflation. To reduce exposure to these rising costs and to have access to more outlets, it is an option that POTWs consider the installation of volume reduction technologies (see Section 3.2). Producing fewer solids will provide ongoing savings for the POTW and make operations less susceptible to disruptions at management outlets (i.e., incinerators, landfills, and biosolids processing facilities). While volume reduction would not reduce the amount of PFAS in sludge, lower volumes of material to manage could open up more opportunities for managing the resulting sludge.

Investing in sludge volume reduction now can have several benefits if PFAS treatment is needed or desired in the future:

- **Solids equipment downstream of anaerobic digestion can be sized smaller due to the conversion of some solids to biogas**
- **Drying is required before pyrolysis and gasification, allowing for a phased deployment of technology. Dryers installed now will provide benefits from reduced solids management until such a time as PFAS treatment is needed.**
- **Reducing volume will require less hauling if a PFAS treatment facility is developed offsite, such as a regional facility.**
- **It is typically not recommended to thermally dry sludge from primary treatment that has not been digested, so anaerobic digestion could help make a POTW's sludge acceptable for PFAS treatment requiring drying.**

As shown in Figure 3-4 of this report, volume reduction technologies are expensive to both implement and operate. For small facilities, these costs can range from $15-$40M for the 20-Year Net Present Cost. For a medium facility, they can be $55-$155M in Net Present Cost, and for large facilities they cost roughly $30-190M depending on the size of the facility, the complexity of the system, and the type of volume reduction implemented. Options are included below in Section 6.3.4 for state funding approaches for these often cost-prohibitive projects. See also Section 3.8 for a more detailed discussion of potential funding sources and approaches.

6.2.2 Consider Commitments to Regional Facilities

The *Mass Sludge Survey 2018* (NEBRA, 2019) identified 'significant interest' (70% affirmative survey responses) from POTWs in development or future use of regional anaerobic digestion facilities. One of the primary needs for private developers of regional facilities is a commitment to receive consistent tonnages to treat. This reduces the economic uncertainty for the project and can be integral to receiving financial commitments. Taking into account existing sludge management contracts, wastewater utilities can consider committing future sludge production upon the successful completion of a regional facility. This would take coordination with legal and procurement specialists, but early commitments can secure favorable long-term pricing and primary access. See Section 2.1.8 for a discussion of the forms regional facilities can take and key considerations for such facilities. Section 3.6 for steps the legislature and regulators can take to support regional facilities.

It should be noted that there are disadvantages to regional facilities. Unlike with equipment at their own facilities, POTWs bringing sludge to regional facilities typically have no control over the maintenance of the equipment at the regional facility. As has been seen with recent outages at regional incinerators in New England, disruptions at the regional facility can leave a large number of POTWs (and/or their sludge management contractor) simultaneously looking for alternative options. Typically short-term, backup sludge management options are significantly more expensive and uncertain. The limited capacity in the region is mostly reserved for those with long-term commitments.

Regionalization also centralizes the environmental and social impacts, which can be an advantage but also a concern. Truck traffic, odors, air emissions, surface and groundwater contamination and other environmental justice issues are commonly raised by opponents of regional facilities. (In an attempt to mitigate these concerns, host communities are sometimes offered favorable terms for use of the facility.) The "Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy" (2021), requires an assessment of benefits and risks in environmental impact reports for projects.

Intermunicipal agreements are also difficult to finalize and maintain. Materials handling can also be a challenge when accepting sludge from a wide variety of sources. Regional facilities in other states have run into significant operational issues not with the main processing technology (e.g., digesters, dryers), but with seemingly more straightforward receiving and conveyance equipment.

Each of these challenges can be overcome with careful planning, design, construction and maintenance, but it will be critical to keep potential challenges in mind as projects develop.

6.2.3 Undertake Local PFAS Source Reduction

POTWs provide essential services to their communities, and collaboration among POTWs, industries discharging to the collection system, ratepayers, and the larger community can substantially reduce PFAS in wastewater. POTWs can consider reducing or eliminating domestic as well as industrial and commercial sources of PFAS; however, other possible PFAS sources should be investigated as relevant. For example, a POTW known to be impacted by infiltration and/or inflow (I/I) should investigate whether areas of the collection system with both significant I/I and significant PFAS loading are located near landfills or PFAS-contaminated sites. Additionally, some commercial and home-based businesses may be discharging PFAS to the collection system, although they would not fall under an existing regulatory framework. POTWs with a robust understanding of their facility's particular PFAS sources will be well-positioned to execute source reduction strategies.

Industrial Pretreatment Programs

The IPP prevents the discharge of pollutants to POTWs which could interfere with the POTW's operations, use or disposal of municipal sludge, or pollute water bodies receiving POTW discharges,

as defined in 40 CFR Part 403 (U.S. EPA, 2016; eCFR, 2021). EPA Region 1 directly implements and enforces the IPP in Massachusetts.

Under EPA's IPP regulations, POTWs have the authority to regulate indirect dischargers, including imposing monitoring, reporting, and pretreatment requirements such that the users do not adversely affect the POTW's ability to meet its permitted discharge limits or to dispose of or reuse wastewater sludge. Jurisdictions have begun using this authority to implement source control as a means of reducing PFAS loading to POTWs, a strategy endorsed by the EPA. The EPA released a memorandum in December 2022 stating that identification and restriction of PFAS discharges at their sources using existing permitting and pretreatment programs is key to addressing "PFAS contamination more rapidly than possible with monitoring based solely on NPDES permit renewals" (Fox, 2022). Michigan's source reduction program, described in Section 2.6.1, is an example of successful use of the pretreatment program to substantially reduce PFAS discharges. One representative of a POTW in South Carolina also indicated success in reducing PFAS loading by requiring pretreatment of landfill leachate, while a Minnesota landfill that discharges leachate to a POTW has demonstrated successful performance of a proprietary leachate filtration system at the pilot scale.

The industrial PFAS data and case studies discussed in Sections 4.3.2 and 4.3.3, respectively, show that industrial dischargers impact PFAS mass loading in plant influent to widely varying degrees. The data used for these analyses were quite limited in number of industries included and number of samples collected. Therefore, POTWs should consider actively determining the extent to which PFAS emanates from specific users within their collection systems.

Local industries that use PFAS within the collection system can be identified using any or all of the following resources as a starting place:

- Analysis of discharge monitoring samples collected through a POTW's IPP in accordance with the EPA's guidance of December 2022 on *Addressing PFAS Discharges in NPDES Permits and Through the Pretreatment Program and Monitoring Programs* (Fox, 2022).
- Industry surveys developed by the Massachusetts Office of Technical Assistance and Technology (OTA) (OTA, 2022).
- Lists of PFAS-containing products and processes in which PFAS-containing products are commonly used, for example, those being developed by the Massachusetts Executive Office of Energy and Environmental Affairs, Office of Technical Assistance (2022).
- PFAS usage reported through EPA's Toxic Release Inventory and the Massachusetts Toxics Use Reduction Act (MGL c. 21I), which is available via the Toxics Use Reduction Institute (TURI, n.d.).

After identifying PFAS-using industries, POTWs can prioritize dischargers and PFAS contributors with the greatest impact on influent and sludge management by calculating their mass loadings. POTWs can then collaborate with the PFAS-emitting industrial dischargers to reduce or eliminate their PFAS discharges. This may be accomplished via product substitution or equipment replacement. For example, the EPA has found that some chrome finishing facilities may be able to switch from hexavalent chromium to trivalent chromium, which does not require the use of chemical fume suppressants, and that PFAS-free alternative fume suppressants can be used for processes that require hexavalent chromium (U.S. EPA, 2023). However, PFAS have been found, in some cases, to persist in industrial process equipment despite product substitution, requiring replacement of the contaminated equipment to eliminate the discharge (EGLE, 2020b). When industrial use of PFAS continues or legacy contamination persists, imposing facility-specific, technology-based pretreatment requirements can effectively reduce PFAS loading to the POTW (EGLE, 2020a; USEPA, 2022).

Public Outreach and Education

POTWs are essential for managing wastewater and other liquid wastes, protecting public health and the environment while acting in the best interest of their ratepayers. POTWs may leverage this position of community trust to raise awareness about the risks PFAS pose to humans and the environment, sources of PFAS exposure, and how PFAS can affect POTW operations and sludge management. While POTWs may not be able to directly influence manufacturers of consumer products, individual POTWs are well-positioned to educate their community members, and especially ratepayers, about the prevalence of PFAS in everyday items: PFAS are present in consumer products used by households or commercial establishments that may be discharged to POTWs. With access to this knowledge, consumers can privately make informed choices about the products they use. While limited results are available regarding the efficacy of residential PFAS pollution prevention programs, some jurisdictions have begun providing materials for public education.

Pollution prevention education campaigns can be implemented to reduce PFAS loading at POTWs by reducing public use of PFAS-containing products. These activities can range in scale from directing community members to PFAS-free alternatives to many of these products via the EPA's Safer Choice program (USEPA, 2024h) or publication of an online Frequently Asked Question (FAQ) page to a more robust outreach campaign, potentially in collaboration with other local governmental/nonprofit agencies and/or academic institutions.

For example, many consumer products sold commercially can be sources of PFAS exposure for humans and eventually contribute to wastewater. These include cosmetic and personal care products, nonstick cookware, stain-resistant carpets, water-resistant clothing, ski wax and bicycle lubricants, and more. Municipally sponsored take-back programs, consumer awareness and education programs, and training programs for technicians are examples of EPA-identified best management practices that have been implemented in impacted communities.

POTWs can also encourage industrial and commercial users as well as small business owners that fall outside of the IPP to avail themselves of existing pollution prevention resources such as EEA's Office of Technical Assistance & Technology (OTA) and the Interstate Technology & Regulatory Council (ITRC). Increasingly, companies are seeking to reduce or eliminate PFAS in their operations because of environmental regulations, consumer demand, or their own environmental goals. However, sources of PFAS are not always obvious, and PFAS have unique properties that can be difficult to replace in certain applications. OTA offers confidential technical assistance in identifying sources of PFAS in products and raw materials and identifying opportunities for substitution (Massachusetts Executive Office of Energy and Environmental Affairs, Office of Technical Assistance (2022). The ITRC is a state-led coalition working to reduce barriers to the use of innovative environmental technologies to reduce compliance costs and improve cleanup efficacy, and its PFAS Team has developed a wealth of technical and training resources for public use (Interstate Technology & Regulatory Council, 2023b). In fact, POTWs are in a position to assist in identifying industrial and commercial customers who are most in need of pollution prevention technical assistance because they are trusted with providing quality services to the very industries they regulate while protecting public health and the environment.

POTWs' pollution prevention strategies and their impacts are discussed at length in the Journal of Cleaner Production's 1998 article Utilization of publicly owned treatment works to promote pollution prevention (Lindsey,1998). The ITRC's *Risk Communication* documentation and training modules are likely to be particularly useful for POTWs engaging in outreach and education.

Regular Monitoring and Accurate Reporting

POTWs are the recipients of PFAS or PFAS precursors through their influents, although they may transform PFAS from one species to another. They play a crucial role as central collection points and

may serve as key locations to control and potentially mitigate release of PFAS into the environment. To date, 98 Massachusetts POTWs are required to monitor PFAS. Data from the remaining POTWs would be valuable in contributing to the currently limited body of wastewater PFAS data in order to improve collective understanding of PFAS in wastewater, and POTWs are participating in a MassDEP project in which influent, effluent, and sludge samples are being collected from POTWs with NPDES permits and analyzed for PFAS. This knowledge can guide POTWs in investing in capital projects, inform the development of proactive PFAS monitoring programs in anticipation of future regulations, and improve process resilience and flexibility.

Accurate data reporting is critical in this endeavor, although challenging. Measured PFAS concentrations should be reported with clear data qualifiers and quality assurance / quality control (QA/QC) metrics as reported by the testing laboratory, and average daily flow rate (or sludge generation rate) for the date of sample collection should be reported to allow for the calculation of mass or molar loading. Without the ability to calculate mass or molar loading, it is not possible to accurately compare the relative importance of PFAS sources to POTWs or evaluate the impact of a POTW's discharge of PFAS-containing sludge or effluent.

Moreover, some Massachusetts POTWs have misreported sludge quantities, such as by reporting in units of dry U.S. tons rather than the dry metric tons required by EPA Annual Biosolids Reports, and prior sludge management studies have not accounted for known intra-state sludge processing, overestimating statewide sludge generation, as discussed in the Part 1 report (Section 3.2.1; Tighe & Bond and Brown and Caldwell, 2024a). POTW staff should be trained to recognize the critical differences between discharge monitoring reports and EPA annual reporting methods and respond appropriately, with periodic refresher training opportunities. With regular monitoring and accurate reporting, POTWs will play a critical role in public transparency and facilitate ongoing research.

6.2.4 Consider Pilot Testing Promising PFAS Reduction Technologies

The wastewater and sludge PFAS treatment technologies discussed in Section 3.1 are receiving a lot of attention and new facilities are being designed and constructed around the country. POTWs can keep informed on the latest research and experiences from full-scale installations. Utilities can also consider piloting promising technologies to obtain performance measures for their particular situation.

The ability of MassDEP to regulate emerging technologies requires understanding the quantities and quality of waste streams, discharges, and emissions associated with a technology. Such data is limited for emerging technologies, which have few if any full-scale facilities in operation for long periods of time. Pilots can help fill in these information gaps.

6.3 Regulatory and Legislative Options to Consider

There are several options the state could consider that could help improve sustainable sludge management while protecting human health and the environment—by helping to stop PFAS use in the first place, including establishing sludge PFAS limits for land application and supporting volume reduction and PFAS treatment projects.

6.3.1 Implement PFAS Source Control Measures

Reducing or eliminating the use of PFAS at the source prevents these contaminants from entering wastewater collection systems in the first place, reducing or eliminating their burden on POTWs. Once PFAS are discharged to the collection system, they become diluted and more challenging to remove because of their chemical stability and resistance to conventional treatment practices. Effective PFAS removal from wastewater requires advanced treatment technologies such as

adsorption, membrane filtration, foam fractionation, or oxidation methods, as discussed in Section 3.1.1. Many of these technologies remain under development or would require costly process upgrades at POTWs. Furthermore, the accelerated costs of sludge management associated with the dwindling availability of end use or disposal outlets and increased reliance on long-distance hauling are passed onto ratepayers. Growing awareness of health and environmental impacts associated with PFAS and resulting concern over PFAS in wastewater sludge have contributed to these rapidly increasing management costs, as discussed in the Part 1 report in Section 3.8.

PFAS Use Restrictions

PFAS have been detected in a growing list of consumer products and have been used in a variety of industrial applications. While major manufacturers of PFOS and PFOA-related chemicals have ceased production in the U.S., they persist in the environment from historical use, products containing these compounds continue to be imported, and a wide range of PFAS continue to be produced in this country. Until PFAS are removed from production and adequately destroyed, they will continue to be detected in significant concentrations within the environment. Several states, including Connecticut, Maine, Michigan, and Vermont, have implemented or are actively pursuing initiatives to reduce or eliminate PFAS from commercial products and industrial applications, as discussed in Section 2.6.

The Massachusetts legislature could consider legislation that requires phasing out the most toxic PFAS from consumer products, which may also include provisions to improve public awareness of PFAS or require labelling that identifies products that contain PFAS.

In addition to considering legislative action, Massachusetts may consider restricting the state's own use of PFAS-containing products. Government agencies and other groups using state purchasing contracts have significant spending power and can model environmentally friendly supply chain practices. Minnesota, for example, has successfully eliminated PFAS-containing products from state contracts for compostable food service products (e.g., plates, cups, utensils, and take out containers). As indicated in Minnesota's PFAS Blueprint (2021), the effort to remove PFAS-containing products from state purchasing agreements creates an economic incentive for companies to find safer alternatives to PFAS and reduce PFAS in their supply chains, signaling that PFAS will not continue to be an acceptable additive for many high-volume consumers. Indeed, Massachusetts state contracts are used by eligible universities, cities, counties, and municipalities.

Industrial Pretreatment

EPA Region 1 is responsible for both the implementation and enforcement of IPPs in Massachusetts, as Massachusetts is not delegated to issue NPDES permits under the Clean Water Act. However, Maine and Rhode Island, with EPA authorization, are responsible for overseeing IPPs within their respective states, while Connecticut and Vermont provide direct oversight of their significant industrial users (USEPA, 2016a).

Like Massachusetts, New Hampshire is a non-delegated state under the Clean Water Act. The EPA is responsible for managing Industrial Pretreatment Programs in non-delegated states. New Hampshire's water quality regulations include provisions related to industrial dischargers that are more stringent than the federal regulations. These aspects are regulated by the New Hampshire Department of Environmental Services (NHDES) which employes one individual to manage all aspects of the state's IPP including review of approved and non-approved IPPs, review of municipal updates to sewer use ordinances some of which include local limits, review of inter-municipal agreements, inspections and audits of IPPs, and inspections of specific industries.

This precedent suggests that Massachusetts can explore the potential benefits of increased state involvement in IPPs in cooperation with EPA, which may include setting forth more stringent PFAS discharge requirements. In turn, these requirements would shift responsibility for managing PFAS in

wastewater from POTWs to industrial sources, effectively requiring industrial pretreatment and/or encouraging product or process substitution.

Determining the appropriate roles, responsibilities and costs for an IPP Section within MassDEP would require establishment of an appropriate legal authority, coordination with EPA, and a staffing analysis that is beyond the scope of this study.

Public Outreach & Education

Elected leaders and public servants can support Massachusetts residents in understanding the risks of PFAS contamination, the sludge management crisis identified in the Part 1 report from this study, and how they can contribute to mitigating these issues by mobilizing the state's financial and technical resources in a public outreach campaign. Leadership at the state level could serve as a model for localized and regional public outreach and education activities, unifying PFAS source reduction and sludge management efforts. Public outreach and education can empower individuals to make informed decisions regarding their private purchase and use of PFAS-containing products and in raising public awareness of and support for environmental initiatives. This is also the motivation for California's warning label requirements for consumer products containing chemicals known to cause cancer, birth defects, or reproductive harm, established under California's Safe Drinking Water and Toxic Enforcement Act of 1986. PFOS, PFOA, PFNA, and their derivative salts are now included in California's list (Ca.gov, 2021).

Successful public outreach campaigns require clear communication, public participation, and, typically, the use of various media to engage the community effectively to foster transparency and build trust and support among the public. Several states have implemented specific strategies to enhance public engagement on environmental issues such as PFAS contamination. Maine utilizes public email accounts and leverages media inquiries to educate the public, while Minnesota has developed a dedicated webpage to address public concerns and provide information on PFAS, demonstrating the importance of using digital platforms for outreach. Vermont has demonstrated the value of direct communication with affected parties by conducting one-on-one conversations with biosolids managers and farmers, which can lead to more personalized and impactful engagement (Hughes, 2023b. Peer education has been demonstrated in previous studies to improve the implementation of pollution prevention best practices in small and home-based businesses. (Ramírez et al., 2015).

Data Collection and Management

Effective PFAS data management is crucial due to the environmental and health implications associated with widespread PFAS contamination. The Massachusetts Executive Office of Energy and Environmental Affairs Wastewater Data Portal containing NPDES PFAS data serves as a useful starting point for this endeavor, as discussed in Section 4.2. Implementation of specific recommendations can enhance the utility of the database by improving public accessibility and contributing to ongoing research and development to facilitate monitoring and mitigation of PFAS in various environmental media, inform the public, and guide policy decisions.

As discussed in Section 6.2.4, robust quality assurance measures should be established. Measured PFAS concentrations should be reported with clear data qualifiers and QA/QC metrics for accurate and transparent data processing when necessary. In addition, average daily flow rate (or sludge generation rate) for the date of sample collection should be reported to allow for the calculation of mass or molar loading. With this information, regulators, POTWs, and researchers will be able to accurately compare the relative importance of PFAS sources to POTWs and evaluate the impact of a POTW's discharge of PFAS-containing sludge or effluent. This information is crucial to the success of future pilot studies and emerging technologies.

The use of geographic information system (GIS) tools to represent PFAS data offers additional opportunities for transparency and data analyses. Dashboards and geospatial information maps such as those hosted by Mass GIS, the Massachusetts Bureau of Geographic Information, provide interactive visualization tools that can improve public understanding of the nuanced issues at the nexus of PFAS pollution and sludge management as well as support environmental planning efforts and transparency in government operations.

Recommendations for future study are discussed further in Section 6.4 and Appendix H.

6.3.2 Limit Biosolids Land Application

Section 5.1 discussed the potential direct and indirect impacts and estimated associated costs with a biosolids land application ban or other restrictions that would amount to a de facto ban. As an alternative and to help transition the market, many other states have pursued regulatory limits for PFAS concentrations in sludge. It is our understanding that MassDEP intends to establish regulatory limits for PFAS for land applied biosolids. Most states that have established PFAS limits for sludge (e.g., New York, Michigan, Maryland, Minnesota (draft)) have set up a tiered system, whereby biosolids containing the highest levels of PFAS, which are indicative of industrial impacts, are not allowed to be applied to the soil, lower levels requiring lower application rates or taking steps to reduce industrial impacts, and the lowest levels having no additional restrictions. (See Section 2.5 for further discussion of other states' regulations.)

The EPA biosolids risk assessment (see Section 2.5.4) was published as a draft in January 2025. The associated risk mitigation strategy, required prior to rulemaking, would typically be expected 12-18 months later. The initiation of rulemaking, if deemed necessary, would then follow. This process is widely expected to lead to federal PFOS and PFOA limits applicable to land applied biosolids. Massachusetts could wait for those limits to be finalized and then adopt them or take the approach that New York is taking and pass interim limits in the state until the federal limits are available.

6.3.3 Promote PFAS Treatment Technologies

Managing sludge is rarely straightforward, but it has been particularly uncertain for a few years. Concerns over PFAS have added significant complexity to an already challenging sludge management landscape: aging infrastructure, difficulty in siting new facilities, difficulty finding reliable hauling, increasing hauling costs, seasonal restrictions on some outlets, constant production and minimal onsite storage, lack of operators and more. Emerging technologies such as pyrolysis, gasification and SCWO (see Section 3.4.4) greatly reduce the quantity of solids requiring management and show promise in significantly reducing PFAS concentrations in sludge. However, for these technologies to become a reality, there needs to be a clear regulatory pathway indicated.

The ability of MassDEP to develop these pathways requires understanding of the quantities and quality of waste streams, discharges, and emissions associated with a technology. Such data is limited for emerging technologies, which have few if any full-scale facilities in operation for long periods of time. These gaps can be addressed by technology vendors based on their experience in other states and through pilots in Massachusetts.

This evaluation has focused on mature (incineration) and emerging (pyrolysis, gasification, and supercritical water oxidation) technologies for sludge PFAS treatment . The following technologies are less developed, but are showing promise for PFAS reduction in sludge and could warrant further consideration:

- Hydrothermal carbonization
- Hydrothermal liquefaction

See Appendix B: "PFAS Mitigation Technologies - Sludge" for additional detail on all of these technologies.

MassDEP could consider developing a straightforward checklist clearly stating all permitting requirements (as is done for other permitting processes on the Department website) for sludge PFAS treatment technologies. The checklist could cover all necessary permitting, including air quality, wastewater, siting (M.G.L. c. 83, §§ 6 and 7), Massachusetts Environmental Policy Act (MEPA; 301 CMR 11. 03 (5)), end product usage, etc.

State permitting ensures compliance with applicable state environmental statutes. In Massachusetts, the MassDEP issues these permits, and the relevant regional MassDEP office will facilitate the permitting process. Project proponents are encouraged to arrange a pre-application coordination meeting with MassDEP. For POTWs, permitting processes including, but not limited to, the WM 16 (Treatment Works Plan Approval for New/Modified Facility associated with Surface Water (NPDES) Individual Permits) process is typically used for new treatment installation at POTWs. This process appears to be sufficient for PFAS treatment technologies. Permitting of sludge processing facilities will likely involve the Bureau of Air and Waste and the Bureau of Water Resources. If the facility includes thermal processes, an air permit will likely be required (310 CMR 7.00). Pre-permitting meetings with the permittee and MassDEP will address the permitting pathway for the specific project.

Massachusetts has a comprehensive air permitting program that regulates many types and sizes of air emissions sources, including the emissions sources operated at wastewater treatment plants (e.g., boilers and diesel electric generators). MassDEP does not currently regulate PFAS air emissions and there are no proposed changes for PFAS air emissions. However, PFAS concerns can still be raised during the public comment period, which could influence the outcome of a given air permitting process.

The permitting program was recently expanded to include a required Environmental Justice (EJ) review for facilities meeting the criteria for an EJ review (i.e., quantity of emissions, facility location).

Massachusetts has an involved project review and certification process through the Massachusetts Environmental Policy Act (MEPA) Office at the Executive Office of Energy and Environmental Affairs (EEA). A sludge PFAS treatment facility could meet at least one MEPA threshold, requiring a MEPA project review and certification. EEA may issue a certificate on the environmental notification form or the environmental impact report. This is a critical and necessary process as the MassDEP will not issue and, in some cases, will not start a permit until the MEPA certificate has been issued.

The MEPA review thresholds are listed and described in Section 11.03 of 301 CMR 11.00: MEPA Regulations. The thresholds include several categories or aspects of projects that are considered likely to cause damage to the environment. There are thresholds for wastewater projects listed in Section 11.03(5) including a threshold that would likely pertain to new biosolids processing facilities described in the threshold as "New Capacity or Expansion in Capacity for storage, treatment, processing, combustion or disposal of sewage sludge, sludge ash, grit, screenings, or other sewage sludge residual materials." The requirements listed in this threshold depend on the site assignment

(M.G.L. c. 21 or M.G.L. c. 83, section 6.) and state that any facility fitting this description that processes 150 or more wet tons per day and is not appropriately sited will need to submit an ENF followed by a mandatory EIR. Project proponents are encouraged to arrange a pre-application coordination meeting with MEPA.

If the new biosolids processing facility is to be located at a wastewater treatment plant or a solid waste facility, the site assignment in place will need to be verified and a determination made by MassDEP on its applicability to the new process. If the facility is to be located at a site that does not have a site assignment or the site assignment is not applicable, the site assignment process will most likely need to be conducted prior to the MEPA review and certification and will be a requirement for the MassDEP permitting process. Ultimately the site assignment decision is made by the local board of health, who receives a written assessment from MassDEP.

Both the MEPA review process and the site assignment process are public notification and participation processes and can take a significant amount of time and effort. Planning for these activities as well for the MassDEP permitting processes will need to be considered at the project conception stage for scheduling and budget inclusion in the overall project plan.

In the case that a process specific to emerging technologies would be preferable, a neighboring state can provide a guide; the New Hampshire legislature charged the Department of Environmental Services "to set standards of design and construction for sewerage and sewage or waste treatment systems and standards or design guidelines as the department determines to be appropriate for innovative/alternative waste treatment systems" (NH Rev Stat § 485-A:4 (2023)). The resulting regulations (Env-Wq 717 Innovative and Alternative Technologies) outline a technology evaluation and approval process, general operating requirements, design processes, and performance assessments over the first year of operation. The Massachusetts legislature could consider passing a similar law, allowing MassDEP to develop a similar process for the Commonwealth.

It also needs to be clear what the management options will be for the end product of PFAS treatment technologies. The State of Maine banned the land application of all sludge and products derived from sludge, and, thus far, regulators have interpreted the legislation to extend to the solids remaining after treating for PFAS through these technologies. This disincentivizes treating sludge for PFAS in Maine, since the resulting material still is only able to be landfilled or sent out of state. Most of the states that have existing pyrolysis installations or planned projects in the regulatory phase have regulated or plan to regulate the end product (i.e., biochar) as Class A biosolids. Ash from SCWO and some gasifiers will have essentially no remaining organic matter, similar to incinerator ash. In some states, incinerator ash no longer falls under biosolids regulations since all that remains is an inorganic mineral ash. For instance, in New Hampshire, incinerator ash is regulated as a Certified Waste-Derived Product by the Department of Environmental Services. In Massachusetts, options that could be explored to regulate these materials could be to regulate them as soil conditioners (per Title XIX, Chapter 128 Section 64) or by obtaining a beneficial use determination (BUD) as defined by 310 CMR 19.060.

New legislation could take into account regulatory efforts to address PFAS contamination and include an implementation schedule that would allow for regulatory and market response and rate adjustments, reducing potential adverse effects to POTWs. Capital budgets for wastewater utilities are planned years in advance, with planning, design and financing typically required before proceeding with a project. It is therefore difficult for POTWs to adjust quickly to new laws. In Maine, a ban on the land application of biosolids and solid waste restrictions that were enacted quickly led to the "sludge crisis," during which the cost to some POTWs (and, ultimately, to ratepayers) for sludge management doubled in a matter of weeks.

6.3.4 Support Sludge Volume Reduction and PFAS Treatment Projects

Funding for Full-Scale Projects

In addition to the existing funding sources discussed in Section 2.1.9, to meet the scale of the demand it is likely that additional funding sources will be needed to avoid drastic increases in ratepayers' water and sewer bills (Section 2.5) and to encourage project development.

Construction of full-scale projects for dewatering, drying, digestion, and/or PFAS treatment will require substantial capital expenditures that will have major rate impacts, particularly for POTWs with a small or economically disadvantaged user base. Table 6-3 and Table 6-4 summarize capital costs estimates for sludge volume reduction and PFAS treatment technologies, respectively, from Section 3.4.4. The state can assist these POTWs by incentivizing projects through grants and low or no-interest loans.

Table 6-3. Project Capital Cost Estimates with Estimating Range (-50% to 100%) for Installation of Sludge Volume Reduction Technologies at Various POTW Sizes

Technology Type	Technology	Small (90 dtpy)	Medium (900 dtpy)	Medium-Large (1,800 dtpy)	Large (3,600 dtpy)
Dewatering	Screw Press	$9.0M ($4.8M - $19.1M)	$19.3M ($9.1M - $36.5M)	$27.4M ($13.9M - $55.8M)	*POTWs of this size assumed already to have dewatering*
	Centrifuge	$8.8M ($4.6M - $18.5M)	$14.5M ($6.8M - $27.2M)	$18.0M ($9.2M - $36.8M)	*POTWs of this size assumed already to have dewatering*
Digestion	Mesophilic Anaerobic Digestion	*Not typically installed at the scale of Small facilities*	$33.5M ($16.3M - $65.3M)	$50.0M ($25.6M - $102.6M)	$89.0M ($44.3M - $177.2M)
Thermal Drying	Belt Dryer	$19.1M ($9.0M - $36.1M)	$29.6M ($14.1M - $56.2M)	$35.0M ($19.7M - $78.6M)	$63.5M ($30.8M - $123.4M)
	Rotary Drum Dryer	*Not typically installed at the scale of Small facilities*	$71.6M ($41.5M - $166.0M)	$139.7M ($58.5M - $234.0M)	$139.7M ($75.5M - $302.1M)

Table 6-4. Project Capital Cost Estimates with Estimating Range (-50% to 100%) for Installation of Sludge PFAS Treatment Technologies at Various POTW Sizes

Technology	Small (90 dtpy)	Medium (900 dtpy)	Medium-Large (1,800 dtpy)	Large (3,600 dtpy)
Gasification	*Not typically produced at the scale of Small facilities*	$97.8M ($43.7M - $174.8M)	$97.8M ($56.7M - $226.8M)	$170.6M ($82.7M - $330.7M)
Pyrolysis	*Not typically produced at the scale of Small facilities*	$43.7M ($22.9M - $91.7M)	$77.3M ($37.0M - $148.1M)	$129.3M ($65.2M - $260.8M)
Supercritical Water Oxidation	*Not typically produced at the scale of Small facilities*	$57.1M ($26.3M - $105.3M)	$58.1M ($32.8M - $131.3M)	$106.4M ($51.1M - $204.3M)

In July 2020, the Massachusetts Clean Water Trust (Trust) through the Drinking Water State Revolving Fund (DWSRF) Program approved a 0% interest loan program to assist communities in remediating PFAS contamination in drinking water. Shortly after in April 2021, the Trust expanded the program to also include the Clean Water State Revolving Fund (CWSRF) Program. In addition to 0% interest, both the DWSRF and CWSRF Programs include funding for design costs associated with PFAS remediation projects. The CWSRF and DWSRF Programs have historically been offered annually through MassDEP and are a reliable funding resource for communities. Projects submitted through these Programs are scored based on their Project Evaluation Forms (PEF) for eventual inclusion on MassDEP's Intended Use Plans each year. MassDEP can continue to support sludge projects by maintaining 0% loans, principal forgiveness, funding associated design efforts, and using scoring criteria that recognize the benefits of sludge volume reduction and PFAS treatment in the PEFs scoring system.

In February 2023, EPA announced grant funding for remediating emerging contaminants in small, rural, and disadvantaged communities drinking water supplies including PFAS through the Emerging Contaminants in Small or Disadvantaged Communities Grant Program. This Program offers grants up to $1M to communities fitting certain size and/or economic disadvantaged classification with its primary focus being PFAS remediation. Expanding this program to include PFAS treatment at POTWs and sludge volume reduction would assist similarly classified communities with funding addressing these challenges.

Support Pilots and Development of PFAS Treatment Technologies

There is not a clear regulatory process in Massachusetts for piloting emerging sludge technologies, such as pyrolysis, gasification and SCWO. A process does exist for drinking water systems (MGL c. 111, s. 160A; 310 CMR 22.04), which could be a template for wastewater systems. MEPA regulations (301 CMR 11. 03 (5)) are not applicable to installations with a capacity of less than 50 wet-tons/day; pilots would typically be far less than this threshold. Depending on the technology, the MassDEP's Bureau of Air and Waste may need to provide approval of air emissions.

The regulatory process in New Hampshire mentioned in Section 3.2 for full-scale projects includes a section on requirements for piloting "innovative" technologies (Env-Wq 717.04). The regulation lays out requirements for a pilot test plan and test summary report. Additional guidance documents have been issued by NHDES for specific technologies.

The state could also fund studies to help better establish the fate of PFAS in existing incinerators to understand the extent to which existing infrastructure can be leveraged to break the PFAS cycle. As discussed, there is very limited research on PFAS transport and transformation in incinerators, but preliminary results are promising (Winchell et al., 2024). This report explored the costs associated with retrofitting incinerators specifically for PFAS treatment (Section 3.4.4), but existing incinerators may be able to meet PFAS reduction and emissions targets once established without additional equipment.

Once the regulatory process is clear, the state can also support pilots by issuing funding to entities wishing to pilot emerging PFAS treatment technologies. Some of the sources of funding mentioned in the previous section could be used for piloting. "Pilot studies" are explicitly listed as "eligible project costs" in the Massachusetts policy document on CWSRF eligibility (MassDEP, 2023); other states (e.g., North Carolina) have made CWSRF Emerging Contaminant funding available for pilot-scale studies of PFAS treatment technologies. The state could also establish a grant or loan program specifically for pilots.

The results of pilots can facilitate development of permitting guidance and permit application by MassDEP as they can improve the understanding of waste stream quantity and quality for all media (i.e., water, air, solids).

NEIWPCC, the North East Biosolids and Residuals Association, state universities and others are looking to establish a "Northeast Circular Bio-Economy Engine." One of the aims of the Engine would be supporting research, testing, and demonstration phases of emerging technologies, along with translating innovation to practice across the region. If the Engine receives funding, it could be a source of technical and financial support for pilots of emerging technologies. The state could play a role in coordinating piloting between the Engine, state universities, technology vendors and POTWs.

Within Massachusetts, MassDevelopment provides a variety of services that may support the execution of pilot projects for emerging technologies, development of regional facilities, and process upgrades. These include loans, tax-exempt bonds, and grants for capital projects (MassDevelopment, n.d.). Water and wastewater treatment, along with solid waste disposal facilities (including landfills and recycling operations) are eligible for MassDevelopment's programs.

The innovation required for effective PFAS management provides fertile ground for public-private-academic partnership. Some such partnership opportunities exist at Massachusetts academic institutions. For example, the University of Massachusetts (UMass) promotes key initiatives to connect curriculum and research with industrial applications "in support of industrial growth and the advancement of the common good" (University of Massachusetts, n.d.) The UMass Innovation Institute serves as a bridge between fundamental research and downstream technology development by facilitating collaboration among researchers and industry partners. UMass also offers access to research facilities for academic, industry, and government users on a fee-for-service basis. Leveraging such tools with state support can improve existing understanding of the fate and transport of PFAS in environmental media and incubate novel PFAS treatment technologies. The Massachusetts Innovation Voucher Program previously funded by the state legislature gave small and medium-sized businesses access to UMass' research facilities at reduced rates, although the program was not funded for the 2025 fiscal year.

Some states incubate public-private partnerships as an alternative source of funding and support for programs and projects with environmental benefits. Funds can be directed to help foster development of research, data collection and analysis, and project development. Minnesota's Legislative-Citizen Commission on Minnesota Resources (LCCMR) serves as one example of public-private-academic partnership driving innovation to maintain and enhance the state's environment and natural resources (LCCMR, n.d.). The LCCMR makes funding recommendations to the legislature for special environment and natural resource projects, which are funded primarily by Minnesota's Environment and Natural Resources Trust Fund (ENRTF). The ENRTF, funded by a combination of State Lottery proceeds and investment income, is constitutionally dedicated to providing consistent and stable funding for activities that protect, conserve, preserve, and enhance Minnesota's natural resources and the environment. Massachusetts could consider developing dedicated funding sources to support the state's long-term wastewater management needs, including PFAS treatment.

6.3.5 Promote Regional Facilities

The appeal of regional facilities is clear. Sludge treatment technologies are relatively complex and expensive, and the need for reliable outlets is widespread. These drivers lend themselves to large, centralized operations where capital and operating costs, technical capacity, and operations and maintenance expertise can be centralized. The sludge management gap estimated in the report produced for Part 1 of this study for 2028 was around 12,000 dtpy (, Section 7.1). The planned capacity for imported ("merchant") sludge at the facility being considered by the Springfield Water

and Sewer Commission, UBCW, and the Narragansett Bay Commission in Rhode Island is just short of this amount at around 11,000 dtpy (Borkowski et al., 2024) so one successful regional facility could bring significant stability to the uncertain sludge management environment detailed throughout this report.

See Section 1.7.3 for a discussion of potential organizational structures for regional facilities and case studies of where they have been successfully implemented. There are two main ways that the state can support development of regional facilities: providing regulatory certainty and clarity and providing funding.

Regulatory and permitting uncertainty is reportedly acting as a hinderance to the development of regional projects in Massachusetts. Uncertainties about what will be able to be done with the end product, particularly in light of the proposed sludge land application restrictions in pending bills in the Massachusetts legislature (see Section 2.5.5), has been cited as a significant hinderance to moving beyond the planning stage for one regional project being pursued by public partners and for another to advance beyond partial design. The on-going cost of managing the solids product is a major factor in determining the economic viability of a regional project so providing as much regulatory certainty as possible is a way the state can support these efforts. Similarly, a private development project looking to construct a regional sludge PFAS treatment facility met with enough regulatory hurdles and delays that the project has effectively been on hold for years. If the Commonwealth sees regional facilities as part of the solution to sludge challenges there are steps that can be taken to elucidate the process.

Provide Regulatory Certainty

Similar to the options for PFAS treatment technologies in Section 3.2 above, DEP could consider creating very clear guidance documents outlining the requirements for regional facilities. The document could cover conventional (e.g., anaerobic digestion, thermal drying) and emerging (e.g., pyrolysis, gasification, SCWO, hydrothermal carbonization, and hydrothermal liquefaction) technologies, and consider development of a various configurations of regional facilities, including:

- At a POTW, where the new equipment is owned and operated by the wastewater utility.
- At a POTW, where the new equipment is owned and/or operated by a private entity.
- At another publicly owned location (e.g., a municipal-owned transfer station or landfill).
- At a privately-owned location.

Siting will be a key consideration for regional facilities. As discussed in Section 1.7.3, regional facilities at a POTW would likely fall under wastewater regulations. For siting of wastewater facilities, M.G.L. c. 83, §§ 6 and 7. As 310 CMR 16.00: Site Assignment Regulations for Solid Waste Facilities makes clear that the solid waste site assignment process does not apply to “Facilities which manage waste-water treatment plant residuals subject to the siting process pursuant to M.G.L. c. 83, § 6 and regulated pursuant to 314 CMR 12.00” (i.e., the regulations for POTWs).

The Massachusetts Environmental Policy Act (MEPA); (M.G.L. c. 30, § 61) is an important process, particularly for projects like a regional sludge processing facility that could have a range of potential impacts (odor, air emissions, traffic, noise, stormwater, site impacts, etc.). The process, however, can be complex for project developers to navigate, including environmental justice notification requirements (see Section 1.1.2.7). To facilitate a similar process, the Pennsylvania Department of Environmental Protection assigns staff from a regional office to act as a liaison with each project going through environmental review. The liaison helps answer questions from the project team, puts them in touch with the proper people within the Department for more detailed questions, and pushes the review process within the Department. They also help navigate the state funding processes.

Massachusetts could consider adopting a similar model to ensure efficient progress through the MEPA process.

In anticipation of multiple projects with these emerging technologies, the Secretary also could consider a Special Review Procedure for the MEPA process as a "prototype project" for the first regional sludge project that makes it to that stage. The prototype Special Review Procedure (11.09.4.d) is designed to streamline review of future, similar projects and so could be used to encourage the development of multiple projects in different parts of the state. The Secretary could also consider allowing a single Environmental Impact Report (EIR) for projects meeting the mandatory EIR threshold (150 wet-tons/day) and requiring only an Environmental Notification Form (ENF) for projects below the threshold where an EIR is not required by statute. MassDEP is able to expedite the overall regulatory process by proceeding with some steps of the MassDEP permit process (e.g., public participation) in parallel with the MEPA process (with the understanding that MassDEP cannot complete technical review of an application before MEPA certification is obtained).

To ensure timely permitting review, the state could consider adding additional permit review staff. Particularly for private developers, the economics of a project improve the quicker it can be implemented.

Provide Funding

The other major role the state could play in supporting regional projects that make a significant dent in the sludge management gap articulated throughout this report would be through funding. The state could set up a grant program for POTWs interested in pursuing a regional facility, with an aim to support projects across the state. This grant program could use the existing authority from M.G.L. c. 21 § 33E or be a new program established in a similar manner. Allowing for a portion of grants to pay for planning and design will accelerate the development of regional projects. In addition, funds awarded from any successful lawsuits filed by the State against PFAS manufacturers may be made available to support the development of regional sludge management facilities.

6.4 Conclusion

The Commonwealth of Massachusetts and POTWs have many significant opportunities to mitigate the sludge management challenges identified in the MassDEP PFAS and Residuals Technology and Management Study, Part 1 and Part 2. While pursuing all of the approaches described herein may prove impractical, implementing even a subset would help stabilize Massachusetts sludge management. Stabilizing the system would help avoid runaway management costs and curb the public health and environmental impacts associated with exposure to PFAS in sludge generated or managed in the Commonwealth.

POTWs can take the following actions:

- Explore volume reduction technologies to produce less, drier sludge.
- Consider providing commitments to regional facilities.
- Undertake local PFAS source reduction.
- Consider piloting sludge PFAS treatment technologies.

In addition, the state government can consider:

- Implementing PFAS source control measures that include encouraging reduction of PFAS in household products to lower overall PFAS levels in domestic sewage.
- Establishing PFAS sludge limits for land application, considering a tiered approach so that land application of biosolids can remain as a viable management option, while limiting potential food-chain health impacts

- Providing regulatory certainty for PFAS treatment technologies so that municipalities and/or private developers can understand and plan for the permits necessary to develop new facilities.
- Supporting volume reduction and PFAS treatment technologies through funding of full-scale projects and facilitating piloting of emerging technologies to facilitate the development of projects that treat PFAS and increase sludge management capacity state-wide.
- Supporting the development of regional facilities through regulatory guidance and funding, as they can provide cost-effective means of sludge management for the many small and medium sized POTWs for which onsite facilities would be cost-prohibitive.

As a critical next step toward developing evidence-based technical solutions and regulations, MassDEP has commissioned a new study, the PFAS Testing Study for NPDES POTWs ('PFAS Testing Study'). PFAS testing requirements for wastewater influent, effluent, and sludge are being added to NPDES and Surface Water Discharge (SWD) monitoring programs as POTWs' permits are renewed, as discussed in Section 4. The PFAS Testing Study will further increase the Commonwealth's understanding of PFAS in wastewater influent, effluent, and sludge by accelerating sample collection from all 114 NPDES-permitted POTWs in Massachusetts to significantly expand the existing Executive Office of Energy and Environmental Affairs Wastewater NPDES PFAS Data Portal database. PFAS concentrations will be measured using non-targeted Total Oxidizable Precursor Assay (TOPA) and Adsorbable Organic Fluorine (AOF) analyses in addition to the targeted EPA Method 1633 required for NPDES and SWD permit monitoring to gain insight into the presence of PFAS precursor compounds and PFAS transport and transformation within POTWs. The PFAS Testing Study is expected to be completed later in 2025.

Supplemental Recommendations for future scientific research and methodological approaches are discussed further in Appendix J.

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Appendix A: Sample Questions

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION PFAS & RESIDUALS TECHNOLOGY AND MANAGEMENT STUDY QUESTIONNAIRE

Interview Framework:

- Each 1-hour interview will be conducted virtually over MS Teams, invite to be sent from Celine Mina
- Interview panel consists of Tighe & Bond project team members:
    - Todd Brown – Project Director,
    - Joe Popielarczyk – Project Manager,
    - Prashanth Emmanuel-Task Lead,
    - Celine Mina – Project Engineer
- The interview will begin with a 5-minute introduction of the project background, followed by a discussion of each question, with a maximum of 3 minutes per question
- Extra time has been provided at the end for additional discussion

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Interview Questionnaire *(Please note some questions may not be applicable to all stakeholders)*

1. What impacts are you currently experiencing or anticipating due to the presence of PFAS in biosolids/sludge to your current treatment and/or disposal process?

2. What regulations and/or permits drive your current processes regarding PFAS in biosolids/sludge handling or disposal process (e.g., federal, state, local regulations)?

3. How are you preparing for changes to (assuming more stringent) pending regulations for PFAS in biosolids/sludge? What are some of the nuances/considerations you are concerned about?

4. What would be the impact to your operations based on applicability of the following (to your facility):
    a. Land application ban in Massachusetts
    b. Land application ban in surrounding states (New England, New York, Canada)
    c. Strict limits on landfill leachate PFAS levels
    d. Strict limits on POTW effluent PFAS concentrations
    e. Strict PFAS air emissions limits

5. What new research or emerging technologies are you currently or interested in exploring for managing PFAS in biosolids?

6. How are you currently screening for PFAS in the influent and ultimately in biosolids? What sampling protocols and/or methods do you currently employ?

7. What current or pending regulations do you think hinder the ability to solve the existing PFAS problem in biosolids? Why?

8. What would you like your officials to know? What would you like to see or what would you support in future biosolids regulations concerning PFAS?

9. How do you see PFAS, and contaminants of emerging concern play a role in end-use options? For example, continued use in land application for agricultural purposes?

10. What are some methods for improving public perception on biosolids utilization?

11. (Specific to regulators) What is your current process for working with facilities to reduce PFAS in the effluent? How are the decisions made to either install or replace technology and/or replace internal/external sewer pipes or both? Do you have any details on enforcement issues you can share, if applicable?

Appendix B: PFAS Mitigation Technologies – Wastewater Liquid Fraction

Contents

B-1. Granular Activated Carbon B-2
B-2. Ion-Exchange Resin B-3
B-3. High Pressure Membranes – Nanofiltration and Reverse Osmosis B-4
B-4. Continuous Foam Separation/Foam Fractionation B-6
B-5. Novel Adsorbents B-6
a. Coated Sand B-6
b. Zeolites/Clay Minerals B-7
c. Biochar B-7
B-6. Destructive Technologies B-7
a. Electrochemical Oxidation B-7
b. Cold Plasma B-7

B-1. Granular Activated Carbon

Description: Granular activated carbon (GAC) is a filter media typically made from coal or organic material (e.g., coconut husk) feedstock. The raw feedstock material is subjected to various thermal and chemical processes often referred to as "activation." The carbon activation process creates a complex pore structure and extremely high surface area on a unit mass basis. Most GAC has a total surface area of approximately 100 acres per pound. GAC removes contaminants through adsorption, which means the compounds are attracted to and "stick" to the media surface within the complex pore structure. GAC is especially effective at removing non-polar, hydrophobic compounds, which preferentially attach to the media and travel slowly into the pore structure. However, large compounds, such as natural organic matter (NOM), can block pores or compete with trace compounds (e.g., PFAS) for adsorption sites and reduce adsorption capacity.

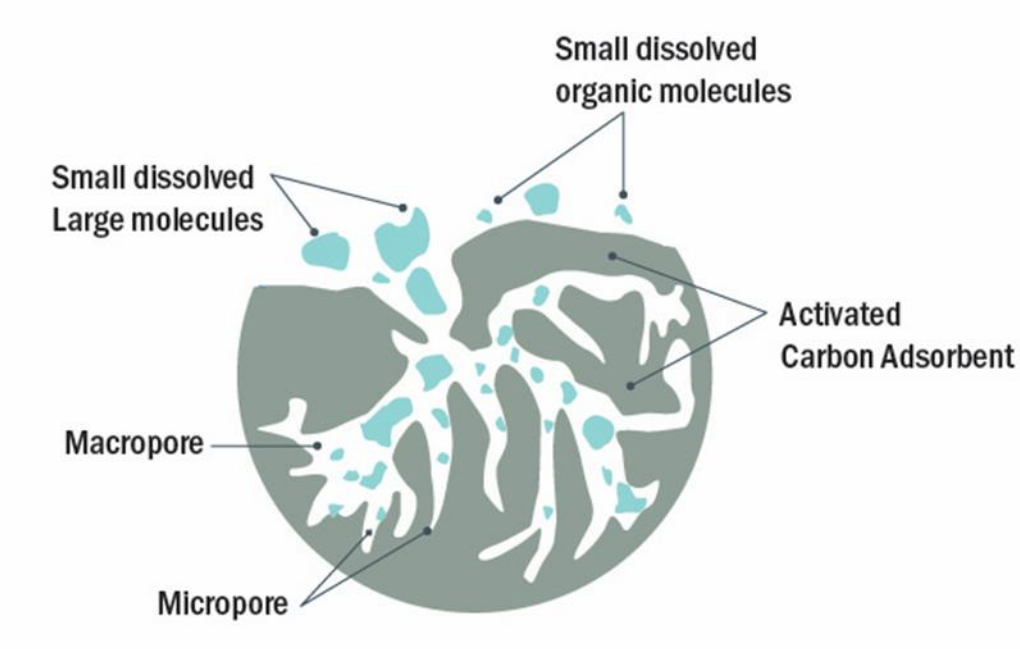


Figure B- 1. Porous structure of granular activated carbon absorbing organic compounds

Courtesy of Brown and Caldwell

GAC adsorption is a non-steady-state process, meaning that media must be replaced with fresh GAC after adsorption sites are used up. For removal of compounds such as PFAS, where the treatment target is often at or near the detection limit, it is typical to run GAC treatment in a lead-lag configuration. This configuration consists of two vessels in series, with monitoring of the contaminant after the first, or lead, vessel. When breakthrough is observed in the lead adsorber, the media is replaced and the lag adsorber becomes the lead. This maintains the treated water concentration below the low treatment target because the lag adsorber provides an extra polishing step. In addition, a lead-lag configuration allows for more efficient GAC use because the adsorption capacity of the media in the lead vessel is more thoroughly exhausted, as the filter can continue to remove PFAS with its remaining capacity, though not enough to meet the treatment goal.

The pros of GAC for PFAS treatment include:

- A long track record of success for treating PFAS with numerous installations around the country.
- Robust media that is effective with a large variety of influent water quality.
- GAC is a non-selective media, meaning it removes other organic compounds, such as NOM, volatile organic compounds, and synthetic organic compounds in addition to PFAS.
- Typically, GAC is the least expensive treatment media on a volume or weight basis.

The cons of GAC for PFAS treatment include:

- An empty bed contact time (EBCT) of approximately 10 minutes per vessel (in lead-lag) is required to contain the mass transfer zone. This EBCT is longer than an equivalent IX system (described below), which results in the comparative need for larger media vessels (i.e., larger footprint, larger capital expense).
- The non-selective nature of GAC allows for competition of adsorption sites, which results in lower efficiency in waters with high concentrations of other organic compounds.
- GAC can release, or roll off, PFAS and other compounds as available adsorptions sites decline and competition with other compounds increases. This may result in effluent concentrations being temporarily higher than influent concentrations. Shorter-chain PFAS are more likely to desorb than longer-chain compounds

Spent GAC media can be shipped to a reactivation facility, often coordinated by the GAC supplier. Based on current research (DiStefano et al., 2022), the reactivation process provides enough thermal energy to cleave the C-F bond and the byproducts (carbon dioxide, carbon monoxide, and hydrogen fluoride) are mitigated with stack emission capture equipment (e.g., wet scrubbers). The reactivated GAC can be reused on site or used elsewhere in non-drinking water applications. Spent GAC media can also be landfilled at appropriate disposal facilities when reactivation facilities are not available or when the reactivation process cannot remove all the hazardous material.

B-2. Ion-Exchange Resin

Description: Whereas GAC adsorbs PFAS onto the media and into the pore structure primarily through hydrophobic interactions, Ion-Exchange (IX) resins rely on electrostatic forces to capture charged molecules (ions) from the bulk solution onto the resin surface. Similar to GAC, IX is a non-steady state process, meaning that IX resins must be replaced with fresh media when exchange sites are consumed. Unlike GAC, resins can be manufactured to be more selective in targeting compounds for removal.

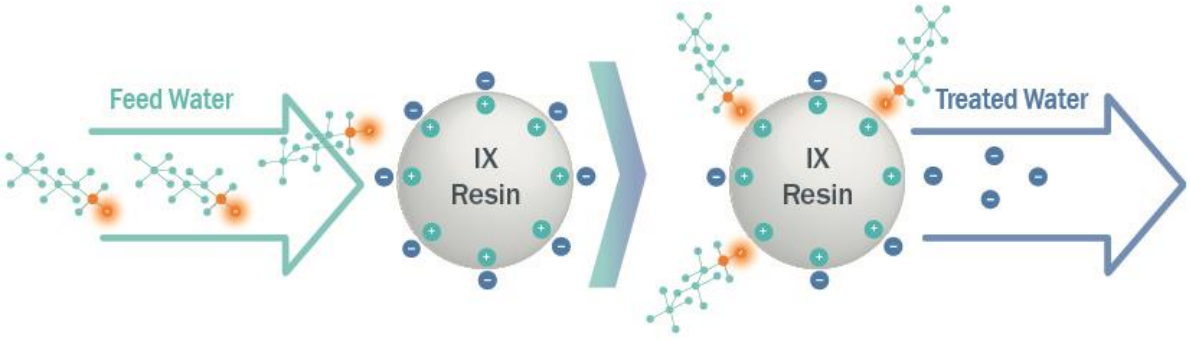


Figure B- 2. Ion exchange resin relies on electrostatic interactions to remove charged PFAS molecules from impacted water

(Courtesy of Brown and Caldwell)

The pros of IX for PFAS treatment include:

- There are specialty anionic exchange resins designed to more selectively target PFAS removal. With these resins, PFAS is removed more efficiently without as much competition from other water quality constituents.
- The ion exchange process is more kinetically favorable than GAC adsorption, meaning that EBCTs can be much shorter, typically in the range of 2 to 3 minutes. This results in less media and smaller pressure vessels compared to GAC treatment (i.e., smaller footprint, smaller capital expense).
- IX resin has been demonstrated to have better treatment performance on short-chain PFAS compared to GAC.

The cons of IX for PFAS treatment include:

- IX media is more expensive than GAC on a volume or weight basis (IX can be approximately 3x to 5x more expensive on a per unit volume basis),
- IX can pose more operating challenges compared to GAC. The IX resin is smaller and more likely to foul (physically or biologically).
    - It is also more difficult to clean fouled media, so extensive pretreatment may be required to minimize fouling problems. True backwashing of IX is not possible due to the media's low specific gravity. In water, IX beads are close to neutral buoyancy. This property results in the need to keep the backwash loading rate low to prevent over-expansion of the filter bed and media loss out the top of the vessel. This makes it difficult to remove solids that may accumulate within the filter; thus, prefiltration is typically required.
    - IX resin beads are typically a proprietary plastic blend that tend to degrade when exposed to oxidants such as chlorine. Once an IX filter becomes biologically active, alternative methods of disinfection may be required to control the growth.

Spent IX media is shipped off site to an incineration facility where the media is brought to a temperature high enough to break down the C-F bond, and the byproducts (carbon dioxide, carbon monoxide, hydrogen fluoride) are mitigated with stack emission capture equipment (e.g., wet scrubbers). The incineration process destroys the IX resin, so it cannot be reused like GAC. However, ongoing research and development of regenerable IX resins are showing promising results. Regenerable IX resins will still produce a PFAS concentrated residual that will require management. Spent IX exchange can also be landfilled at appropriate disposal facilities.

B-3. High Pressure Membranes – Nanofiltration and Reverse Osmosis

Description: Nanofiltration (NF) and Reverse Osmosis (RO) are high-pressure membrane filtration processes that force water through semi-permeable membranes. Membrane filtration selectively removes compounds based on their size and charge. Unlike GAC and IX, high-pressure membranes are a liquid phase separation process, meaning that they generate a permeate stream of treated water and a residual concentrate stream, which will have high concentrations of PFAS in addition to other constituents rejected by the membrane. Commercially available NF and RO membranes span ranges of selectivity from loose NF to tight NF and loose RO to tight RO. NF membranes are less selective than RO membranes and have pore sizes ranging from 0.1–1 nanometers (nm); RO membranes are generally selective to less than 0.1 nm. PFAS is not retained on the membranes, and

therefore their replacement rate is based on maintenance needs. However, pretreatment (e.g., pH adjustment) and routine cleaning-in-place procedures are usually required to minimize fouling.

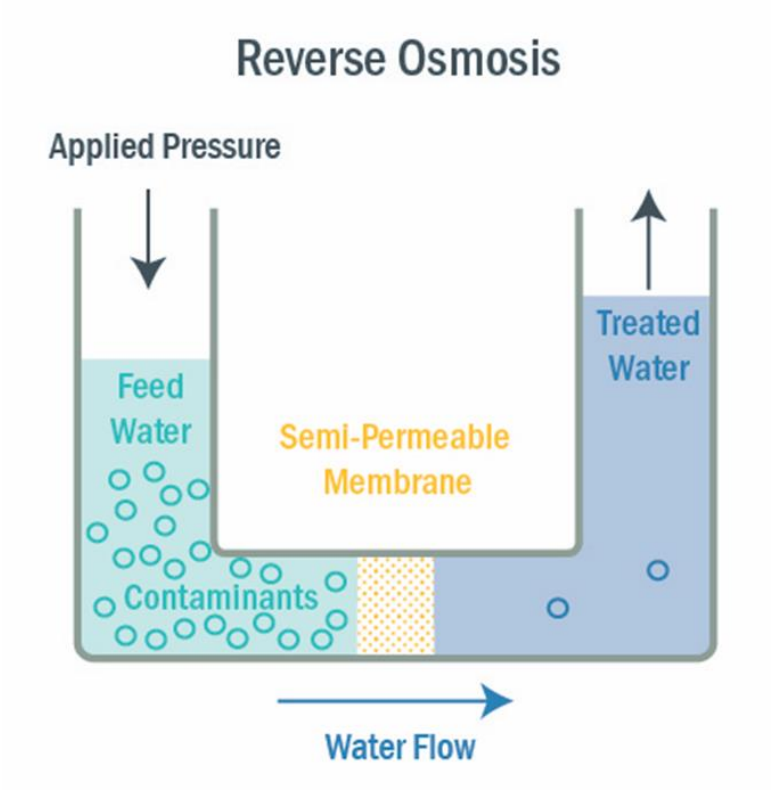


Figure B- 3. RO and NF are separation processes that retain contaminants like PFAS and allow water to permeate through the membrane

(Courtesy of Brown and Caldwell)

The pros of NF and RO for PFAS treatment include:

- NF and RO have a long track record of use for other trace organic constituents, but there has been limited implementation for targeted PFAS removal to date. RO has demonstrated to be very effective for removing PFAS, while recent studies also indicate that some NF membranes can be very effective.
- Non-selective technology that will remove many other larger contaminants and salts that are present in the water.
- Likely the most effective treatment technology for PFAS, including shorter-chain compounds, with a high rate of removal.

The cons of NF and RO for PFAS treatment include:

- Typically have the highest capital cost of the three most common separation technologies discussed, posing a barrier to widespread implementation (when PFAS is the sole constituent of concern).
- Relative to GAC and IX, membrane treatment has higher electrical and operating costs.
- Because other minerals, such as bicarbonate, can be removed by high-pressure membrane treatment, remineralization of the treated water may be required to stabilize pH and control corrosivity.

- Membrane filtration is a separation technology and not an adsorptive media like GAC and IX. Therefore, it produces a concentrated liquid waste stream that requires appropriate management. In conventional high-pressure membrane applications, the residual waste stream may comprise 15 percent to 20 percent of the influent volume. Often at full-scale, in-land high pressure membrane installation, residual concentration becomes economical based on concentrate disposal costs. Some facilities pursue zero liquid discharge (ZLD) that often includes significant residual concentration/management infrastructure to produce a highly concentrated, low volume, solid waste for offsite disposal.

B-4. Continuous Foam Separation/Foam Fractionation

Description: Many PFAS compounds have hydrophilic heads and lipophilic tails, making them amphiphilic or surface active. This structure creates a tendency for amphiphilic PFAS to congregate at the interface of water and oil or water and air. Continuous foam separation is a chemical process that leverages this property to treat water contaminated with PFAS.

In continuous foam separation, a steady stream of air or other gas is injected into the contaminated water through a sparger. Bubbles float up from the sparger to the liquid surface, carrying surface active PFAS with them. The bubbles collect to form a foam containing concentrated PFAS at the liquid surface. The foam is then skimmed off or collected in a column, removing collected PFAS from the solution. Bubbles in the collected foam are then collapsed to separate the liquid and gas phases. The gas is either recycled or allowed to escape while the PFAS-rich liquid is captured and ready for disposal.

This method has been tested on PFAS-impacted landfill leachate and appears to be highly effective for most PFAS species. Pilot-scale studies have demonstrated the feasibility of using foam fractionation for PFAS removal in various settings, including wastewater reclamation facilities and in-situ groundwater remediation sites

Continuous foam fractionation is a promising technology that boasts several advantages as follows:

- Effective at removing high PFAS concentrations
- Can handle water with co-contaminants
- Produces very low waste
- Relatively low costs
- Requires minimal energy

Disadvantages of continuous foam fractionation are:

- Additives might be necessary for low PFAS concentrations
- Less effective for short-chain compounds
- Less effective for non-amphiphilic PFAS that lack a hydrophilic functional group

B-5. Novel Adsorbents

a. Coated Sand

Polymer-coated sand is an adsorbent material with a high affinity for organic contaminants including PFAS. The material consists of a polymer coat which serves as the active component that removes contaminants and an inactive support base. The polymer coat entails of cyclodextrin molecules that

have been polymerized with a cross-linking agent, forming cavities that readily adsorb organics. Coated sand has shown similar performance in removing PFOA and PFOS as GAC. The adsorbent is also effective at removing chlorinated solvents such as trichloroethene (TCE), perchloroethylene (PCE), and hexavalent chromium(Badruddoza et al., 2017).

b. Zeolites/Clay Minerals

Zeolites are naturally occurring aluminosilicate compounds that are widely used in chemical separation and purification due to their high surface are and small uniform pore size. Clay minerals are similar to zeolites in composition but have a different crystalline or chemical structure. Surface-modified clays have been reported to have enhanced adsorption performance for a variety of constituents including PFAS(Zhou et al., 2010). Zeolites and clay minerals use both ion exchange and adsorption mechanisms to remove PFAS from water. These materials exhibit widely varying PFAS adsorption capacities, so performance should be assessed for each specific zeolite or clay-based media.

c. Biochar

Biochar is a carbon-rich porous solid that is synthesized by heating biomass, such as wood or manure in a low oxygen environment. Biochar may also be produced by pyrolysis of PFAS-impacted media (Thoma et al., 2022).This material has primary applications for carbon sequestration, improving soil fertility, and most recently for pollutant removal. Biochar has a high affinity for organic compounds which is dependent on the pore structure and functional groups of the biochar material. The variability of these performance parameters and current lack of quality control makes it difficult to procure large volumes of consistent material and to implement biochar on a large scale.

B-6. Destructive Technologies

d. Electrochemical Oxidation

Electrochemical oxidation is an iteration of advanced oxidation processes increasingly applied in water treatment. During the process, a current is passed through the water, generating powerful oxidants such as hydroxyl radicals that readily break down contaminants into smaller molecules. The reaction mechanisms of electrochemical oxidation involve complex and competitive reaction pathways that are influenced by many factors such as electrode material, pH, temperature, applied electrical potential, and reaction kinetics.

The high oxidative conditions created allow these reactions to progress until completed degradation to elemental precursors are all that remain, such as CO^2 and H^2 gas, fluoride ions, and other mineral salts (Louis LeBrun, 2024).

e. Cold Plasma

Cold plasma is another novel but promising technology to treat contaminated water for PFAS. Cold plasma is generated by applying an electromagnetic field to a gas such as air or argon. The electromagnetic field excites electrons in the gas, creating a mixture of reactive species including

radicals and ions. The plasma is either applied directly to the surface of the water or used to create plasma-activated water. The reactive species in the plasma then break down the strong carbon-fluorine bonds of the PFAS molecules, degrading them into less harmful substances.

Appendix C: PFAS Mitigation Technologies – Sludge

Contents

C-1. Incinerators C-2
C-2. Pyrolysis and Gasification C-3
C-3. Supercritical Water Oxidation C-4
C-4. Hydrothermal Carbonization C-4
C-5. Hydrothermal Liquefaction C-5

C-1. Incinerators

High temperature incineration systems, the current standard method for PFAS destruction are most applicable for addressing PFAS treatment residuals that span a wide range of characteristics. The temperature used for thermal incineration of PFAS in carbon regeneration is usually higher than 1,000 degrees Celsius (°C)(Lee et al., 2013); however, in laboratory studies, more than 99 percent of PFOS is transformed at 600°C (Taylor & Yamada, 2003). Studies have shown the required degradation temperature generally increases with increasing perfluoroalkyl chain lengths (Rayne & Forest, 2009).

All incinerators in the U.S. are required to meet emissions criteria with extensive air pollution control measures. Typically, incinerators employ some type of wet scrubber for air pollution control. Researchers have hypothesized that any PFAS compounds escaping the furnace would be captured in the wet scrubber. Some facilities use wet electrostatic precipitators downstream of the wet scrubber to capture fine particulates that could include adsorbed PFAS compounds.

Many incinerators also include equipment to remove mercury from the flue gas, which requires an activated carbon or sorbent polymer composite system. Activated carbon removal of PFAS is well accepted for drinking water applications, and PFAS removal can be expected from the gas phase via activated carbon as well.

As the state of understanding regarding incineration as an effective PFAS destruction technology develops, waste generators are relying on permitted, high temperature, hazardous waste combustors that operate at temperatures in excess of 1,000°C to promote maximum PFAS destruction (Figure 1-2). Standard municipal, commercial, and industrial waste incineration units are not believed to provide sufficient thermal energy to completely mineralize PFAS. While the EPA acknowledges that data gaps remain regarding the understanding of PFAS fate in high temperature incineration processes, hazardous waste incineration providers have documented six log (99.9999 percent) destruction of select PFAS (Clean Harbors, 2023).It is important to note that installations of permitted hazardous waste combustors in the United Stated are limited. Currently, the EPA identifies 26 permitted hazardous waste combustors in the United States(U.S. Environmental Protection Agency (EPA), 2023).

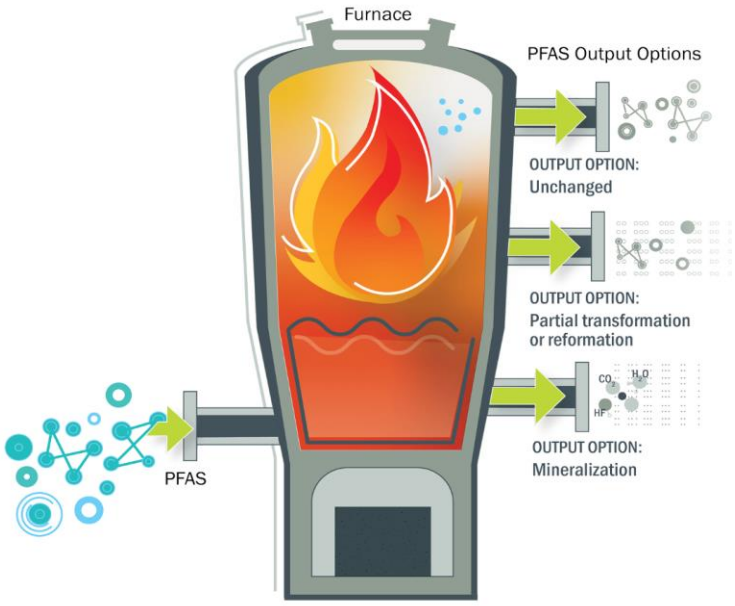


Figure C- 1. PFAS Destruction Using Incineration

(Courtesy of Brown and Caldwell)

While currently there is no published work on PFAS removal within an incineration application across the stated pollution control equipment, Brown and Caldwell is leading this research as part of Water Research Foundation Project #5111 (Studying the Fate of PFAS through Sewage Sludge Incinerators), with results to be available before summer of 2024.

C-2. Pyrolysis and Gasification

In the absence of oxygen and/or at temperatures lower than required for combustion, PFAS can still be destroyed through thermal processes. In the strict absence of oxygen, the thermal process is called thermolysis. Calcination of limestone to quicklime using heat to drive off carbon dioxide is a simple thermolysis example.

Pyrolysis and gasification, examples of thermal processes in oxygen-limited environments, have been sparingly applied in the water/wastewater industry but are gaining interest given the regulatory challenges of permitting and compliance requirements for incinerators. While pyrolysis and gasification have been used for biosolids management to generate biochar and simpler hydrocarbon substrates for subsequent use, the promise of also addressing PFAS has prompted specific research to document the ability of pyrolysis and gasification to destroy PFAS.

Pyrolysis and gasification are thermal decomposition processes that convert solid carbon-based feedstocks into combustible gases. Pyrolysis subjects feedstocks to high temperatures (200°C to 1,100°C) in the absence of oxygen and generates a carbon-rich, porous product called biochar. Gasification introduces a limited quantity of oxidant (typically air) at high temperatures (800°C to 1,650°C) to refine the volatile organic fraction through partial oxidation and reforming reactions, while converting the solid mass to ash. Limited experimental data are available on PFAS removal during pyrolysis and gasification, which has prompted Brown and Caldwell to advance a Water Environment Federation project that will evaluate PFAS destruction through laboratory and full-scale pyrolysis and gasification systems, including a mass balance to understand the fate of PFAS through the process (Water Environment Foundation (WEF), 2022).

If the PFAS or partial decomposition products do volatilize and exit the reactor in the pyrolysis/gasification effluent gas (often called syngas), a thermal oxidizer may be necessary to combust the syngas and mineralize remaining organic compounds, including PFAS. Excess heat from thermal oxidizers may be captured and recycled for upstream drying processes or conversion to electricity. Thermal oxidizers are already permitted for 99.99 percent PFAS emission reduction, which has been validated by testing (Focus Environmental Inc., 2022). Consequently, the critical step for achieving potential PFAS emissions control in pyrolysis and gasification systems may be implementation of a thermal oxidizer.

C-3. Supercritical Water Oxidation

Beyond the bench and/or pilot scale, super critical water oxidation (SCWO) has recently achieved a level of commercialization for PFAS destruction beyond many of the other developing destructive technologies. SCWO can be used to treat any flowable material (including biosolids) and relies on the unique reactive properties of water above the critical point (i.e., high temperature and pressure). To limit fouling and other operating challenges, PFAS-containing wastes may require pretreatment prior to entering the SCWO reactor. Additionally, like high temperature incineration, the energy requirement for complete PFAS mineralization in an SCWO reactor limits the economic viability of the technology to high-concentration, low-volume wastes.

C-4. Hydrothermal Carbonization

Hydrothermal carbonization (HTC) is an embodiment of pyrolysis technology that is performed in the presence of water, thus it is known as wet pyrolysis. C-Green has developed the OxyPower HTC process, which uses hydrothermal carbonization to treat sludge. Hydrochar is the solid product produced from the HTC process. It does provide solids volume reduction. Aragon-Broceno et al. (2020) evaluated how HTC works on anaerobically digested sludge. The date showed that pairing anaerobic digestion with HTC had a net electrical and thermal power production. C-Green (Swedish company) has developed the OxyPower HTC process which uses hydrothermal carbonization to treat sludge. Their Finland facility accepts approximately 18,000 wet tons per year of waste sludge from paper mills. C-Green has tried batch of sewage sludge in their system; however, they have not operated continuously with sewage sludge only. Their process treats sludge for one hour at 200 °C in a hydrothermal carbonization reactor. The schematic of the process can be seen in the figure below (C-Green, 2022).

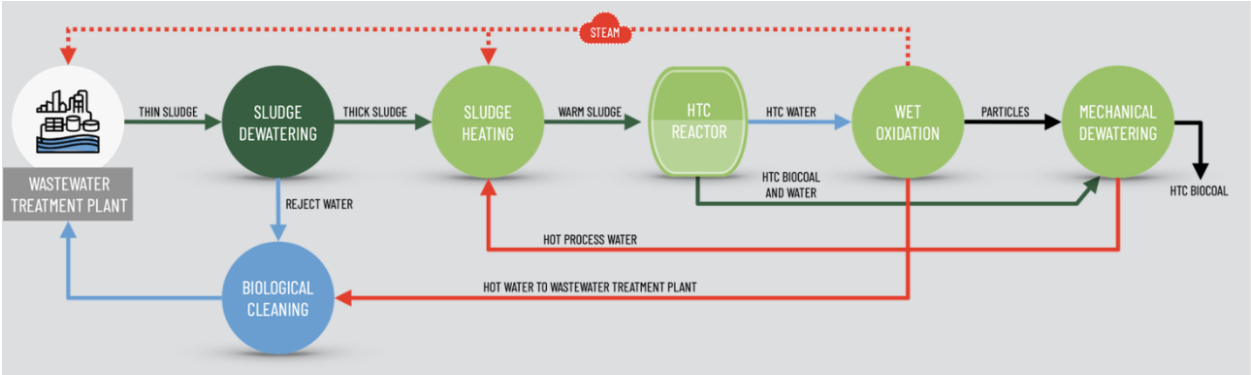


Figure C- 2. Process flow for OxyPower HTC

HTC could present some interest in addressing the PFAS. As two fractions are obtained from HTC, and as elevated levels of temperature and pressure are used, it could be possible that some PFAS

could preferably end up in one of the produced fractions and/or be modified or destroyed during the reaction.

The amount of data available to assess the impact of HTC treatments on PFAS is quite limited, for several reasons. Internally in C-green, the topic did not seem a priority for our prospects and customers over the last years, but this trend is slowly shifting. A few results have been acquired by C-Green, but the low levels of PFAS (close to the limits of detection) and the significant uncertainties regarding the obtained values have not allowed us to reach any conclusions. More work would be required to further qualify and quantify the impact and efficacy of HTC on those pollutants.

Wet oxidation (the treatment that C-Green uses for the liquid fraction) could be a relevant polishing treatment, as some studies claim that thermal oxidation could be one step in the removal of PFAS. C-Green's wet oxidation is carried out at lower temperatures than thermal oxidation. Studying the impact of the wet oxidation on the levels of PFAS of the liquid effluents could be beneficial.

C-5. Hydrothermal Liquefaction

Hydrothermal liquefaction (HTL) subjects solids to high temperatures and pressures (250–350°C, 10–25 mega Pascals [MPa]) to generate a liquid biocrude oil. A significant benefit of HTL is its ability to convert what are, in many cases, environmental liabilities and challenges such as sewage sludge, manure, and food waste into sustainable biocrudes which can subsequently be converted into sustainable fuels. That is, HTL provides an opportunity to deliver on the promise of waste-to-fuels in sectors where they are needed: aviation, heavy trucking, and marine sectors in a manner that has environmental benefits. For example, there is real potential to address environmental liabilities associated with sewage sludge disposal such as leaching of PFAS.

Laboratory-scale HTL experiments with wastewater sludge demonstrated varying levels of PFAS degradation based on analysis of the functional groups of the compounds and operational parameters(Yu et al., 2020). Greater than 99% transformation efficiency was observed for PFAS compounds with carboxylate functional groups, specifically PFOA, fluorotelomer carboxylic acid (FTCA), and fluorotelomer unsaturated carboxylic acids (FTUCA). Conversely, less than 34% degradation was observed with the sulfonic acid compound PFOS, even when the temperature was elevated to 350°C for 90 min. Both the original PFAS compounds and defluorinated intermediary products were found in the biocrude oil fraction, which presents a research need for understanding its resulting fate. The authors proposed potential application of reactive amendments to the HTL process to further promote destruction of recalcitrant PFAS compounds such as PFOS during HTL. It was found that amending a plant biomass-fed HTL process with potassium hydroxide (KOH) increased removal of perfluorosulfonic acids from <20% to 86%, indicating the potential efficacy of this strategy (Zhang & Liang, 2021).

Appendix D: Sludge Volume Reduction Technologies

Contents

D-1. Thickening D-2
D-1a. Gravity Thickening D-2
D-1b. Dissolved Air Flotation Basins D-2
D-1c. Gravity Belt Thickeners D-3
D-2. Dewatering D-3
D-2a. Centrifuges D-3
D-2b. Screw Presses D-5
D-2c. Rotary Press D-7
D-2d. Belt Filter Press D-8
D-3. Anaerobic Digestion D-10
D-4. Thermal Drying D-11
D-4a. Belt Dryers D-13
D-4b. Indirect Dryers D-19
D-4c. Rotary Drum Dryers D-21

D-1. Thickening

a. Gravity Thickening

True to their name, gravity thickeners leverage the force of gravity to settle higher-density solids out of solution. Influent sludge flows into the center of a cylindrical tank, which often has a conical bottom. As the sludge flows outward from the center, suspended solids begin to settle to the bottom of the tank. The settled solids form a concentrated layer at the bottom of the tank, which is typically scraped into the outlet by rotating scrapers. The liquid that remains after the solids have settled, the supernatant, then flows over an effluent. weir at the tank surface. Figure 1 is a diagram of a gravity thickener.

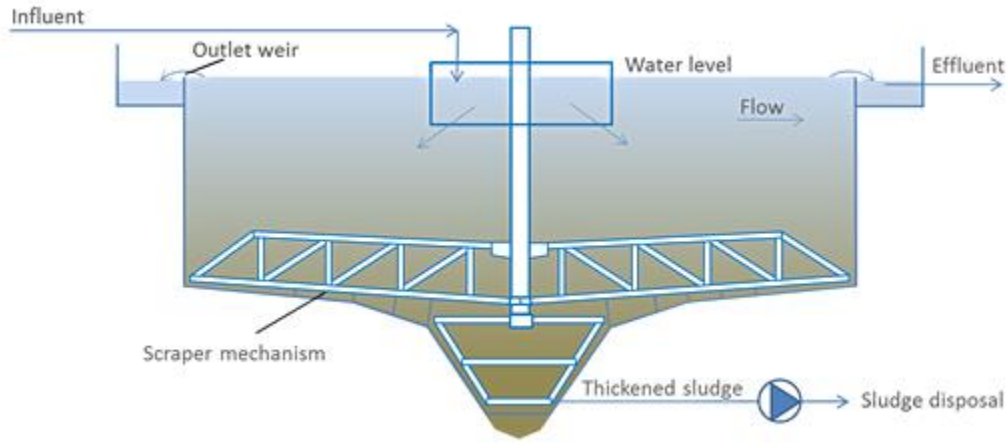


Figure D- 1. Gravity thickener

(Courtesy of Trevi Environmental Solutions)

b. Dissolved Air Flotation Basins

In the dissolved air flotation process, water is saturated with air under high pressure in a saturation tank. The air-saturated water is then released into a flotation basin at atmospheric pressure. This transition causes the dissolved air to form tiny bubbles. The bubbles attach to the suspended solids in the wastewater, increasing their buoyancy. The buoyant solids then rise to the surface, forming a sludge layer. A skimmer removes the floating sludge layer from the surface. The clarified water is then discharged from the bottom of the basin. This method is particularly effective for treating wastewater with fine particles that are difficult to settle by gravity alone. Figure 2 is a schematic of the dissolved air flotation process.

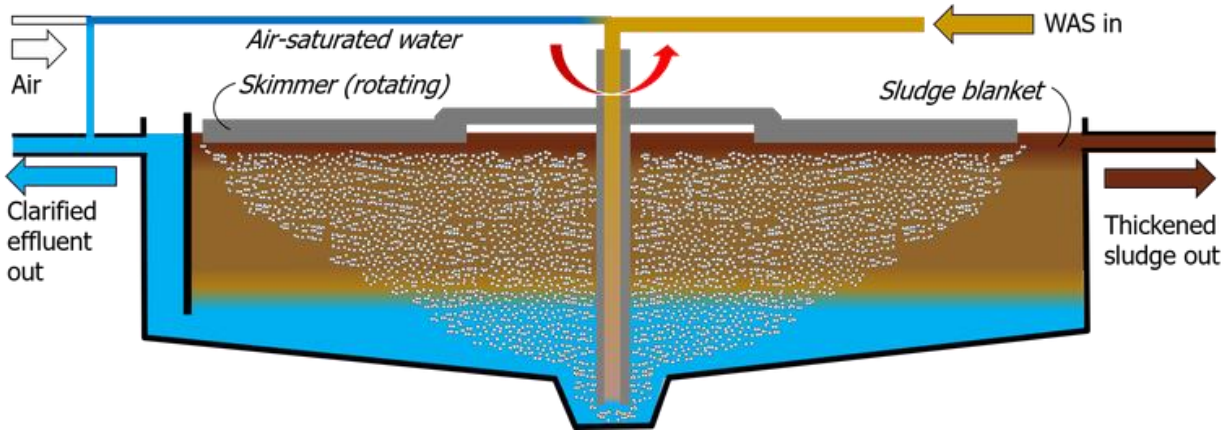


Figure D- 2.- Dissolved Air Flotation

(Courtesy of Judd Water & Wastewater Consultants)

c. Gravity Belt Thickeners

During the gravity belt thickening process, sludge is applied to a moving, permeable belt. As the belt moves, water drains through the belt by gravity. Plows or picket fences are positioned along the belt to gently agitate the sludge, promoting further water drainage. The thickened sludge forms a layer on the belt surface that is then scraped off into a collection vessel. The drained water is collected into a sump below the belt. A spray system is used to clean the belt and prevent clogging. Figure 3 is a diagram of a gravity belt thickener.

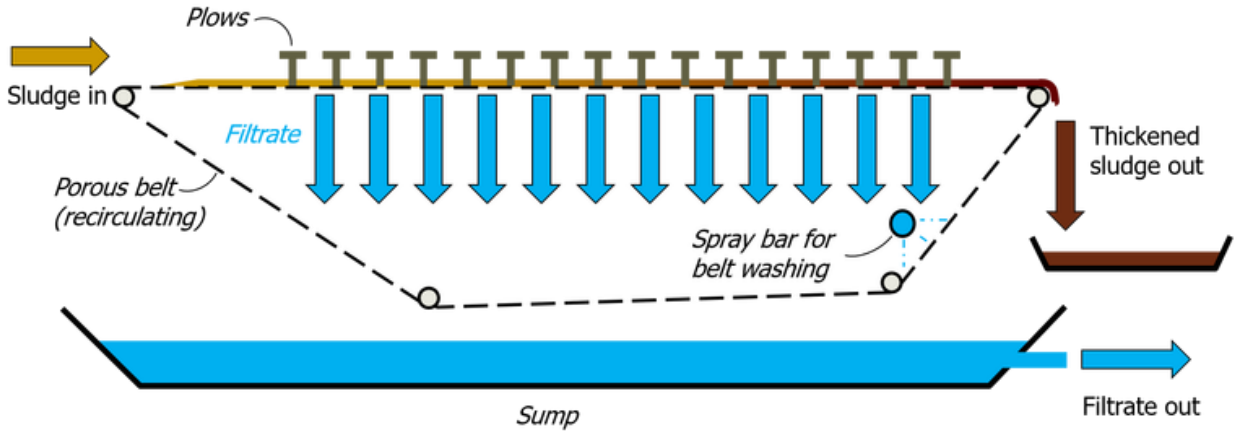


Figure D- 3. Gravity Belt Thickening

(*Courtesy of Judd Water & Wastewater Consultants*)

D-2. Dewatering

a. Centrifuges

A centrifuge utilizes the operating principle of centrifugal force to decrease the settling time of a suspended solid particle in a liquid stream. A two-phase decanter centrifuge commonly used in the

municipal US market is composed of a cylinder (bowl) and internal auger (scroll), rotating at slightly different speeds. The bowl rotates at high-speed creating a centrifugal force. This force drives solids to the wall of the bowl at accelerations of up to 3,000 gravitational units (Gs). The added centrifugal force increases the terminal (settling) velocity of the solid particles. This greatly decreases the amount of time required for suspended solid particles to separate from the liquid stream versus normal gravity clarification. Refer to Figure D- 4. Figure for a picture of a dewatering centrifuge.



Figure D- 4. Figure Dewatering Centrifuge

(Courtesy of Alfa Laval)

The scroll rotates at a slightly different speed from the bowl. This differential speed allows the scroll flights to convey solids collected along the bowl periphery towards the solids discharge end. Near the solids discharge the bowl diameter gradually decreases, creating a conical section referred to as the beach. The scroll transports the solids up the beach angle and out of the liquid stream. Solids travel up the beach provides for additional dewatering before discharging out of the centrifuge.

The clarified liquid stream discharged from a centrifuge is referred to as centrate. The centrate will discharge on the opposite end of the centrifuge from the dewatered sludge discharge. Clarified liquid will flow through the machine to the liquid discharge. A liquid level in the centrifuge will build along the bowl wall and overflow a concentric weir installed on the liquid discharge end of the bowl. Refer to Figure D-5 for a graphic displaying centrifuge solids separation.

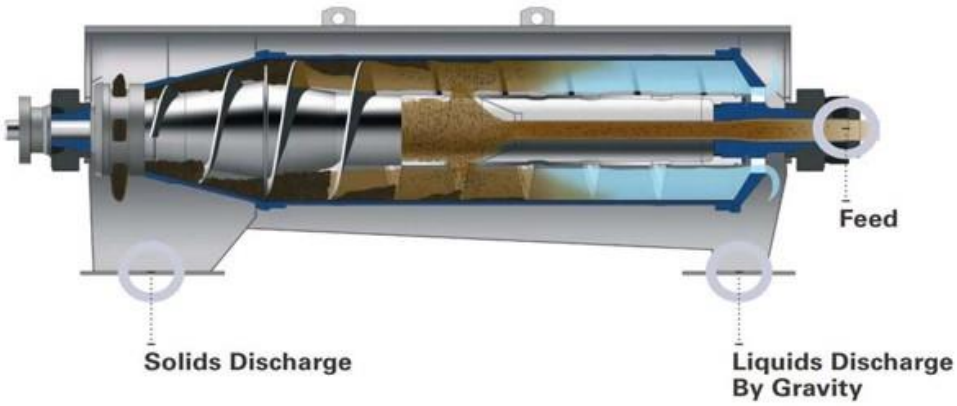


Figure D- 5. Centrifuge Cross-Section

Image courtesy of Flottweg

Multiple operational adjustments are critical for maintaining the solids separation performance in a centrifuge. These include the following:

- Polymer dose rate

- Bowl speed
- Bowl and scroll differential speed
- Sludge feed rate

Polymer must be used to condition sludge prior to dewatering. The dosage affects the capture of solids and, to a lesser degree, solids content of the cake. For mixed primary and secondary sludges, a polymer dosage of 15 to 25 active lbs/ton of dry solids is commonly required to achieve cake densities between 25 percent and 30 percent solids at reasonable flow rates. It is important to note that centrifuges provide optimal results when operating well below their maximum solids loading, or 40 – 80 percent of their maximum capacity. The best operating range can be determined through pilot testing.

Centrifuges are common at larger municipal wastewater treatment plants primarily due to their high capacity to footprint relationship. In other words, the space requirement for centrifuges is low relative to the solids dewatering capacity provided. This is a mature proven technology with multiple well-respected manufacturers active in the U.S municipal wastewater market. The electrical power requirement for centrifuges is typically high relative to other dewatering technologies, however manufacturers have made recent improvements to significantly improve the centrifuge efficiency. Centrifuge maintenance may be provided by trained operations staff or through a manufacturer service program. Extended service and training programs are also available through most major centrifuge manufacturers. Centrifuges are subject to accelerated wear when significant amounts of grit are present in feed sludge. Most manufacturers will provide equipment with replaceable abrasion resistant wear surfaces to prevent damage to equipment.

Optimal operating ranges for dewatering equipment, like other characteristics, can be better explored through pilot testing, and will depend on factors such as the mix of primary and secondary sludge. However, some preliminary guidelines can be included here as a reference. Flottweg, a centrifuge manufacturer, noted their centrifuges operate best in the range of 40 -70 percent of max loading. Another manufacturer of centrifuges, GEA Westfalia, noted there may be a trend in the industry of guaranteeing performance rates at 60 percent of the maximum loading. This would provide flexibility in operation of a given unit.

b. Screw Presses

A screw press applies filtration principles to separate solid and liquid phases in combined sludge streams. Sludge is typically pumped to a flocculation tank after polymer conditioning for building of floc prior to entering the screw press feed hopper. The screw slowly rotates and conveys feed sludge into and through the drum. A flighted expanding shaft diameter screw gradually increases mechanical pressure as sludge travels through a porous drum to force separation and drainage of liquid from the sludge. Solids are then conveyed axially by the flighted shaft to the machine discharge. An adjustable plug at the drum discharge provides backpressure on the discharging sludge for further dewatering.

An image of a typical screw press is presented in Figure 6. A schematic describing the operation of a screw press is shown in Figure 7.



Figure D- 6. An Image of a Ishigaki Screw Press

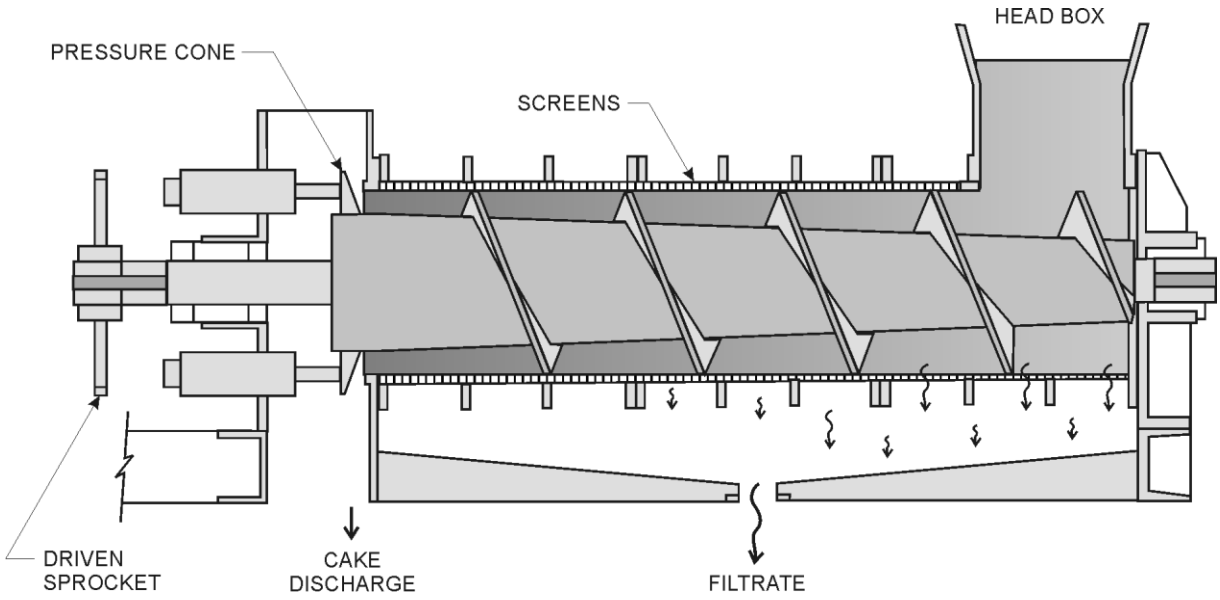


Figure D- 7. Configuration and Operation of a Typical Screw Press

Image courtesy of FKC

The slow rotational speed allows for the use of a small electric motor to turn the screw, thus minimizing energy requirements. The slow rotating speed also reduces wear and maintenance requirements and provides a high level of reliability. The screw press is intended for continuous service and typically provided with an automatic spray system for cleaning of the porous drum screen.

Screw presses are typically automated with little operator input. The operational adjustments that can be made are summarized below:

- Sludge feed rate
- Polymer dose rate
- Screw rotational speed
- Discharge back pressure setting

Screw speed controls the residence time of the sludge in the drum and the back pressure setting provides for additional dewatering by finding the optimal back-pressure to encourage release of water from the sludge. Compared to centrifuges and belt filter presses, screw presses are relatively newer to the municipal wastewater market and as such have a somewhat less robust installation base. Historically, they have also been more limited in capacity, though certain manufacturers have recently been working to increase capacity of available units. Huber and FKC are two of the most well-known and experienced (within the US) manufacturers, but their current products only have maximum rated capacities of around 100-150 gallon per minute (gpm). The relatively low capacity typically requires more screw press units than other dewatering technologies, and more dewatering units require more associated support equipment (feed pumps, polymer pumps, cake conveyance, etc.). Schwing and Ishigaki currently offer larger screw presses, but with limited installation experience. Huber has indicated they are developing a higher capacity screw press unit. Differences between manufacturers can include items such as sludge feed (e.g., direct pipe feed or feed through a flocculation tank), screw removal and screen construction and cleaning.

c. Rotary Press

The principle of operation of the rotary press is essentially to feed polymer flocculated sludge into a rectangular channel formed between two parallel revolving stainless steel chrome plated screens. The filtrate passes through the screens as the flocculated sludge advances within the channel. The sludge continues to dewater as it travels around the channel, eventually forming a cake near the outlet side of the press. The frictional force of the slow-moving screens, coupled with the controlled outlet restriction, results in the extrusion of dewatered cake. The sludge is fed at low pressure into the space between the two parallel filtering elements. As the free water comes away from the sludge, solids accumulate in the channel until enough pressure is generated against the outlet gate. The slow rotational speed of the filtering element generates enough back pressure to dewater the remaining solids.

The rotary press can typically achieve higher solids content than a belt filter press with only slightly higher polymer and power requirements. The low rotational speed has been reported to result in lower maintenance requirements, and like the centrifuge and screw press the units are totally enclosed, minimizing odor control requirements.

An additional feature of the rotary press is the ability to add units to the same press as the need arises in the future. For example, a two-channel machine could ultimately be expanded to a maximum of six channels per machine.

Figure 8 shows a picture of a typical rotary press dewatering installation.



Figure D- 8.- Typical Rotary Press

d. Belt Filter Press

A belt filter press is a dewatering device that relies on principles of filtration to separate solid and liquid phases. A flocculation tank is typically provided immediately upstream of the BFP. After conditioned sludge is conveyed across a gravity drainage section on top of the BFP, mechanical pressure is applied to sludge sandwiched between two tensioned filter cloths, referred to as belts. Those belts follow a serpentine path between decreasing-diameter rolls to increase the pressure in the interstitial space between belts. The pressure exerted by the belt and roller configuration supplies the force for separating liquid and solid phases in the combined stream. The serpentine pathway of the belts also imparts shear to the compressed solids, further aiding in dewatering. A BFP has three distinct sections performing critical operational steps for the dewatering process:

- Gravity zone: free-draining water is drained by gravity through a porous belt.
- Wedge zone: solids are prepared for pressure application.
- Pressure zone: medium and then high pressure is applied to the solids.

A photograph of a typical BFP is shown in Figure 9.



Figure D- 9. Belt Filter Press

Image courtesy of Alfa Laval

In addition to two-belt models, some manufacturers offer three-belt filter presses. The primary advantage of the three-belt model is independent control over the gravity zone to support optimization of dewatering. A diagram of a three-belt filter press is provided in Figure 10.

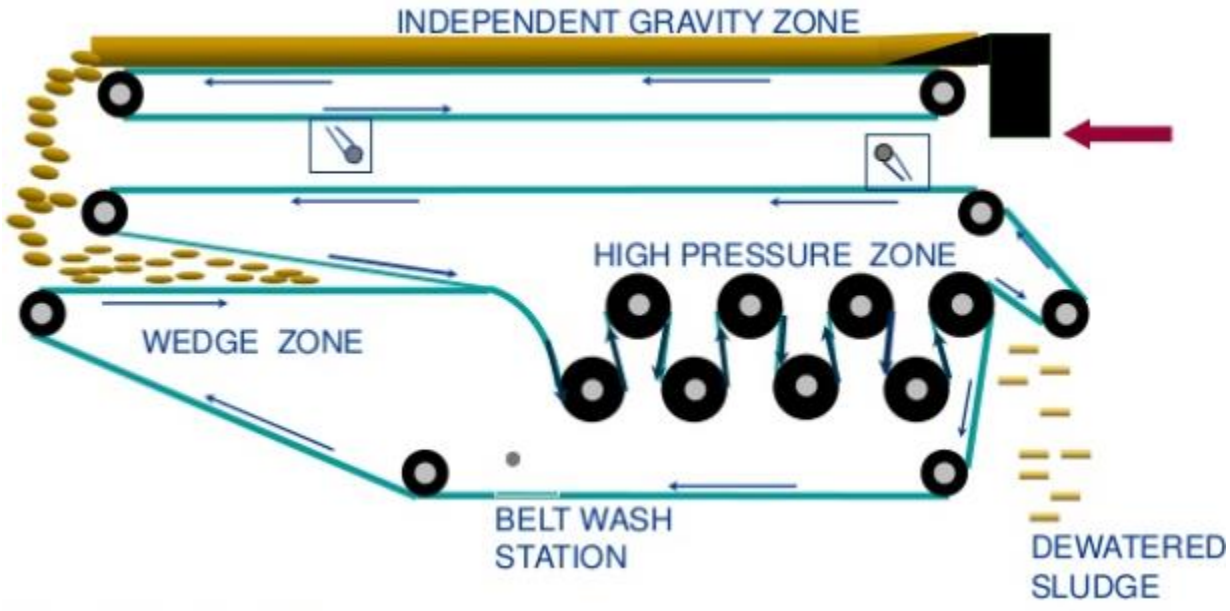


Figure D- 10. Belt Filter Press Cross-Section

Image courtesy of Alfa Laval

The dewatered sludge cake discharges after the high-pressure zone. The cake will typically come off of the belt as a thin sheet before falling into a chute or collection bin. A scraper is typically installed

in the discharge zone to clean the belt of residual cake after discharge. A spray system is also provided to clean the belts before they are cycled back to the feed/gravity zone area.

Multiple drive rollers, belt washers, and belt steering (tracking) rollers are provided within the BFP. Operational adjustments include feed rate, belt speed, belt tension, belt type, and wedge adjustment. Polymer addition and polymer/sludge mixing are also critical factors. Excessive turbulence downstream of polymer/sludge mixing can deflocculate the conditioned sludge, resulting in degraded solids capture and increased solids in the recycle stream. A flocculation tank is typically provided immediately upstream of the BFP gravity drainage section. BFPs are manually adjusted and require more operator attention than a centrifuge or screw press.

BFPs are preferred by many municipal wastewater treatment plants for reliable low-tech dewatering. They rely on slow-moving belt compression in contrast with other higher speed and more complex dewatering technologies. This is a mature proven technology with multiple well-respected manufacturers active in the U.S municipal wastewater market. BFPs generally require more space relative to centrifuges for the units themselves as well as access walkways and maintenance space. Maintenance and housekeeping requirements can also be relatively high and operator exposure to solids and odor is higher unless enclosed units are provided.

Odor control hoods are commonly provided over BFPs to evacuate odorous air and require a more substantial ventilation system. Belt filter presses can be provided with covers to contain odors and reduce foul air withdrawal rate requirements. However, the covers are sometimes viewed as an impediment to optimal belt filter press operation since the gravity zone is no longer visible.

Belt filter presses are typically not capable of achieving as high a solids content as newer generation centrifuges. With the optimum polymer dosage, dewatered sludge concentrations of 18 percent to 20 percent would be expected. The impact of dewatering equipment wash water flow of the recycle stream on plant processes should also be evaluated since BFPs require a continuous spray to clean the belts discharging a relatively high flow of wash water.

D-3. Anaerobic Digestion

Anaerobic digestion is a sludge stabilization technology that reduces pathogens and vector attraction while improving aesthetic characteristics of the final product, such as odor. In the heated anaerobic environment of the digesters, biological activity decomposes organic matter to produce biogas and reduce overall total solids. Digestion is typically operated to meet regulatory requirements of biosolids land application and can also produce on-site energy if the digester biogas is utilized. Along with the remaining organic material, nitrogen and P remain in the solids and can provide additional benefit during land application.

For biosolids land application, pathogen classes (A and B) and vector attraction reduction designations are defined and the conditions of compliance are specified in EPA 40 CFR Part 503. These designations, in turn, determine the type of land onto which different types of biosolids may be applied. Class B biosolids have less-stringent pathogen destruction demonstration requirements than Class A, but greater restrictions for land applications associated with crop harvesting, animal grazing, and public access.

Mesophilic anaerobic digestion (MAD) is a conventional sludge stabilization process. MAD typically employs operating temperatures between 95 and 102 °F and solids are digested under anaerobic conditions. Typically, MAD systems are operated at a minimum hydraulic retention time (HRT) of 15 days, which, when requirements for vector attraction reduction are met, guarantees Class B

pathogen status for land application (Labatut et al., 2014). This stabilization process has the longest operational history of the processes under consideration.

Although this alternative provides the benefits of operational simplicity and a long history of operation, the process has its disadvantages when compared to newer, more aggressive technologies. While MAD operates efficiently, the degradation rates are relatively low when compared with other advanced digestion processes. This lower biological degradation rate results in lower VS destruction, lower gas production, more tankage volume required, and additional mass of solids for disposal relative to the advanced digestion processes evaluated. In addition, use of MAD allows for less available capacity for co-digestion substrates because of the inherently lower organic loading rate (OLR) associated with the process. Table 1 summarizes the advantages and disadvantages of MAD by comparison with the other digestion technologies discussed in this section.

Table D 1. Mesophilic Anaerobic Digestion Considerations and Typical Operational Parameters

Advantages	Disadvantages	
• Existing familiarity • Operational simplicity • Can be paired with other processes • Low operating temperatures • Long history of operation	• Potential for struvite scaling • Lower volatile solids destruction • Lower gas production • Greater capacity required • Greater mass of solids remaining • Less flexibility for additional co-digestion • Digester gas entrainment requires careful monitoring	
Operational temperature range	**Minimum Hydraulic Retention Time**	**Max Volatile Solids Loading Capacity**
95 to 102°F	15 days	1.15 lb-VS/ft^3-d

D-4. Thermal Drying

There are three main types of thermal dryers used for biosolids applications in the US: belt, indirect, and rotary drum. Belt and rotary drum technologies advance product through the dryer vessel through a rotating belt or drum, respectively, while hot gasses are passed through the product to facilitate evaporation. Indirect dryers use metal discs or paddles to advance product, while transferring heat to the product through the disc or paddle surface using thermal oil or steam to heat the metal surfaces (US EPA, 2006). Each dryer technology has unique operational characteristics, but are subject to the classical drying curve, shown below in Figure 11.

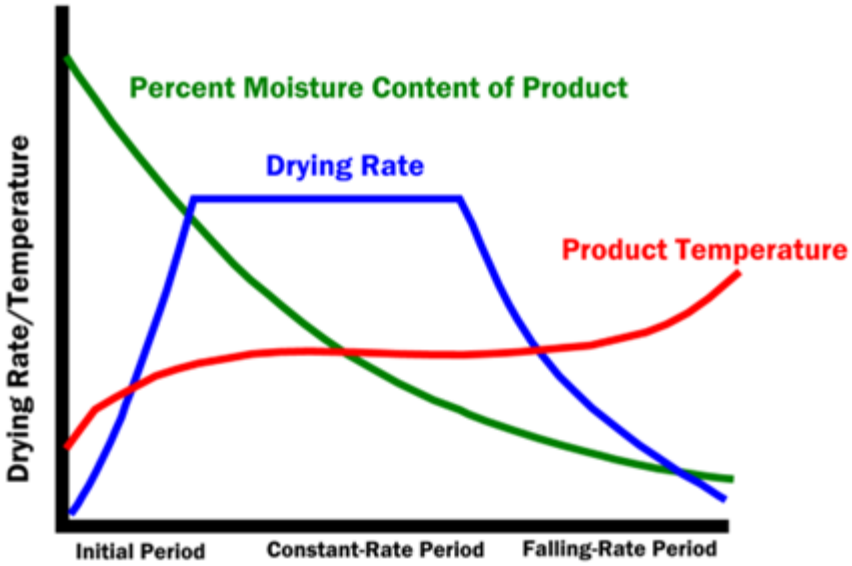


Figure D- 11. Thermal Drying Process Curve Over Time.

The drying curve demonstrates two key phenomena that all dryer types are configured to account for. First, there is a substantial heat sink involved with bringing the feed material to evaporation temperatures. Second, once a target %TS is reached (or critical moisture), the product is no longer cooled by the evaporation process and starts to heat. While the different dryer types have different operational features, these features share a common intent to maximum operation within the constant drying rate zone to maintain dryer efficiency and the target product %TS.
A summary of the primary characteristics of the main dryer types, their operational parameters, and a high-level comparative review is provided below in Table 2.

Table D 2. High Level Dryer Type Comparison			
	Belt	Indirect	Drum
Heating Medium	Water/Steam (190 - 284°F), Thermal Oil (430°F), or Flue Gas (250 - 330°F)	Thermal Oil (385°F) or Steam (<290psi)	Flue Gas (650 – 1,100°F)
Material Conveyance	Rotating belt	Rotating (heated) paddles or screw	Rotating drum
Typ. Thermal Efficiency	1,200 - 1,600 BTU/lb-H_2O evap.	1,450 BTU/lb-H_2O evap.	1,500 BTU/lb-H_2O evap.
Typ. Minimum Throughput	1,000 lb-H_2O/hr (4 dtpd at 24%TS feed, 24/7 operation)	700 lb-H_2O/hr (3 dtpd at 24%TS feed, 24/7 operation)	4,000 lb-H_2O/hr (15 dtpd at 24%TS feed, 24/7 operation)
Typ. Product Diameter	Cylindrical granule (1 – 8mm)	Irregular, dusty granule (0 – 15mm)	Dense pellet (2 – 4mm)
Comparative Assessment			
Footprint Requirements	Most	Least	Most (lower at large facilities)
Product Quality	Moderate	Poor	Greatest
Energy Recovery Opportunities	Greatest	Moderate	Moderate
Safety Concerns	Moderate	Moderate	High

A primary differentiator between technologies is product throughput. Rotary drum dryers have a substantially higher throughput than the other two technologies, making them most efficient at large size facilities and limiting their applications at small to medium size facilities. Additionally, they contain substantially more ancillary components, increasing operational and maintenance demands, as well as the potential for dust formation. However, they are the only dryer technology capable of producing pellets meeting the product characteristics (e.g. density, size gradation) required for marketing and sale to the higher-value specialty and retail fertilizer outlets.

While belt and indirect dryers are both commonly installed at small to medium size WRRFs, the primary differentiator between the two technologies is dryer vessel footprint requirements. Indirect dryers are substantially smaller than belt dryers and there are multiple examples of indirect dryer installation in existing building footprints because they were the only dryer type to meet existing building constraints. Where space allows, belt dryers can typically be supplied at the lowest capital cost and provide the most flexibility in heating temperatures and methodology, which allows for utilization of low-temperature waste heat sources like hot water from a cogeneration system.

a. Belt Dryers

Belt dryers shape and distribute dewatered solids into noodle or granule shaped particles onto a slow-moving porous belt. Warm process gasses are circulated in through the belt chamber to evaporate the water content in the feed solids. The material's shape provides a large surface for exposure to the warm process gas and the slow-moving belt provides contact time and generates minimal dust and fines. Belt dryer exhaust is commonly dehumidified with a condenser, reheated, and mixed with incoming air to minimize exhaust volume and reuse waste heat. Alternatively, some belt dryers use an air-to-water heat exchanger in the exhaust to capture waste heat and return it to the dryer inlet to heat in the incoming process gas stream. A graphic of a belt dryer operation is provided in Figure 12.

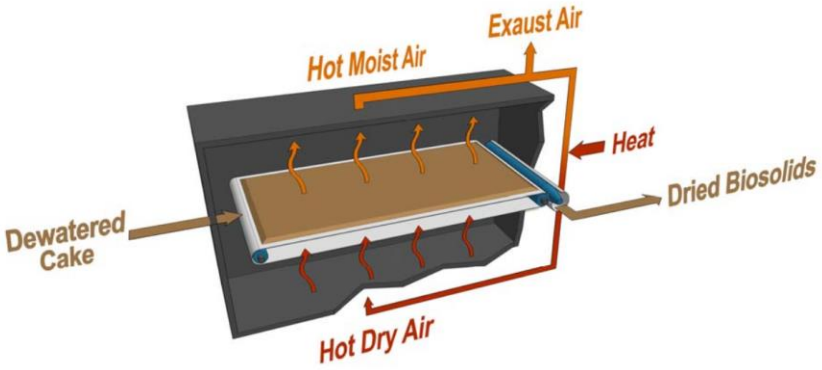


Figure D- 12 Representative Belt Dryer Operation Schematic

Inlet process air is heated through either direct-fired or indirect-fired process heaters. Direct-fired heaters burn a fuel source (typically natural or digester gas) directly into a dryer inlet chamber containing the inlet process air stream, transferring the hot flue gas directly into the air stream and then dryer. The advantage of this system is that there is no separate process heater that needs to be sited and higher process temperatures, and consequently dryer throughout capacity, can be obtained without needing to manage steam or thermal oil. Indirect-fired systems use a separate process heater to generate hot water, steam, or thermal oil that is circulated through heat exchangers that warm the process gas fed to the dryer. Hot water systems are limited to temperatures below 200°F and require a larger footprint, but can make use of any supplemental hot water source, including a cogeneration system. Figure 13 illustrates the basic differences between these two process configurations and further discussion on their use in belt dryers is provided below.

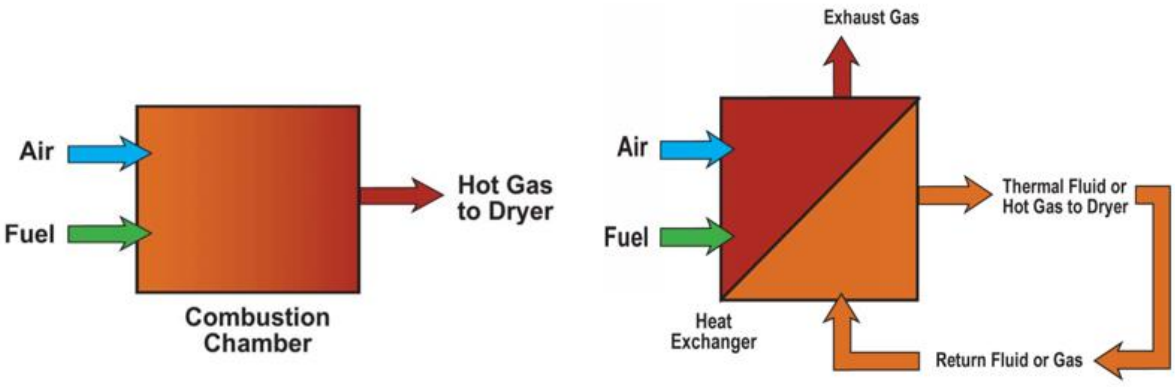


Figure D- 13. Direct And Indirect-Fired Process Heating System Illustrations, Show Respectively

Direct-fired Belt Dryers

One representative example of a direct-fired belt dryer technology is the Gryphon dryer. The Gryphon dryer utilizes a single blower for process air circulation with a gas-fired burner located at the blower outlet for process heating. After passing through the belt chamber, the process air is collected and passed through a 49 micron filter and then cold water-supplied condenser for dehumidification prior to being directed back into the blower. The Gryphon dryer is unique in that it makes use of perforations under the belt to expand the gas in the lower chamber, decreasing its pressure and increasing its capacity to absorb moisture from the product. Process gas temperature exiting the dryer vessel is monitored and used to modulate the blower speed and

burner temperature to achieve the target %TS of the dried product. An operational schematic and model of the Gryphon dryer are provided in Figure 14 and Figure 15, respectively.

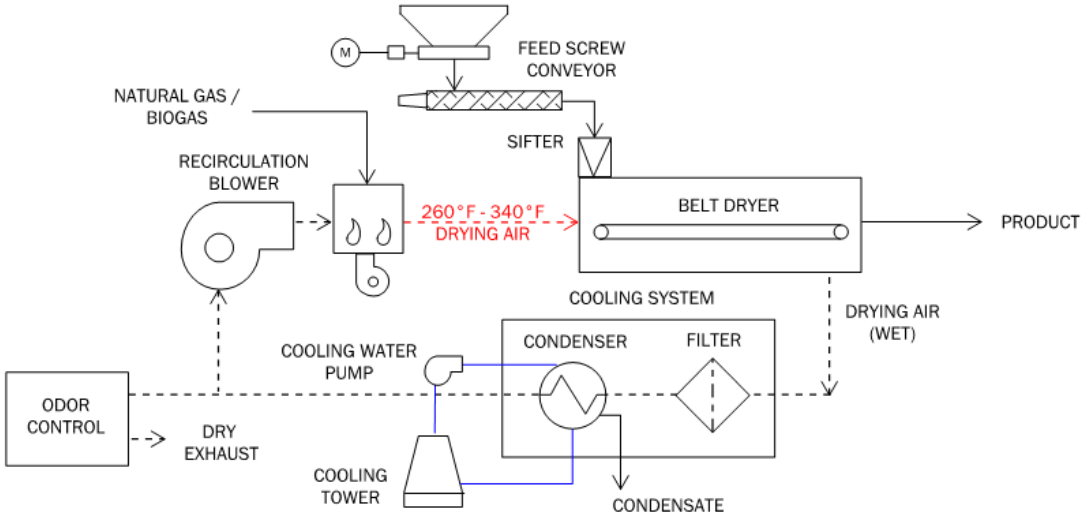


Figure D- 14. Representative direct-fired belt dryer operation schematic

Based on Gryphon Environmental' s dryer system.

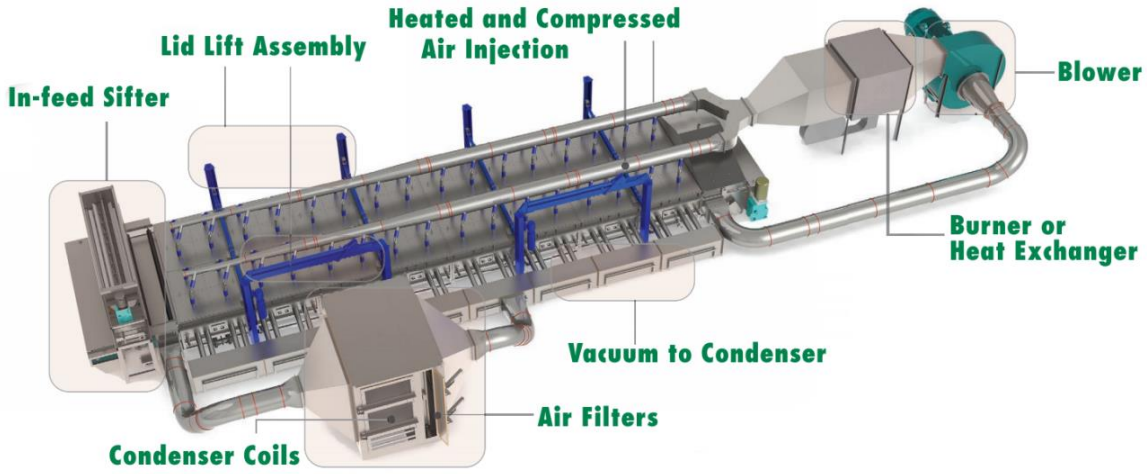


Figure D- 15. Representative Direct Dryer Model

Courtesy of Gryphon Environmental.

While digester gas, or biogas, can be used to fuel direct-fired dryers, the burners typically have a moisture and hydrogen sulfide limit to prevent rapid fouling or corrosion of the burner assembly. Typically, this requires installation of a dehydration system to condition the biogas feed but may also require means of hydrogen sulfide removal via filtration media or chemical injection depending on the supplier's limits and strength of the hydrogen sulfide in the biogas. Typically, siloxanes do not pose the same concern for combustion in these burners compared to engine generators as the direct-fired dryer burners typically are fired at a lower combustion chamber temperature, similar to a low nitrogen oxide burners, which is hypothesized to prevent the complete mineralization of siloxanes to silicon dioxide, the compound responsible for abrasion in internal combustion systems.

Indirect-fired Belt Dryers

Indirect-fired belt dryers can be configured to run at low temperatures with hot water or medium temperatures with steam or thermal oil. Huber's belt dryer is a representative technology that can operate using hot water as the heat source. A boiler is used to heat a dedicated hot water loop connected to an array of heat exchangers inside the belt dryer chamber. The dryer's exhaust temperature setpoint modulates automated valves at the heat exchanger array to introduce hot water when heat is required for the drying process. Recirculation fans situated on top of the dryer draw process air into the dryer and circulate it through the belt and out through the discharge stack. Huber's systems have used condenser assemblies to dehumidify process air from the dryer prior to returning it, but their current recommendation is to typically forgo the process air recirculation and discharge it directly to an odor control system. This reduces the thermal efficiency of the system by 10% - 15%, but eliminates the preventative maintenance required for the condenser system.

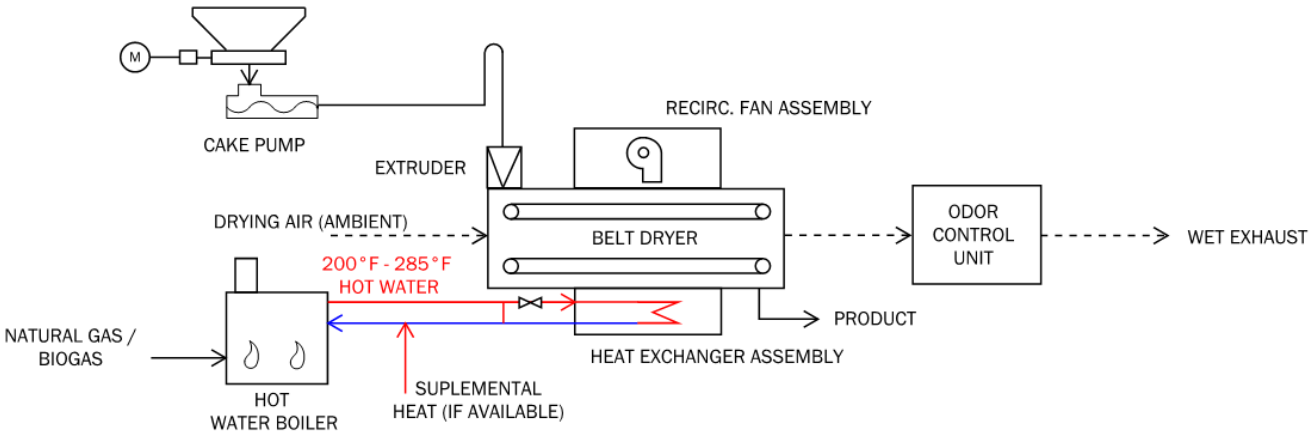


Figure D- 16. Representative Indirect-Fired Belt Dryer Operation Schematic

Based on Huber's s dryer system.



Figure D- 17. Representative Indirect-Fired Belt Dryer Photograph

Courtesy of Huber.

As the low temperature belt dryer operates on hot water it can be configured to run off an existing hot water loop tied to other process equipment, such as anaerobic digestion and cogeneration. In this example, the dryer may be able to recover heat from the cogeneration system typically wasted in the summer and if the hot water loop has excess boiler capacity, there may be no need for additional boiler installation. An example schematic of a low temperature belt dryer tied into a plantwide heat loop is provided in Figure 18.

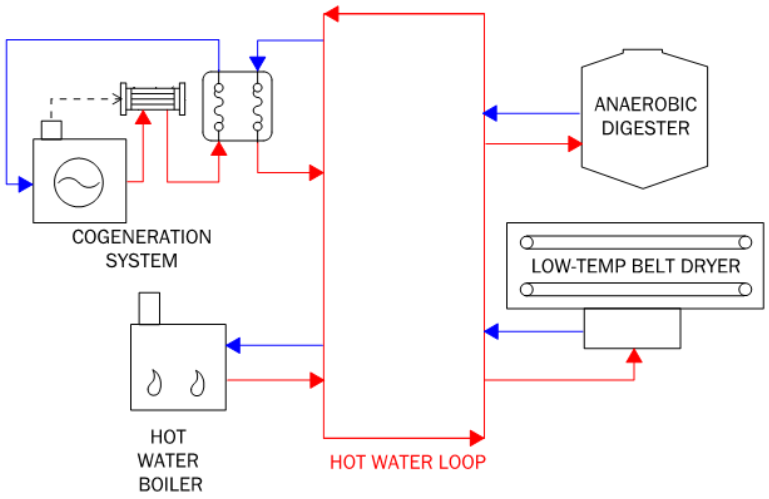


Figure D- 18. Representative Low Temperature, Indirect-Fired Belt Dryer Tied into a Plantwide Heat Loop

Heat Pump Belt Dryers

A variant on the indirect-fired belt dryer currently being introduced to the US market is the use of a heat pump to both dehumidify and bring recirculated process air to temperature. The primary manufacturer supplying this technology is Shincci-USA (Shincci), the US-based arm of SHINCCI Energy Equipment Co., Ltd in China. The belt dryer has recirculation fans in the lower chamber that transfer moist process air into a separate compartment where it is filtered, dehumidified with a condenser, and brough to temperature with a heat exchanger before being transferred back to the dryer. The chamber is completely sealed and the only process air that enters and exits is the minimal air volume that leaks into the vessel. The heat pump uses an electric powered compressor to heat a glycol loop to supply heat to the heat exchanger, and then an expansion valve to cool the glycol for use in the condenser, creating a closed loop that only requires electricity and no gas. Initial estimates show that this technology is 3x to 4x more efficient than conventional belt dryers, but electricity can be more expensive than natural gas by the same factor and the technology is highly specialized and dependent upon overseas parts and service at this time. An overview of the Shincci heat bump belt dryer operation is provided below in Figure 19.

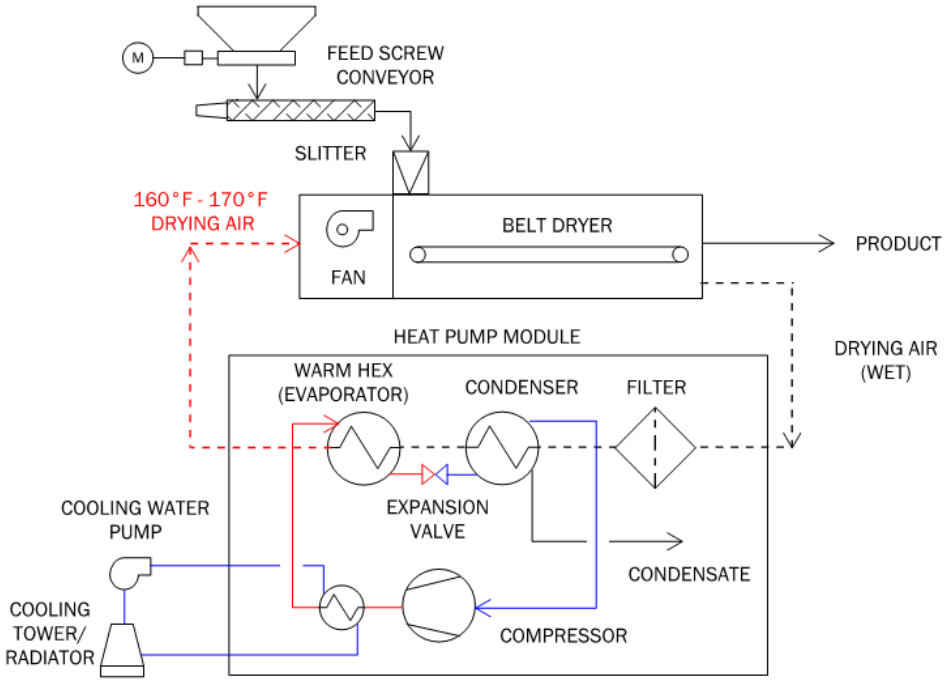


Figure D- 19. Representative Heat Pump Belt Dryer Operation Schematic

Based on Shincci's dryer system.



Figure D- 20. Representative Heat Pump Belt Dryer Photograph

Courtesy of Shincci.

Service and Maintenance

Common preventative maintenance items for belt dryer operation include greasing rotating assemblies cleaning the feeding mechanism, filters, and condenser (if present); inspecting conveyor belts for tracking alignment, blinding, and wear; and identifying and replacing worn seals

and instruments. Larger maintenance efforts include cleaning and repair and replacement as needed of the gear box, motor and couplings, fans, motors, and belt.

b. Indirect Dryers

Indirect dryers apply a thermal fluid to heat a metal wall that separates the dewatered biosolids from the fluid. Heat transfer occurs by conduction across the metal barrier. A commonly used indirect dryer is the paddle dryer that consists of hollow paddles, discs, or augers that are used to turn, agitate, or transport the biosolids throughout a stationary or rotating horizontal, jacketed vessel or trough. A heated fluid, usually a specialized thermal oil, circulates within the jacket and the hollow paddles, discs, or augers, allowing for heat transfer with the agitated biosolids. The heat supply is recirculated, reducing heat loss and fluid requirements. Greater degrees of agitation facilitate more heat transfer and less caking on internal dryer surfaces. A representative photograph of a paddle dryer is provided in Figure 21.

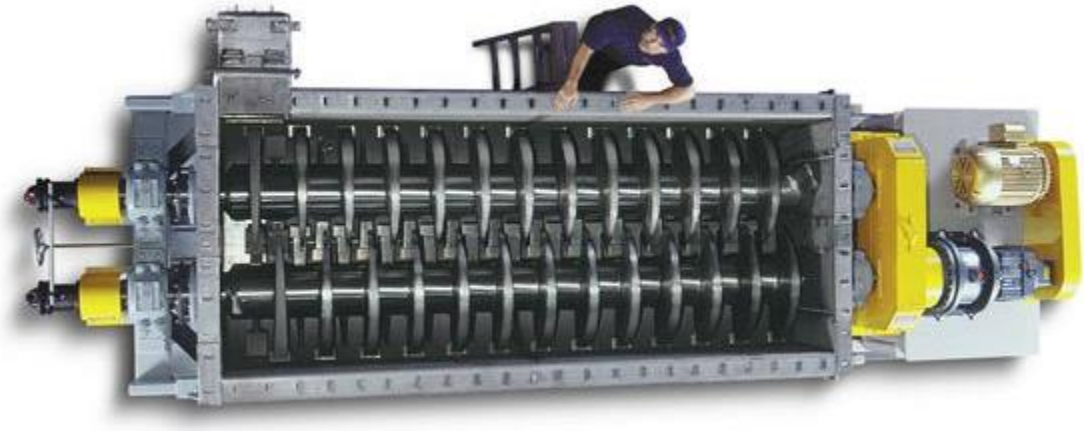


Figure D- 21.Representative Paddle Dryer Photograph

Courtesy of Komline-Sanderson.

As the heat supply to the system is constant, the dryer maintains a constant amount of product within the dryer to maintain a consistent heat sink. This is accomplished using an automated, modulating overflow weir in paddle dryers, or with a continuous, batch feed system in simpler screw dryers.

There have been several instances of paddle dryers requiring major retrofits after several years of operation due to abrasion of the paddles and particularly the trough at the downstream dry end of the dryer. This has been linked to high grit content in a sludge cake as well as repeatedly starting and stopping the dryer.

While a significant advantage of the paddle dryer is a reduced footprint, a disadvantage is the quality of the product, which is often finer and dustier than other dryers. This can be improved by adding an oil to the final product or screening and backmix of the final product at additional operational expense. The quality of the final product may not be an issue if it continues to go to landfill but if it is anticipated to be land applied, then implementation of a paddle dryer might require an analysis of viable markets marketed for land application.

A process schematic of a representative paddle dryer based on the Komline-Sanderson system is shown in Figure 22 and key elements are discussed in the following paragraphs.

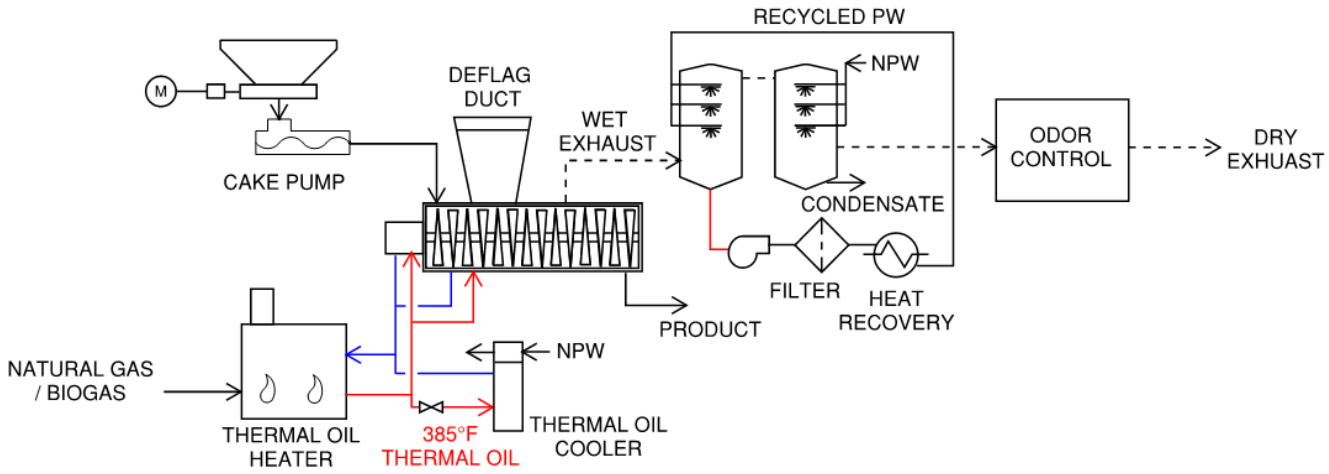


Figure D- 22. Representative Indirect, Paddle Dryer Operation Schematic

Based on Komline-Sanderson' s dryer system.

Thermal oil system components

The thermal oil system uses a process heater capable of running on digester and natural gas with a separate recirculation pump and expansion tank skid. The high temperatures of the thermal oil requires a specialized pipe and support stress analysis to ensure piping supports have adequate strength to support the additional thermal expansion loads, but this service, along with pipe support design, is typically provided by the dryer manufacturer.

A thermal oil cooler is provided with the system to redirect and cool a portion of thermal oil to 200°F during system shutdown. Once shutdown is initiated and the dryer no longer receives feed material, there is a potential for the product to overheat within the dryer as there is less product to absorb the heat. The thermal oil cooler serves to lower the temperature of the thermal oil during this step. While this process is automated, it can lead to dryer shutdown times of 6 to 8 hours which can be a disadvantage if operational staff time is limited.

Deflagration venting

Given the risk of product overheating, and potential material ignition or explosion during the shutdown period, the standard in the paddle dryer industry is to provide explosion panels in the hood of the dryer ducted to an explosion, or deflagration vent at the building wall. The intent of the deflagration vent is to direct any explosion away from the dryer facility to a safer location. While the likelihood of a deflagration event is minimal, Brown and Caldwell is aware of two WRRFs that have experienced an event. The deflagration system is designed based on guidance from NFPA 68: *Standard on Explosion Protection by Deflagration Venting* and the trajectory of the event assessed to direct its path away from existing objects. If the vents rupture, the replacement of the vents can be completed quickly, typically in less than two hours. Paddle dryers are provided with a secondary fire protection system using spray pipes in the dryer hood that can douse the dryer with water if the temperature of the offgas exceeds 250°F.

Condensate heat recovery

As the paddle dryer does not use process air for heating, the dryer off-gas is only made up of ambient drawn into the system and has a comparatively low volume and high concentration of water vapor. A new feature added to Komline-Sanderson's dryer systems is to install a two-stage spray tower condenser assembly for off-gas treatment prior to discharge. The first spray tower uses a

closed loop water system that can supply hot water at 170°F to a heat exchanger to transfer usable heat prior to recirculation back to the spray tower. As Komline-Sanderson only has one recent installation of this system, the rate of corrosion within the closed loop system is unknown, but it is expected that a water treatment system would be required to maintain operable conditions of the closed loop.

Service and Maintenance

Components requiring regular inspection and preventative maintenance include rotating assemblies (including custom pillow block bearing assemblies, seals and packing glands, and offgas compressor and thermal fluid heater burner train. Dryer manufacturers typically offer annual service contracts that are comparable in cost to belt dryers and can use the service trips to provide training to plant staff.

c. Rotary Drum Dryers

Rotary drum dryers have been used to treat wastewater sludge since the 1920s. Drum dryers are heated via a fuel-burning furnace that exhausts directly into a long, cylindrical steel drum that rotates on roller bearings. Some drums move the solids through in a single pass, while others use interlocked concentric drums to make multiple passes through the drum. Material is propelled through the drum by the hot gas air stream (750 – 1,200°F) and is continuously lifted by the cylinder flights and cascaded through the hot gas. The dryer exhaust and dried product are passed through an air/solids separator and the dried product is screened and processed for recycling back to the feed solids or routed to storage silos.

A relatively large volume of dried recycle product is mixed with the dewatered feed solids to increase the average %TS in the blended feed (60% - 80% TS) to the dryer. When the sludge reaches this dryness region, it becomes crumbly and easier to handle and is said to be outside of the “sticky region”. The sticky region has been correlated with the organic content of different sludges, and shear tests can be conducted to determine at what %TS the sludge moves into the preferred dryness region.

Typically, a majority of the air/gas stream (70% - 90%) is recycled back to the dryer furnace to increase the overall thermal efficiencies and help maintain an inert atmosphere, which reduces the risk for thermal events. Recycling the air also minimizes the volume of exhaust air treated in air pollution and odor control equipment. Typically, additional particulate removal via tray condenser and venturi scrubber is conduced followed by regenerative thermal oxidation (RTO) to destroy odors and volatile organic compounds (VOCs).

Given their higher operating temperatures, drum dryers have a higher throughput compared to other drying technologies and typically can achieve a thermal efficiency better than 1,500 Btu/lb of water evaporated. The footprint required for the drum drying system can be high given the ancillary equipment and the system is the most operationally complex of all dryers

A process schematic and model of a typical rotary drum dryer is shown in Figure 23 and Figure 24, respectively.

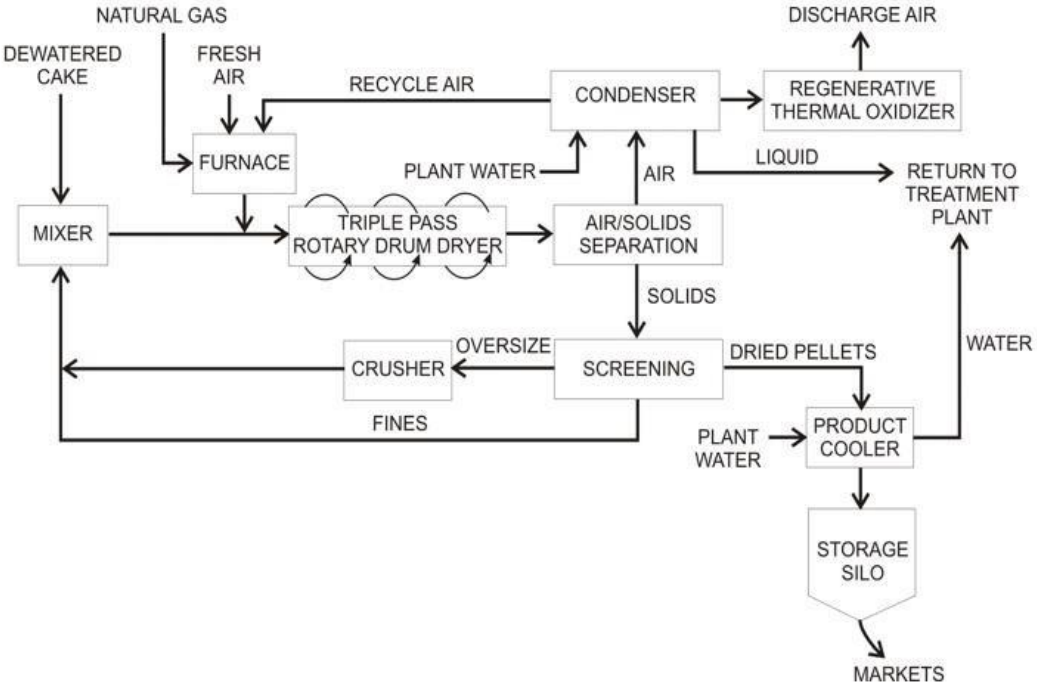


Figure D- 23. Representative Rotary Drum Dryer Operation Schematic

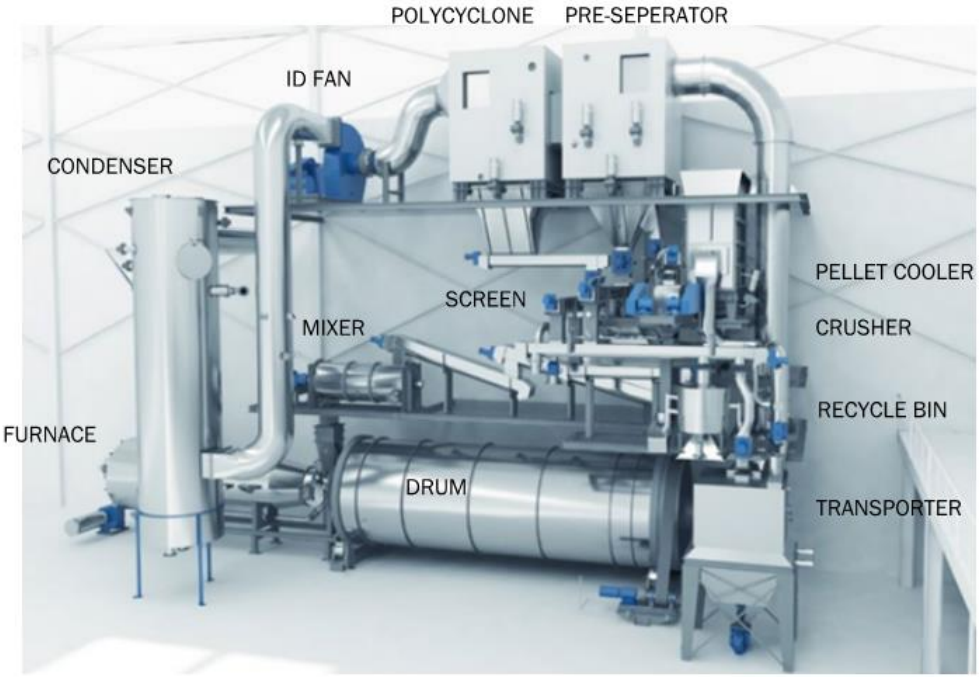


Figure D- 24. Representative Rotary Drum Dryer Model

Courtesy of Andritz.

Operational Variables

Rotary drum dryer operation requires monitoring and adjustment of several primary variables and ancillary systems. Dryer inlet and outlet temperature, typically set at 850°F and 200°F, respectively, provides a key indication of dryer performance, but operators must also monitor the dryer wet feed ratio, based on dewatering performance and dried product recycle rate, every 30 minutes to ensure it also stays within target range. The furnace inlet pressure also provides a key indication of system performance as it is a function of several key ancillary systems such as induction and exhaust fan load and flow rate, air/solids system separation performance, and debris collection within the product screening and processing steps.

If high temperature is detected within the recycle or product bins, the system is inerted with a nitrogen purge system. Temperature excursions within the drum vessel are controlled via water deluge water sprays and explosion panels and vents are located at various locations throughout the system. In addition to temperature, carbon monoxide and oxygen instruments are located throughout the system to detect unsafe conditions.

System Maintenance

Preventative maintenance, as well system rehabilitation and repair costs, are considerably more complex and costly than belt or paddle dryers. Component wear is more widespread and extensive as product is in constant contact with the rotary drum dryer internal vessels and mixing and conveyance equipment. Wet feed and recycle product mixing can be an especially abrasive process and require frequent screw replacement. Drum dryer systems typically have a useful life of 15-20 years and require a major overhaul at that point, typically requiring major capital improvements to replace major components such as the rotary drum vessel.

Appendix E: Statistical Methods

Portions of the statistical analyses were conducted using R Statistical Software (version 4.3.2) [12] and RStudio (version 2024.4.2.764) [13]. The R vegan [22] package's vegdist function was used to calculate Bray-Curtis dissimilarly after omitting samples that had no PFAS detected and PFAS species that were not detected in any samples. NMDS was performed using the vegan package's metaMDS algorithm with two dimensions; goodness-of-fit was determined by examining the stress parameter and Shepard's diagram (Figure E-1). The overall significance of independent variables was tested by permutational analysis of variance (PERMANOVA) using the adonis2 function with 10,000 within-group permutations. A key assumption underlying PERMANOVA is that of approximately constant dispersion, which is analogous to the assumption of homoscedasticity in a traditional analysis of variance (ANOVA), to ensure significant differences identified are inherent to the groups themselves rather than dispersion within a given group. The relative influences of within-group dispersion and between-group dispersion were assessed using the betadisper function to perform analysis of multivariate homogeneity of group dispersions (variances) with 10,000 permutations. Pairwise comparisons were made using the permutest function, and resulting p-values were corrected to account for multiple comparisons using the Benjamini-Hochburg transformation [4].

R packages used include:

- broom [5]
- dplyr [6]
- ggplot2 [7]
- ggstatsplot [8]
- purr [9]
- readxl [10]
- shadowtext [11]
- stringr [12]
- tibble [13]
- tidyr [14]
- vegan [3]
- writexl [15]

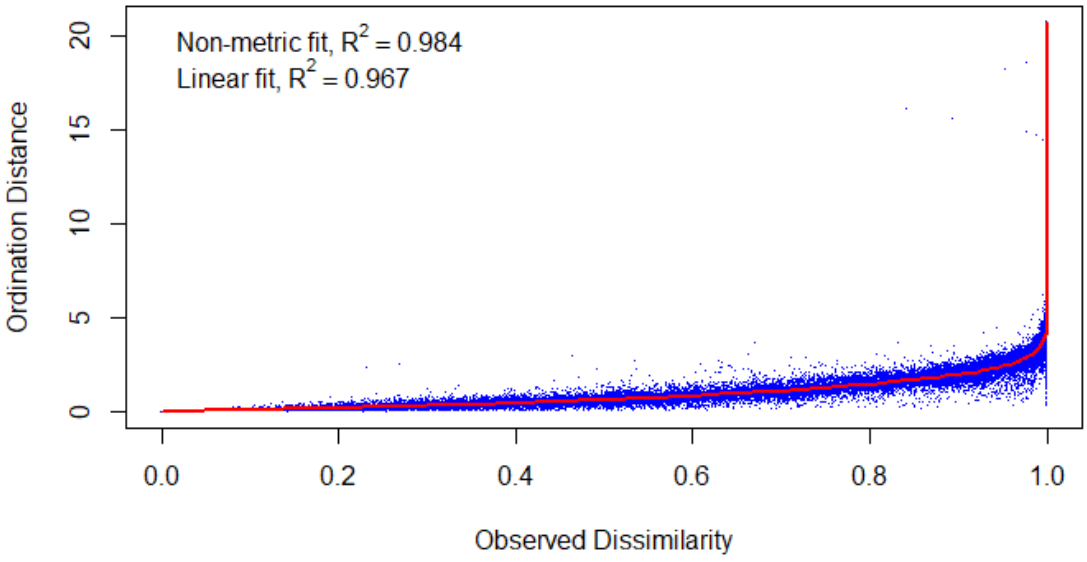


Figure E-1. Shepard Diagram of the NMDS Depicting the Ordination's Goodness-of-Fit

NMDS plots for this ordination are shown in Figure F-3.

Appendix F: Supplemental Figures & Tables

Table F 1. P values[1] for Permutational Analyses of Variance in PFAS composition among POTWs' influent, effluent, and sludge and industrial dischargers[2,3]

	Effluent	Sludge	Industrial Users
Influent	0.0001	0.0001	0.0001
Effluent		0.0001	0.01
Sludge			0.3

Overall p-value = 0.0004

PFAS that were not detected in any samples were omitted, and only samples reporting PFAS measurements for the remaining 37 species were included.

Pairwise p-values have been corrected to account for multiple comparisons using the Benjamini-Hochburg procedure. [23]

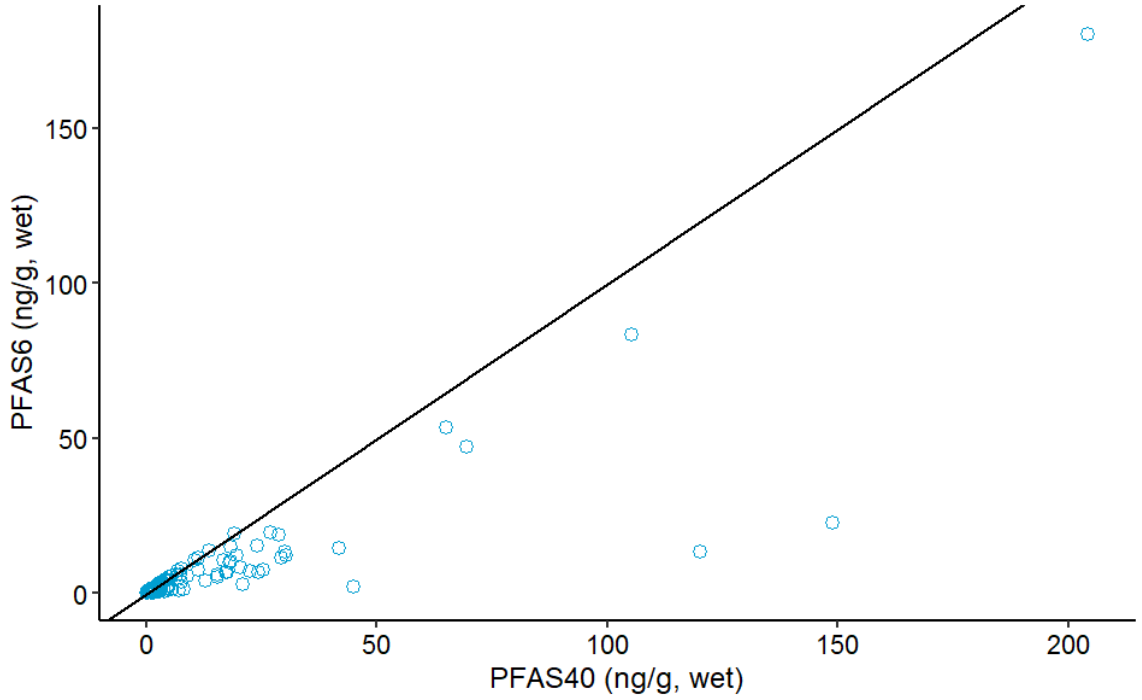


Figure F-1. Correlation between PFAS6 and PFAS40 total mass concentrations

The total mass concentration of PFAS6 is significantly correlated with the total mass concentration of PFAS40 (Spearman's ρ = 0.85, $p<2\times10^{-16}$). The black line represents a theoretical perfect linear correlation between the measurements.

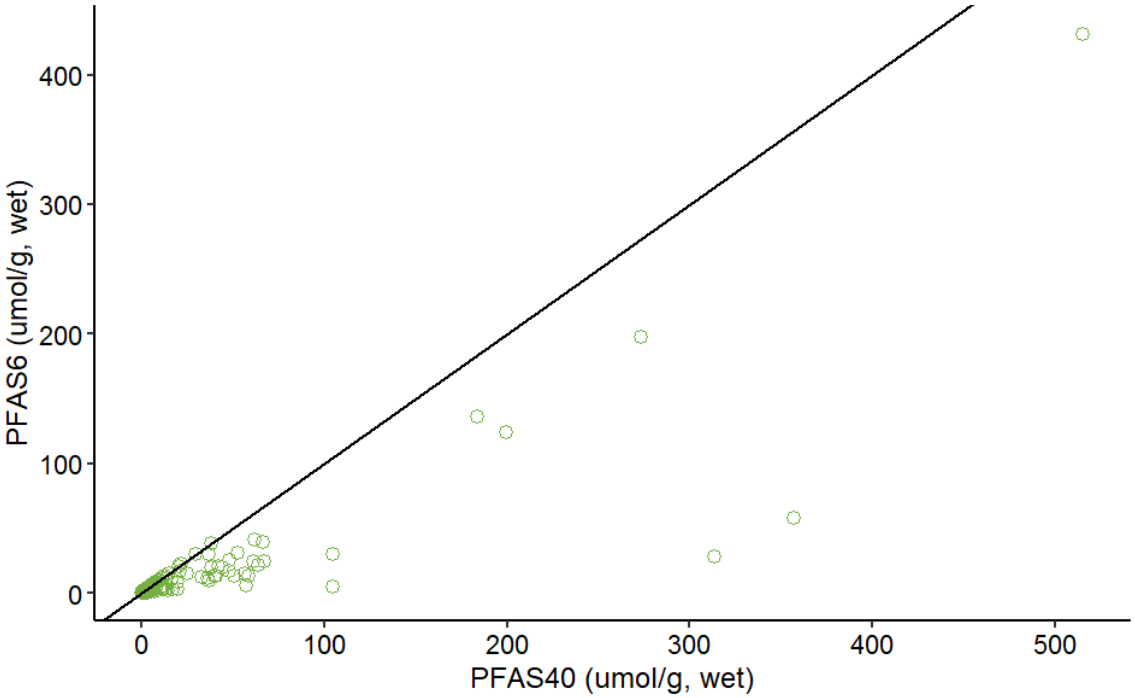


Figure F-2. Correlation between PFAS6 and PFAS40 total molar concentrations

The total molar concentration of PFAS6 is significantly correlated with the total molar concentration of PFAS40 (Spearman's $\rho = 0.86$, $p<2\times10^{-16}$). The black line represents a theoretical perfect linear correlation between the measurements.

Appendix G: Results of the Land Use and Environmental Justice Analyses

Association of POTW PFAS Loadings with Land Use

Given the lack of available PFAS data, the percent of land within a POTW's sewershed classified according to Table G-1 was examined to determine whether land use is associated with PFAS loading at POTWs.

Massachusetts property parcel and sewershed data were compiled for 50 of the 51 POTWs with available PFAS monitoring data, including over 350,000 parcels. A summary of parcel information included in the dataset is presented for comparison with statewide data in Figure G-1. Figure G-1 shows a semiquantitative summary of land use for the 80 municipalities served by these 50 POTWs. Current NPDES permit requirements for PFAS monitoring apply only to POTWs with flow rates between 1 and 5 MGD, and most of the POTWs that provided voluntary monitoring data for this study have flow rates exceeding 5 MGD. Larger POTWs serve more densely-populated areas, so it is not surprising that the sewersheds in this study have disproportionately smaller and more expensive properties in comparison with the rest of the state. Therefore, these results cannot necessarily be extrapolated to small POTWs serving less densely-populated parts of the state. **These results offer a starting point for future analyses, especially as PFAS monitoring requirements expand to apply to small POTWs.**

Table G 1. Summary of Sewershed Parcel Data

	Dataset	Statewide
Mean [median] property value ($)	656,134 [425,100]	544,848 [353,100] [1]
Mean [median] lot size (acres)	2.05 [0.29]	3.74 [0.47][1]
Total land (acres)	717,380	5 million[2]

Calculated from property tax parcel data obtained from the Massachusetts Executive Office of Technology Services and Security Bureau of Geographic Information (MassGIS)

Based on the U.S. Census Bureau Massachusetts profile (Massachusetts, n.d.)

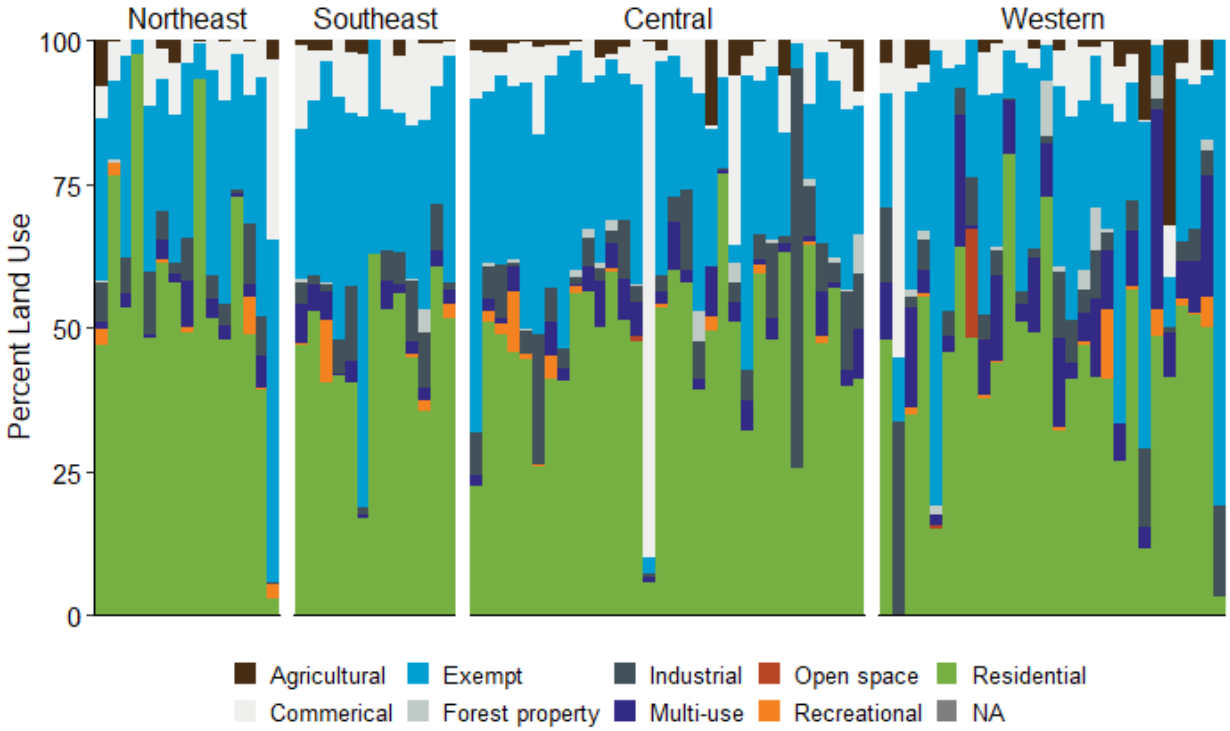


Figure G-1. Summary of land use for 80 municipalities served by 50 POTWs with PFAS data included in the present study

We hypothesized that land use trends within a POTW's sewershed are associated with PFAS loading at the POTW. Several significant correlations were identified between land use categories and influent, effluent, and sludge molar concentrations (Table G-2). Residential land use is positively correlated with total molar PFAS concentrations in POTW influent (Figure G-2) and sludge (Figure G-6), industrial land use is positively correlated with total molar PFAS concentrations in POTW effluent (Figure G-4) and sludge (Figure G-5), and forest land is negatively correlated with total molar PFAS concentrations in POTW influent (Figure G-3) and sludge (Figure G-7).

The low magnitudes of the correlation coefficients indicates that **land use trends alone may be poor predictors of PFAS loading at POTWs**, serving merely to demonstrate the responsibility of anthropogenic activities for PFAS loading at POTWs. In fact, the relationship between industrial land use and effluent PFAS concentration seems to be driven by just a few samples with effluent PFAS concentrations exceeding 1 µmol/g (wet basis). Instead, elevated effluent PFAS concentrations may be associated with specific types of industrial users within the POTW's sewershed; in fact, these effluent samples are from five different POTWs.

Interestingly, two POTWs with effluent PFAS concentrations exceeding 1 µmol/g (wet basis) and four POTWs with sludge PFAS concentrations greater than 25 µmol/g (wet basis) do not currently have IPPs. This further indicates that **the contribution of industrial users to PFAS loading at POTWs should be assessed on a case-by-case basis** with attention paid to the nature of specific industrial activities within the sewershed rather than overall industrial contribution to the POTW.

Table G 2. Summary of Spearman's Correlation Coefficients for land use categories significantly associated with PFAS in POTW influent, effluent, and sludge

Land Use Category	Coefficient (ρ)	p-value
Influent		
Residential	0.2	0.04
Forested	-0.2	0.04
Effluent		
Industrial	0.3	0.004
Sludge		
Industrial	0.2	0.03
Residential	0.2	0.04
Forested	-0.3	0.03

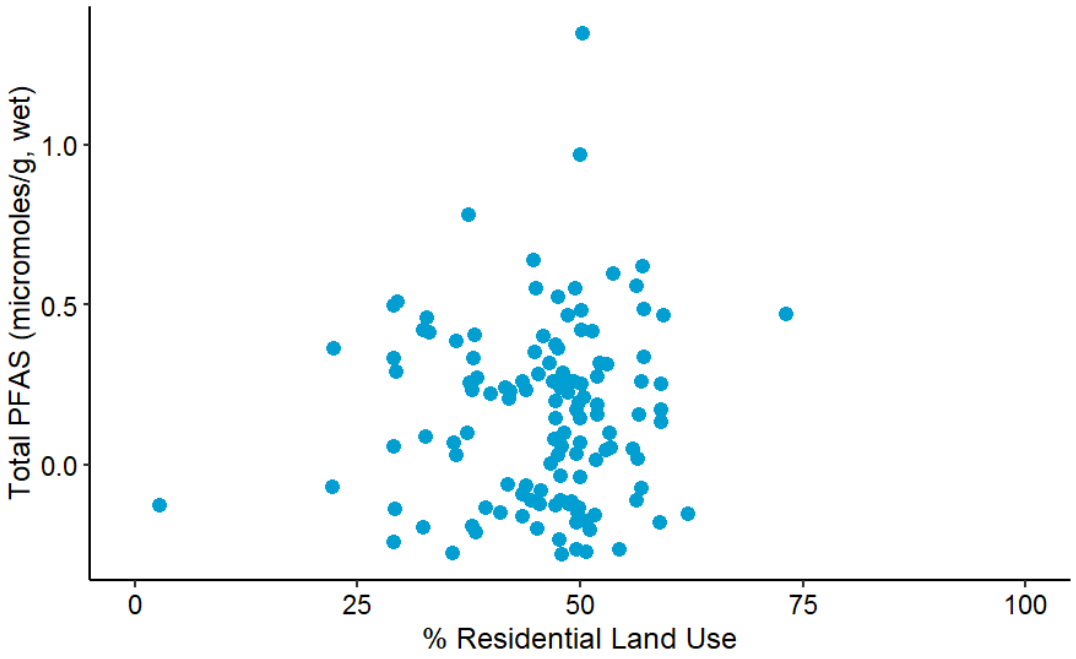


Figure G-2. Total Influent PFAS Concentration is Significantly Correlated with % Residential Land Use in a POTW's Sewershed

Spearman's correlation coefficient = 0.2, p=0.04

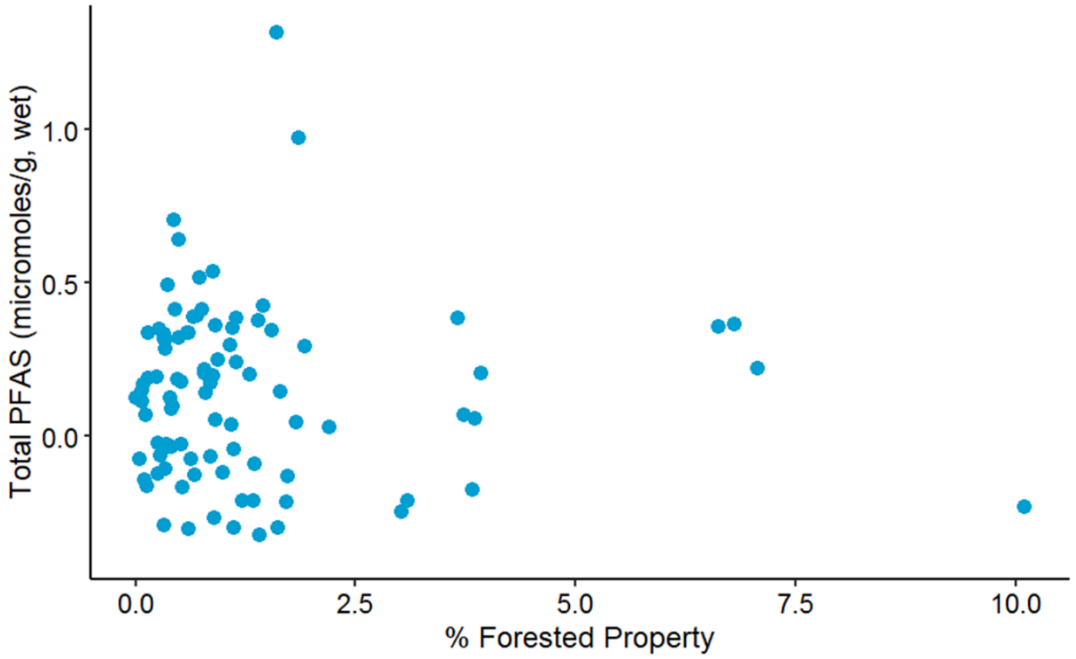


Figure G-3. Total Influent PFAS Concentration is Significantly Correlated with % Forest Property in a POTW's Sewershed

Spearman's correlation coefficient = -0.2, p=0.04

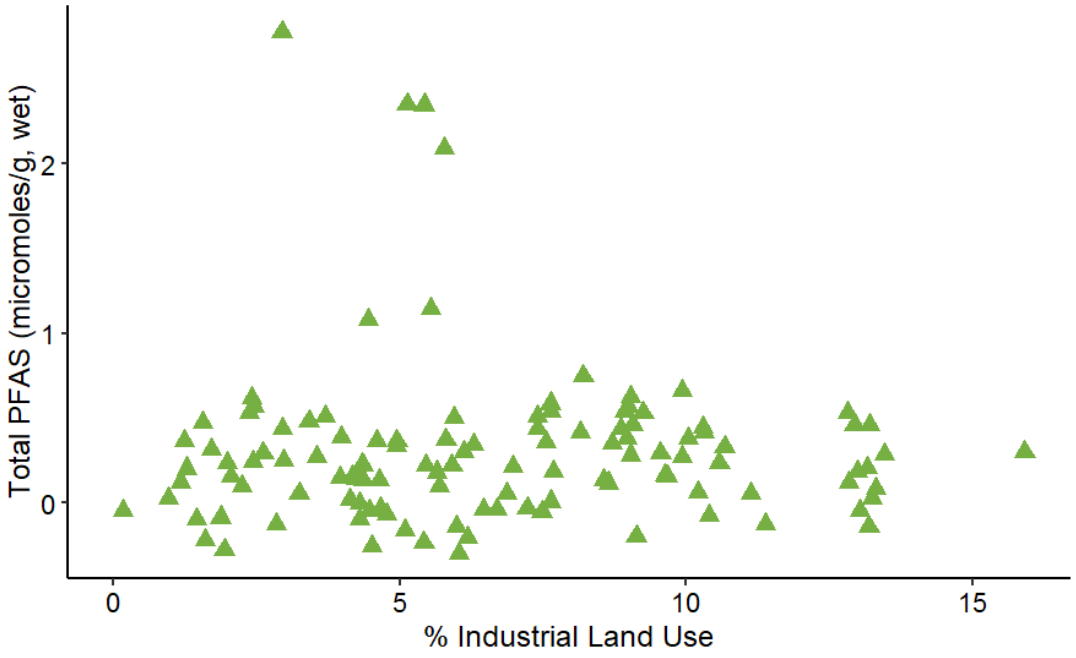


Figure G-4. Total Effluent PFAS Concentration is Significantly Correlated with % Industrial Land Use in a POTW's Sewershed

Spearman's correlation coefficient = 0.3, p=0.004

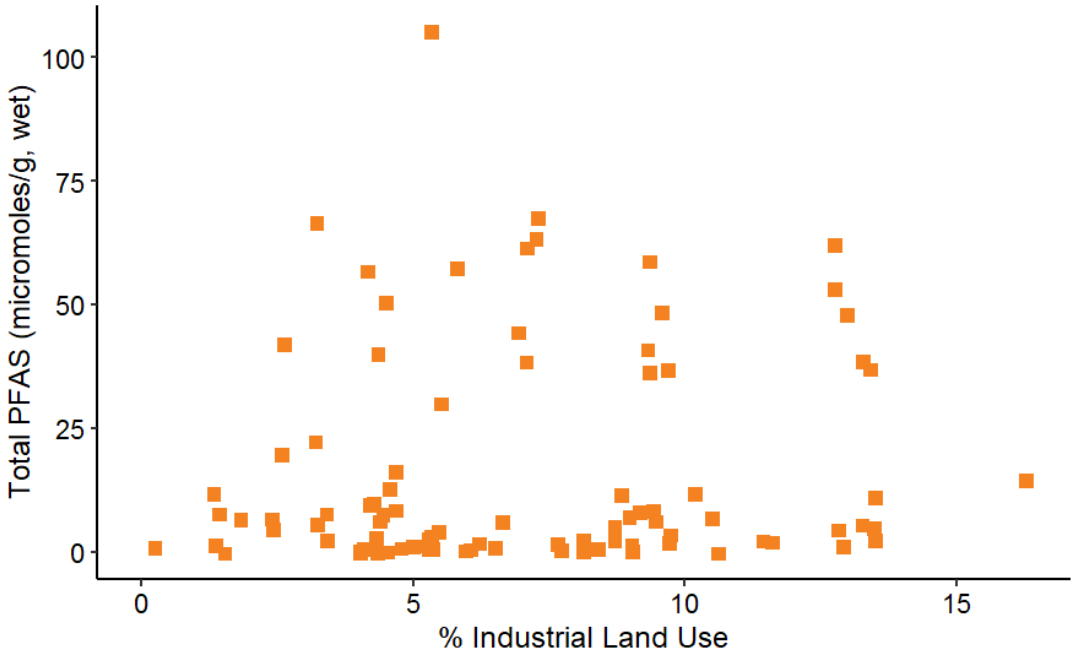


Figure G-5. Total Sludge PFAS Concentration is Significantly Correlated with % Industrial Land Use in a POTW's Sewershed

Spearman's correlation coefficient = 0.2, p=0.03

Note: One outlier with total PFAS > 300 µmol/g (wet basis) is not shown, but it does not significantly affect the relationship between sludge PFAS concentration and % industrial land use.

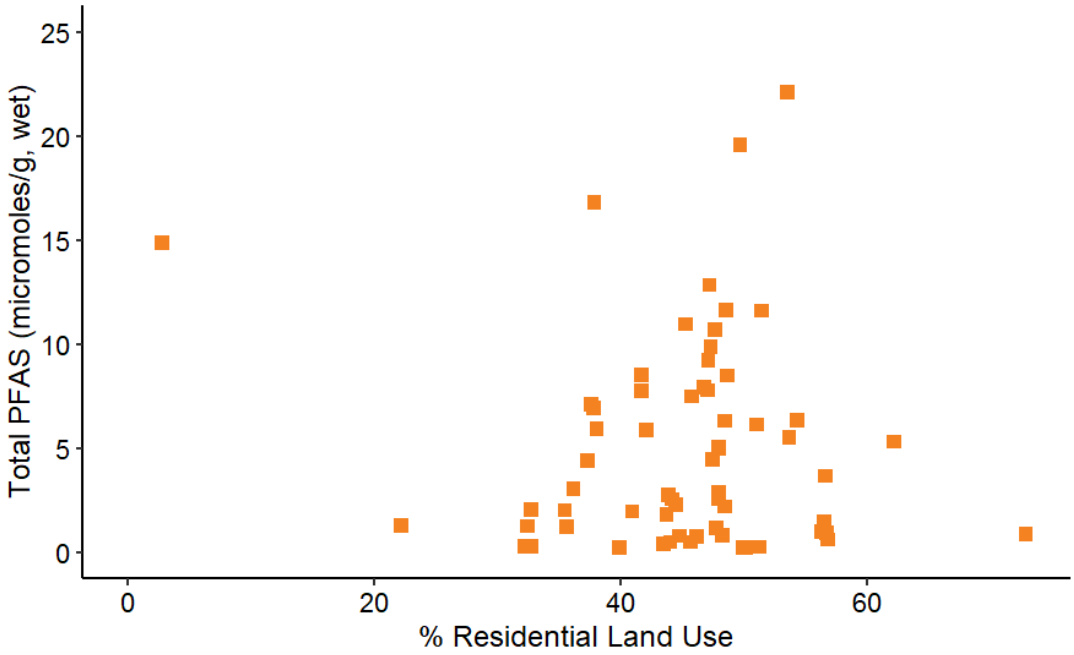


Figure G-6. Total Sludge PFAS Concentration is Significantly Correlated with % Residential Land Use in a POTW's Sewershed

Spearman's correlation coefficient = 0.2, p=0.04

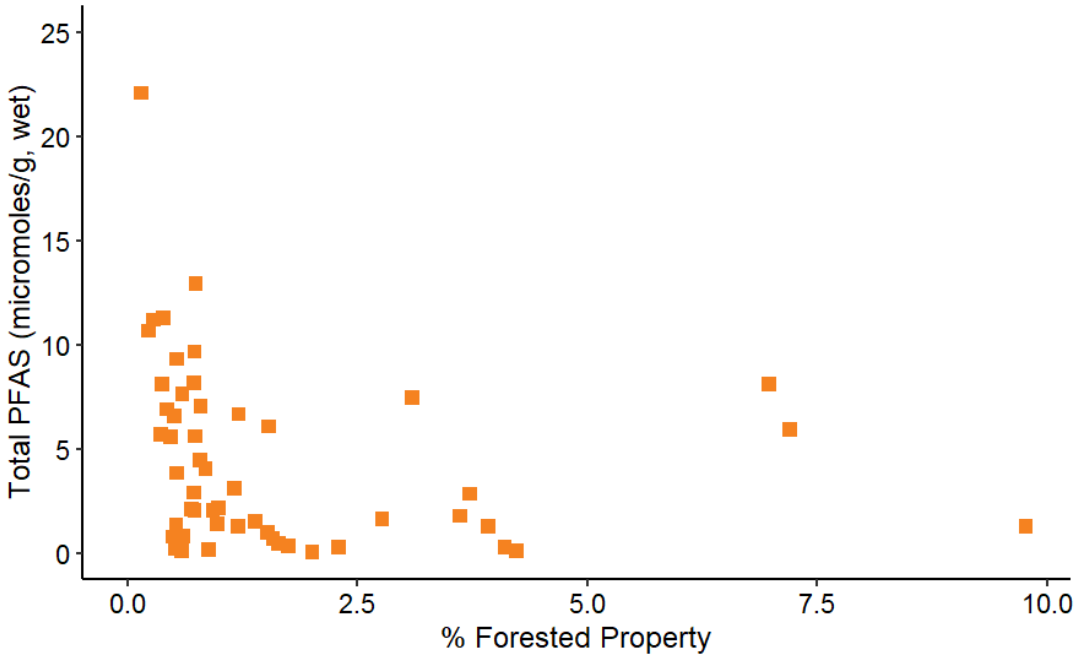


Figure G-7. Total Sludge PFAS Concentration is Significantly Correlated with % Forested Property in a POTW's Sewershed

Spearman's correlation coefficient = -0.3, p=0.03

Association of POTW PFAS Loadings on Environmental Justice Communities

The disproportionate negative impact of pollution on socially and economically disadvantaged communities has been established through substantial previous study, and jurisdictions have increasingly begun to include a variety of population indices in environmental preservation and remediation initiatives, infrastructure upgrades, and funding allocation. We hypothesized that POTWs serving disadvantaged communities may have higher PFAS loading.

Massachusetts sewershed area and environmental justice (EJ) population data for 2020 census block groups were compiled for 50 of the 51 POTWs with available PFAS monitoring data. A summary of environmental justice block group information included in the dataset is presented for comparison with statewide data in Table G-3.

Table G 3. Summary of Sewershed Populations

	Dataset EJ	Dataset Total	Statewide EJ[3]	Statewide Total[1]
Population	696,605	1,326,444	3,486,823	7,029,917
Households	256,360	558,822	-	2,797,776
% Minority[2] Population	46	-	59	30

Based on the U.S. Census Bureau Massachusetts profile (Massachusetts, n.d.)
"Minority" here refers to persons other than non-Hispanic white and white alone
Calculated from MassGIS municipal statistics summary table, which contains statistics for each municipality containing one or more EJ Block Groups

The percent of households within EJ-designated block groups with limited English proficiency is positively correlated with total PFAS concentration in POTWs' influent. However, this relationship is largely driven by a few data exceeding 0.5 µmol/g (wet basis) from a single POTW. The lack of data for sewersheds with a higher percent of households with limited English proficiency indicates that the relationship may be spurious rather than truly significant.

No population parameters for EJ-designated block groups were associated with POTW effluent or sludge PFAS concentrations. For POTW effluent, the lack of observed trend may be caused by data limitations: Only 11 POTW effluent samples from five POTWs were included in the analyses. However, this analysis is even more limited by the fact that data were included only for EJ-designated census block groups. Including data for all the census block groups within a POTW's sewershed would offer the opportunity to compare population parameters for EJ-designated block groups with the overall population served by the POTW or statewide data. As with the sewershed land use analysis, this EJ population analysis serves primarily as a starting point for robust future analyses. Further study will be especially pertinent to funding considerations and when siting potential regional sludge management facilities.

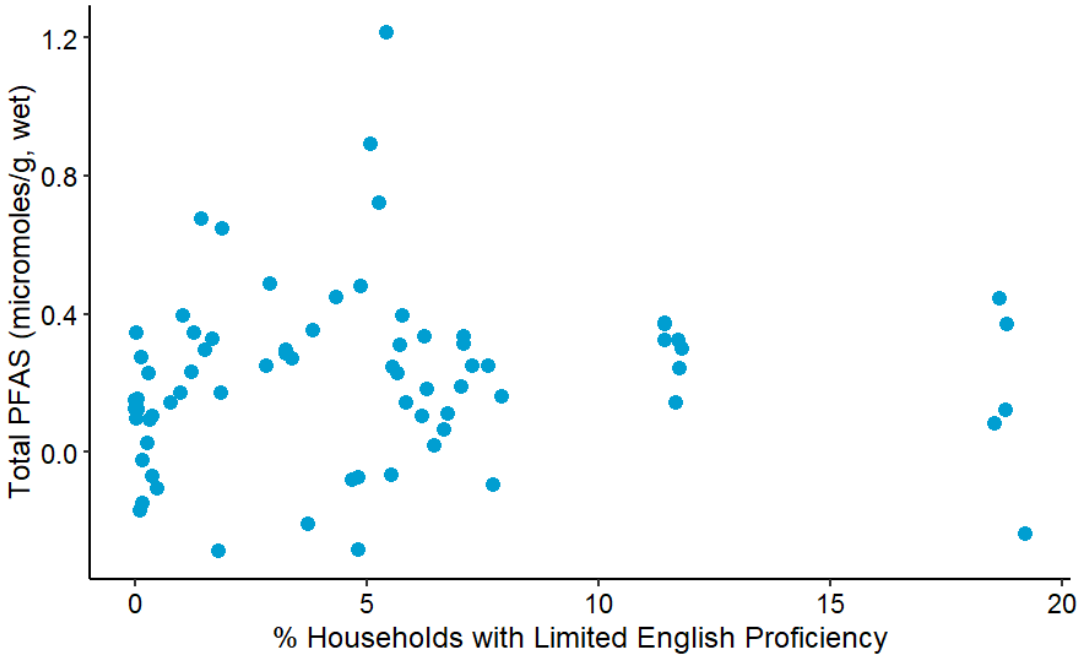


Figure G-8. Total Influent PFAS Concentration is Significantly Correlated with % Households with Limited English Proficiency within EJ-designated census blocks in a POTW's Sewershed

Spearman's correlation coefficient = 0.3, p=0.001

In our review of previous studies, it became clear that PFAS mass concentrations were used in some instances in which the use of molar concentrations would have been beneficial. Commonly, studies have assessed PFAS fate and transport by summing the mass concentrations of individual species or have presented a 'PFAS profile' using stacked bar charts based on mass concentrations. Whether intentional or not, this practice biases results by over-representing larger molecules. Biasing results toward larger compounds may be justifiable in some cases based on their environmental or health risk level; in fact, long-chain PFAS have been found to bioaccumulate more readily than short-chain PFAS (Tavasoli et al., 2021). However, care should be taken to deliberately consider such analytical decisions, their benefits and limitations, and their implications for interpretation of results.

Figure H-1 illustrates the difference in PFAS profiles developed using a mass basis (left) and using a molar basis (right). Using data compiled in Section 4, percent PFAS mass compositions were calculated for POTW influent, effluent, and sludge and industrial wastewater effluent by dividing the mass concentration of each species by the sum of mass concentrations for all species and multiplying by 100 percent. This process was repeated using molar concentrations. For simplicity, PFAS that were not at least 2% of total PFAS were grouped as "Other." Figure 6-2 shows that 3:3 FTCA and PFPeA together comprise at least 30% of the average influent PFAS composition on a molar basis; however, these species make up less than 2% of the average influent PFAS composition on a mass basis because they are among the smallest PFAS measured by EPA Method 1633.

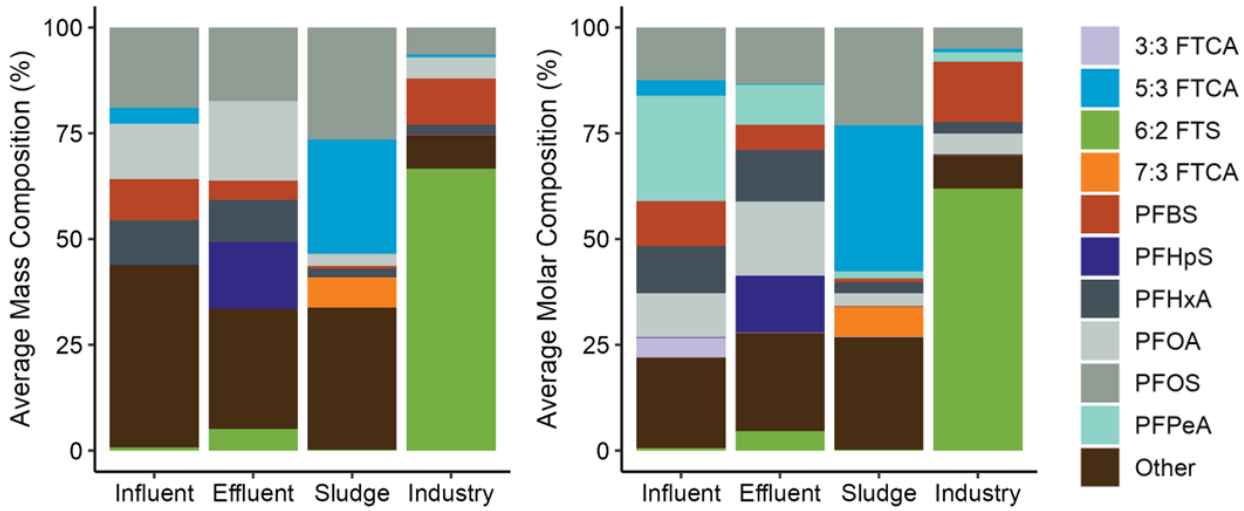


Figure H-1. Average PFAS Profiles for POTW Influent, Effluent, Sludge, and Industrial Effluent

Note: Average percent PFAS compositions were calculated on a mass basis (left) and on a molar basis (right). PFAS that comprised <2% of total PFAS were grouped as "Other" for clarity.

In the absence of explicit justification for the use of a mass basis, we recommend future analyses analyze fate and transport of PFAS on a molar basis. In addition to normalizing the concentration data by molecular weight, this procedure allows for comprehensive mass and energy balances to identify and understand PFAS transport and transformation phenomena within the treatment plant itself and among solid and liquid phases. Unbiased analyses are especially important given the rapidly evolving scientific and regulatory landscape with respect to PFAS. An alternative approach might be representing PFAS mass concentrations in terms of a structural element common to all PFAS. This method of standardization is widely used in wastewater nutrient removal applications: Concentrations of ammonia, nitrite, and nitrate are commonly reported in mass concentrations "as nitrogen," disregarding the specific molecular structures and sizes of the individual compounds to

emphasize the nutrient itself. Representing PFAS quantities in terms of the carbon-fluorine bond, for example, offers an opportunity to standardize mass concentrations. This practice would both facilitate comparison among different species and emphasize the structural component of PFAS that is particularly environmentally persistent. However, there is not yet consensus for expressing the quantity of PFAS in terms of a structural equivalent.

In Section 4 of this study, we present analyses based on both mass and molar concentrations. Data were analyzed on a mass basis for descriptive summaries, such as for the case studies included in Section 4.1.2, primarily to facilitate comparison with previous studies. However, more complex, nonparametric statistical analyses such as NMDS and PERMANOVA require frequency or "count" data and cannot account for the concept of size. Consider the fact that these statistical methods originate from ecology; when assessing ecosystem diversity, one typically compares the total number of species and the number of unique members of each species, where different species tend to be present in different abundances in different ecosystems, forming a "profile." In our case, different PFAS represent different species, moles are the "unique members" of each species, and wastewater media represent different possible "ecosystems." Therefore, these methods based on molarity compare samples' PFAS profiles using the number of moles observed and their frequency of observation to elucidate underlying characteristics of

Appendix H: Potential Sludge Management Scenario Calculations

Appendix H - Additional Information and Calculations for Section 5 Scenarios

Appendix H - Additional Information and Calculations for Section 5 Scenarios
Table H-0: Plants Unaffected by Indirect Impacts
Scenario 1: Land Application Restrictions in Massachusetts
Table H-1A: Plants Directly Impacted in Scenario 1
Table H-1B: Direct Costs for Composting Facilities
Table H-1C: Direct and Indirect Cost Increases for Facilities Sending Biosolids to Land Application in Massachusetts
Table H-1D: Indirect Costs for Remaining Facilities
Scenario 2: Land Application Restrictions Regionally or Nationally
Table H-2A: Plants Directly Impacted in Scenario 2
Table H-2B: Direct and Indirect Cost Increases for Facilities Sending Biosolids to Land Application in CT, NH, or VT
Table H-2C: Indirect Costs for Remaining Facilities
Scenario 3: Landfill Restrictions in Massachusetts
Table H-3A: Plant Directly Impacted in Scenario 3
Table H-3B: Direct and Indirect Cost Increases for Facility Sending Sludge to Resource Control, Inc Landfill
Table H-3C: Indirect Costs for Remaining Facilities
Scenario 4: Landfill Restrictions Regionally or Nationally
Table H-4A: Plants Directly Impacted in Scenario 4
Table H-4B: Direct and Indirect Costs for Facilities Sending Sludge to Landfills in NH, NY, or VT
Table H-4C: Indirect Costs for Remaining Facilities
Scenario 5: Incineration Capacity Reduction in Massachusetts
Table H-5A: Plants Directly Impacted in Scenario 5
Table H-5B: UBCW Hauling Calculations
Table H-5C: Hauling Cost Calculations
Table H-5D: Dewatering Cost Calculations
Table H-5E: Indirect Costs for Remaining Facilities
Table H-5F: Summary of Scenario 5 calculations
Scenario 6: Incineration Capacity Reduction Regionally or Nationally
Table H-6A: Plants Directly Impacted in Scenario 6
Table H-6B: Hauling Cost Calculations
Table H-6C: Dewatering Cost Calculations
Table H-6D: Redirected Cake Hauling Cost Calculations
Table H-6E: Indirect Costs for Remaining Facilities
Table H-6F: Summary of Scenario 6 calculations
Scenario 7: New Capacity Becomes Available
Table H-7A: Plants Directly Impacted in Scenarios 7-10
Table H-7B: Annual Projected Material Quantities by Plant and Sludge Load
Table H-7C: Yearly Unit Prices by Plant and Sludge Load (6.2% escalation)
Table H-7D: Annual Solids Hauling Cost per year, per plant (6.2% escalation)
Table H-7E: Yearly Unit Prices by Plant and Sludge Load (3.1% escalation)
Table H-7F: Annual Solids Hauling Cost per year, per plant (3.1% escalation)
Table H-7G: Summary of Scenario 7 Calculations - Additional sludge disposal capacity
Scenario 8: Additional Sludge Reduction Capacity Becomes Available

Table H-8A: Summary of Scenario 8 Calculations - Additional sludge reduction capacity becomes available

Scenario 9: New PFAS Treatment Capacity Becomes Available

Table H-9A: Summary of Scenario 9 Calculations - New sludge PFAS treatment capacity becomes available

Table H-0: Plants Unaffected by Indirect Impacts

Plant	DEP "region"	Permitted or design flow (MGD)
Bridgewater WWTP	Southeast	1.44
Dartmouth WPCF	Southeast	4.20
Erving Center WWTP (#2)	West	2.70
Greater Lawrence Sanitary District	Northeast	52.00
Hoosac WQD	West	6.50
Lynn Regional WF	Northeast	25.8
Marion WWTP - Marion DPW	Southeast	0.59
MWRA Deer Island WWTP	Northeast	361.00
Shelburne Falls WWTP	West	0.25
Southbridge WWTP	Central	3.77
Templeton WWTP	Central	0.60
Upper Blackstone WPAD (Worcester area)	Central	56
	Total # of Plants	12

Table H-1A: Plants Directly Impacted in Scenario 1			
Land application restrictions in Massachusetts			
Plant	**DEP "region"**	**Permitted or design flow (MGD)**	**Notes**
Acton Wastewater Collection	Central	0.30	
Amesbury WWTP	Northeast	2.40	
Billerica WWTP	Northeast	5.55	
Bridgewater WWTP	Southeast	1.44	Compost facility
Chatham WPCF	Southeast	1.50	
Concord WWTF	Northeast	1.20	Some sludge streams indirectly impacted
Dartmouth WPCF	Southeast	4.20	Compost facility
Gloucester WPCF	Northeast	5.15	
Greater Lawrence Sanitary District	Northeast	52.00	
Hoosac WQD	West	6.50	Compost facility
Ipswich WWTP	Northeast	1.80	Compost facility
Lowell Regional WW Utility	Northeast	32.00	Some sludge streams indirectly impacted
Maynard WWTP	Central	1.45	Some sludge streams indirectly impacted
Merrimac WWTP	Northeast	0.45	
Monroe WWTP	West	0.02	
MWRA Deer Island WWTP	Northeast	361.00	
Newburyport WWTP	Northeast	3.40	
Rockport WWTP	Northeast	0.80	
South Essex Sewerage District	Northeast	29.70	Some sludge streams indirectly impacted
Southbridge WWTP	Central	3.77	Compost facility
	Total # of Plants	20	

Calculation approach
Total Annual Solids Handling Costs were estimated
Column A was multipled by Column B to get Column C (eg, for Bridgewater, 573 wt/yr * $50/wt = $28,660/yr). Numbers will not be exact due to rounding errors.
This provided the total annual solids handling costs for each facility BEFORE price increases
It was assumed all biosolids produced by composting facilities were land applied in Massachusetts to simplify calculations (composting facilities applied between 95% and 100% of their product in Massachusetts)
Thus, all sludge was subject to DIRECT price increase impacts
The cost increase is determined by multiplying the quantity of wet tons produced per year (Column A) by $126/wt
For example, for Bridgewater, Column A was multiplied by $126/wt to get $72,223/yr. This is the INCREASE in solids handling costs seen by Bridgewater each year
For clarity of calculations, results for individual plants or sludge loads are not rounded. When values are totaled for Column F (total direct impacts), this total is rounded.

Table H-1B: Direct Costs for Composting Facilities

		A	B	C	D	E	F
POTW name	**Destination Facility**	**Quantity (wet US tons/year)**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**% Biosolids Land Applied in Mass**	**Directly Impacted Base Costs ($50/wt)**	**Cost Increase ($126/wt)**
Bridgewater WWTP	Bridgewater WWTP	573	$50	$ 28,660	100%	$ 28,660	$ 72,223
Dartmouth WPCF	Dartmouth WPCF	1,653	$50	$ 82,673	100%	$ 82,673	$ 208,337
Hoosac WQD	Hoosac WQD	465	$50	$ 23,240	100%	$ 23,240	$ 58,566
Ipswich WWTP	Agresource/Ipswich Compost Facility	2,364	$50	$ 118,192	100%	$ 118,192	$ 297,844
Southbridge WWTP	Southbridge WWTP	947	$50	$ 47,350	100%	$ 47,350	$ 119,321
						Total	**$ 756,000**

Calculation approach
Total Annual Solids Handling Costs were estimated
For facilities hauling liquid, Column A was multipled by Column C to get Column E (eg, for Acton, 236,361 gal/yr * $0.11/gal = $25,031/yr). Numbers will not be exact due to rounding errors.
For facilities hauling cake, Column B was multipled by Column D to get Column E (eg, for Amesbury, 2,120 wt/yr * $156/wt = $330,739/yr). This provided the total annual solids handling costs for each facility BEFORE price increases
To determine the proportion of those annual costs that would be subject to DIRECT price impacts, the annual cost was multipled by the % of biosolids land applied in Massachusetts, out of the entirety of biosolids land applied
For example, for Acton, they pay $25,031 per year to haul their liquid sludge to GLSD, which then land applies it. Since 40% of what GLSD land applies is applied in Massachusetts, 40% of Acton's hauling costs would be subject to DIRECT price increases due to land app bans in Massachusetts. Column E times Column F equals Column G ($25,031 * 40% = $10,032)
The remainder of their annual costs are subject to INDIRECT price increases - Column E minus Column G equals Column H. (for Acton, $25,031 - $10,032 = $14,999 would be subject to INDIRECT price increases).
Next, to determine the INCREASE in annual sludge handling costs, the proportion of annual solids handling costs that would be directly impacted, are multiplied by the percent increase associated with direct impacts for this Scenario.
According to Table 5-1, since Scenario 1 affects between 15,000 and 20,000 dt/yr, the DIRECT price increase percentage is 45%.
Column G was multiplied by 45% to get the direct price increase, shown in Column I (eg, for Acton, $10,032 * 45% = $4,514)
Indirect price increases are 22.5% (see Table 5-1) - Column H was multiplied by 22.5% to get the indirect price increase, shown in Column J (eg, for Acton, $14,999 * 22.5% = $3,375)
For four plants (Concord, Lowell, Maynard, and South Essex), some of their sludge goes to a plant which land applies in MA, and some goes elsewhere and would not be directly affected by a land app ban in MA. For example, Concord sends sludge BOTH to GLSD (which would be DIRECTLY impacted), and to a landfill in VT (which would be INDIRECTLY impacted). This load that is indirectly impacted is noted in Column F by indicating the % Biosolids Land Applied in Mass as 0%. In this case, Column H is identical to Column E. Column H is in turn multiplied by 22.5% to get the indirect price increase for that sludge load.
For clarity, these plants which have biosolids that are directly impacted and biosolids or sludge that is indirectly impacted are included in this table.
For clarity of calculations, results for individual plants or sludge loads are not rounded. When values are totaled for Column I and Column J (total direct impacts and total indirect impacts), these totals are rounded.

Table H-1C: Direct and Indirect Cost Increases for Facilities Sending Biosolids to Land Application in Massachusetts

		A	B	C	D	E	F	G	H	I	J
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**% Biosolids Land Applied in Mass**	**Direct Impacts - Base Cost**	**Indirect Impacts - Base Cost**	**Direct Impacts - Increased Cost (45%)**	**Indirect Impacts - Increased Cost (22.5%)**
Acton Wastewater Collection	Greater Lawrence Sanitary District	236,361	986	$ 0.11	liquid	$ 25,031	40%	$ 10,032	$ 14,999	$ 4,514	$ 3,375
Amesbury WWTP	Agresource/Ipswich Compost Facility	not liquid	2,120	not liquid	$ 156.00	$ 330,739	95%	$ 314,202	$ 16,537	$ 141,391	$ 3,721
Billerica WWTP	Hawk Ridge Compost Facility	not liquid	7,003	not liquid	$ 146.70	$ 1,027,369	65%	$ 668,323	$ 359,046	$ 300,745	$ 80,785
Chatham WPCF	Hawk Ridge Compost Facility	not liquid	271	not liquid	$ 156.00	$ 42,336	65%	$ 27,540	$ 14,796	$ 12,393	$ 3,329
Concord WWTF	Greater Lawrence Sanitary District	978,417	4,080	$ 0.06	liquid	$ 59,058	40%	$ 23,670	$ 35,388	$ 10,652	$ 7,962
Concord WWTF	New England Waste Services of VT Landfill (Waste USA Landfill)	31,175	130	$ 0.06	liquid	$ 1,882	0%	$ -	$ 1,882	$ -	$ 423
Gloucester WPCF	Hawk Ridge Compost Facility	not liquid	2,604	not liquid	$ 156.00	$ 406,256	65%	$ 264,277	$ 141,979	$ 118,925	$ 31,945
Greater Lawrence Sanitary District	Greater Lawrence Sanitary District	not liquid	6,480	not liquid	$ 366.90	$ 2,377,408	40%	$ 952,850	$ 1,424,558	$ 428,782	$ 320,526
Lowell Regional WW Utility	Hawk Ridge Compost Facility	not liquid	11,211	not liquid	$ 190.37	$ 2,134,202	65%	$ 1,388,339	$ 745,864	$ 624,752	$ 167,819
Lowell Regional WW Utility	Bethleham MSW Landfill NH	not liquid	7,648	not liquid	$ 190.37	$ 1,456,002	0%	$ -	$ 1,456,002	$ -	$ 327,600.44
Lowell Regional WW Utility	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	2,448	not liquid	$ 190.37	$ 466,073	0%	$ -	$ 466,073	$ -	$ 104,866.35
Lowell Regional WW Utility	Synagro in Woonsocket, RI incinerator	not liquid	64	not liquid	$ 190.37	$ 12,165	0%	$ -	$ 12,165	$ -	$ 2,737.13
Lowell Regional WW Utility	Envirem Organics (NB)	not liquid	5,751	not liquid	$ 190.37	$ 1,094,853	0%	$ -	$ 1,094,853	$ -	$ 246,341.84
Maynard WWTP	Greater Lawrence Sanitary District	2,798,422	11,669	$ 1.00	liquid	$ 2,798,422	40%	$ 1,121,590	$ 1,676,832	$ 504,715	$ 377,287
Maynard WWTP	Cranston WPCF Incinerator	35,246	147	$ 1.00	liquid	$ 35,246	0%	$ -	$ 35,246	$ -	$ 7,930.29
Merrimac WWTP	Agresource/Ipswich Compost Facility	678,068	2,828	$ 0.16	liquid	$ 108,491	95%	$ 103,066	$ 5,425	$ 46,380	$ 1,221
Monroe WWTP	Hoosac WQD	488,109	2,035	$ 0.16	liquid	$ 78,098	100%	$ 78,098	$ -	$ 35,144	$ -
MWRA Deer Island WWTP	Massachusetts Water Resources Authority thermal drying facility	not liquid	35,373	not liquid	$ 156.00	$ 5,518,161	8%	$ 441,453	$ 5,076,708	$ 198,654	$ 1,142,259
Newburyport WWTP	Agresource/Ipswich Compost Facility	not liquid	2,729	not liquid	$ 156.00	$ 425,666	95%	$ 404,383	$ 21,283	$ 181,972	$ 4,789
Rockport WWTP	Agresource/Ipswich Compost Facility	not liquid	473	not liquid	$ 156.00	$ 73,840	95%	$ 70,148	$ 3,692	$ 31,567	$ 831
South Essex Sewerage District	Hawk Ridge Compost Facility	not liquid	19,646	not liquid	$ 135.08	$ 2,653,817	65%	$ 1,726,358	$ 927,460	$ 776,861	$ 208,678
South Essex Sewerage District	Bethleham MSW Landfill NH	not liquid	1,389	not liquid	$ 135.08	$ 187,687	0%	$ -	$ 187,687	$ -	$ 42,229.63
South Essex Sewerage District	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	5,020	not liquid	$ 135.08	$ 678,091	0%	$ -	$ 678,091	$ -	$ 152,570.41
South Essex Sewerage District	Synagro in Woonsocket, RI incinerator	not liquid	5,680	not liquid	$ 135.08	$ 767,319	0%	$ -	$ 767,319	$ -	$ 172,646.79
South Essex Sewerage District	Synagro Waterbury CT incinerator	not liquid	2,538	not liquid	$ 135.08	$ 342,788	0%	$ -	$ 342,788	$ -	$ 77,127.22
									Total	**$ 3,417,000**	**$ 3,489,000**

Calculation approach
Total Annual Solids Handling Costs were estimated
For facilities hauling liquid, Column A was multipled by Column C to get Column E (eg, for Amherst, 3,448,975 gal/yr * $0.19/gal = $661,600/yr). Numbers will not be exact due to rounding errors.
For facilities hauling cake, Column B was multipled by Column D to get Column E (eg, for Adams, 983 wt/yr * $170/wt = $167,193/yr)
This provided the total annual solids handling costs for each facility BEFORE price increases
The entirety of these annual costs would be subjected to indirect price increase, therefore Column F is identical to Column E
Next, to determine the INCREASE in annual sludge handling costs, the annual solids handling costs that would be indirectly impacted are multiplied by the percent increase associated with indirect impacts for this Scenario.
According to Table 5-1, since Scenario 1 affects between 15,000 and 20,000 dt/yr, the INDIRECT price increase percentage is 22.5%.
Column F was multiplied by 22.5% to get the indirect price increase (eg, for Adams, $167,193 * 22.5% = $37,619)
Note: data on annual solids handling costs were not available for all plants; these were deemed negligible and not considered.
For clarity of calculations, results for individual plants or sludge loads are not rounded. When values are totaled for Column G (total indirect impacts), this total is rounded.

Table H-1D: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (22.5%)**
Adams WWTP	Synagro Waterbury CT incinerator	not liquid	983	not liquid	$ 170.00	$ 167,193	$ 167,193	$ 37,619
Amherst WWTP	MDC Hartford Connecticut Incinerator	3,448,975	14,382	$ 0.19	liquid	$ 661,600	$ 661,600	$ 148,860
Ashfield	Lowell Regional WW Utility	20,869	87	$ 0.24	liquid	$ 5,044	$ 5,044	$ 1,135
Athol WWTP	Cranston WPCF Incinerator	303,029	1,264	$ 0.26	liquid	$ 78,636	$ 78,636	$ 17,693
Athol WWTP	Upper Blackstone Clean Water	1,804,657	7,525	$ 0.26	liquid	$ 468,308	$ 468,308	$ 105,369
Attleboro WWTP	Attleboro Monofill	not liquid	9,521	not liquid	$ 156.00	$ 1,485,246	$ 1,485,246	$ 334,180
Ayer WWTP	Cranston WPCF Incinerator	1,964,446	8,192	$ 0.14	liquid	$ 267,496	$ 267,496	$ 60,187
Barnstable WWTP WPCD - DPW	Cranston WPCF Incinerator	4,731,738	19,731	$ 0.18	liquid	$ 859,073	$ 859,073	$ 193,292
Barnstable WWTP WPCD - DPW	Upper Blackstone Clean Water	248,482	1,036	$ 0.18	liquid	$ 45,113	$ 45,113	$ 10,151
Barre WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Belchertown WWTP	Cranston WPCF Incinerator	570,594	2,379	$ 0.17	liquid	$ 94,252	$ 94,252	$ 21,207
Brockton WWTP	Veolia Naugatuck, CT	not liquid	17,335	not liquid	$ 148.52	$ 2,574,569	$ 2,574,569	$ 579,278
Charlemont Sewer District		-	-	$ 0.16	liquid	$ -	$ -	$ -
Charles River PCD	Cranston WPCF Incinerator	532,573	2,221	$ 0.15	liquid	$ 78,237	$ 78,237	$ 17,603
Charles River PCD	Upper Blackstone Clean Water	6,247,045	26,050	$ 0.15	liquid	$ 917,709	$ 917,709	$ 206,485
Charlton WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Chicopee WWTP	Synagro Waterbury CT incinerator	not liquid	412	not liquid	$ 140.17	$ 57,796	$ 57,796	$ 13,004
Chicopee WWTP	Cranston WPCF Incinerator	not liquid	366	not liquid	$ 140.17	$ 51,363	$ 51,363	$ 11,557
Chicopee WWTP	Casella composting Grasslands NY	not liquid	3,443	not liquid	$ 140.17	$ 482,629	$ 482,629	$ 108,591
Cohasset WWTF	Cranston WPCF Incinerator	524,258	2,186	$ 0.16	liquid	$ 83,881	$ 83,881	$ 18,873
Devens WWTP	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	3,844	not liquid	$ 170.00	$ 653,421	$ 653,421	$ 147,020
Douglas WWTP	Upper Blackstone Clean Water	1,236,248	5,155	$ 0.10	liquid	$ 125,000	$ 125,000	$ 28,125
Easthampton WWTP	Synagro Waterbury CT incinerator	not liquid	2,539	not liquid	$ 118.17	$ 300,000	$ 300,000	$ 67,500
Edgartown WWTP	Synagro in Woonsocket, RI incinerator	not liquid	1,011	not liquid	$ 119.00	$ 120,271	$ 120,271	$ 27,061
Erving POTW #1	Lowell Regional WW Utility	192,970	805	$ 0.20	liquid	$ 38,451	$ 38,451	$ 8,652
Erving POTW #3	Erving POTW #1	4,958	21	$ 0.16	liquid	$ 793	$ 793	$ 178
Fairhaven WPCF	Synagro in Woonsocket, RI incinerator	4,650,730	19,394	$ 0.09	liquid	$ 410,178	$ 410,178	$ 92,290

Table H-1D: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (22.5%)**
Fall River Regional WWF	Cranston WPCF Incinerator	33,968,066	141,647	$ 0.05	liquid	$ 1,863,588	$ 1,863,588	$ 419,307
Falmouth WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Fitchburg East WWTP	Resource Control, Inc. – RCI Fitchburg Landfill	not liquid	8,748	not liquid	$ 37.59	$ 328,849	$ 328,849	$ 73,991
Gardner WPCF	City of Gardner West St. Sludge Landfill	not liquid	3,276	not liquid	$ 2.72	$ 8,925	$ 8,925	$ 2,008
Grafton WWTP	Upper Blackstone Clean Water	2,769,789	11,550	$ 0.11	liquid	$ 301,245	$ 301,245	$ 67,780
Great Barrington WWTP	Synagro Waterbury CT incinerator	not liquid	937	not liquid	$ 151.00	$ 141,446	$ 141,446	$ 31,825
Greenfield WPCF	Lowell Regional WW Utility	3,138,258	13,087	$ 0.23	liquid	$ 730,183	$ 730,183	$ 164,291
Hadley WWTP	Lowell Regional WW Utility	1,039,319	4,334	$ 0.23	liquid	$ 243,928	$ 243,928	$ 54,884
Hardwick-Gilbertville WPCF	Cranston WPCF Incinerator	238,609	995	$ 0.11	liquid	$ 25,800	$ 25,800	$ 5,805
Hardwick-Wheelwright WPCF	Cranston WPCF Incinerator	148,681	620	$ 0.08	liquid	$ 12,000	$ 12,000	$ 2,700
Hatfield WWTP	Lowell Regional WW Utility	328,759	1,371	$ 0.24	liquid	$ 78,398	$ 78,398	$ 17,640
Haverhill WWTP	Crossroads Landfill in Maine	not liquid	14,583	not liquid	$ 175.00	$ 2,552,052	$ 2,552,052	$ 574,212
Holyoke WWTP	Veolia Naugatuck, CT	not liquid	428	not liquid	$ 140.00	$ 59,920	$ 59,920	$ 13,482
Holyoke WWTP	Cranston WPCF Incinerator	not liquid	312	not liquid	$ 140.00	$ 43,680	$ 43,680	$ 9,828
Holyoke WWTP	Ontario County MSW LF NY	not liquid	3,639	not liquid	$ 140.00	$ 509,390	$ 509,390	$ 114,613
Holyoke WWTP	Casella composting Grasslands NY	not liquid	5,229	not liquid	$ 140.00	$ 732,060	$ 732,060	$ 164,714
Hopedale WWTF	Synagro in Woonsocket, RI incinerator	1,223,998	5,104	$ 0.09	liquid	$ 110,000	$ 110,000	$ 24,750
Hudson WWTF	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	2,133	not liquid	$ 156.00	$ 332,773	$ 332,773	$ 74,874
Hull WWTF	Cranston WPCF Incinerator	1,211,484	5,052	$ 0.16	liquid	$ 193,837	$ 193,837	$ 43,613
Huntington WWTP	Westfield WPCP	72,000	300	$ 0.34	liquid	$ 24,480	$ 24,480	$ 5,508
Kingston Sewer Commission	Cranston WPCF Incinerator	937,999	3,911	$ 0.16	liquid	$ 150,010	$ 150,010	$ 33,752
Lee WWTP	Cranston WPCF Incinerator	1,153,383	4,810	$ 0.19	liquid	$ 224,000	$ 224,000	$ 50,400
Leicester WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Lenox Center WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Leominster WPCF	Upper Blackstone Clean Water	6,370,102	26,563	$ 0.06	liquid	$ 379,114	$ 379,114	$ 85,301
Lynn Regional WF	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	3,306	not liquid	$ 225.00	$ 743,959	$ 743,959	$ 167,391
Lynn Regional WF	Lynn WWTF	not liquid	1,415	not liquid	$ 225.00	$ 318,271	Exception - not directly or indirectly impacted in this scenario	
Manchester By the Sea WWTP	Cranston WPCF Incinerator	111,964	467	$ 0.16	liquid	$ 17,914	$ 17,914	$ 4,031
Manchester By the Sea WWTP	Upper Blackstone Clean Water	129,822	541	$ 0.16	liquid	$ 20,771	$ 20,771	$ 4,674
Mansfield WWTP (MFN)	Synagro in Woonsocket, RI incinerator	4,759,417	19,847	$ 0.11	liquid	$ 541,356	$ 541,356	$ 121,805
Mansfield WWTP (MFN)	Lowell Regional WW Utility	85,106	355	$ 0.11	liquid	$ 9,680	$ 9,680	$ 2,178
Marlborough East WWTP	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	5,598	not liquid	$ 163.75	$ 916,704	$ 916,704	$ 206,258
Marlborough West WWTP	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	3,345	not liquid	$ 156.00	$ 521,814	$ 521,814	$ 117,408
Marshfield WWTF	Cranston WPCF Incinerator	536,735	2,238	$ 0.17	liquid	$ 88,659	$ 88,659	$ 19,948
Marshfield WWTF	Upper Blackstone Clean Water	656,197	2,736	$ 0.17	liquid	$ 108,392	$ 108,392	$ 24,388
MCI Bridgewater	New Bedford WWTP	379,521	1,583	$ 0.19	liquid	$ 70,591	$ 70,591	$ 15,883
MCI Concord		1,216,199	5,072	$ 0.05	liquid	$ 58,515	$ 58,515	$ 13,166

Table H-1D: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (22.5%)**
MCI Norfolk	New Bedford WWTP	366,013	1,526	$ 0.13	liquid	$ 48,497	$ 48,497	$ 10,912
Medfield WWTP	Cranston WPCF Incinerator	2,415,888	10,074	$ 0.13	liquid	$ 306,201	$ 306,201	$ 68,895
Middleborough WWTP	Middleborough MSW Landfill	not liquid	2,195	not liquid	$ 156.00	$ 342,407	$ 342,407	$ 77,042
Milford WWTP	Synagro in Woonsocket, RI incinerator	4,777,199	19,921	$ 0.16	liquid	$ 764,352	$ 764,352	$ 171,979
Montague WPCF	Veolia Naugatuck, CT	not liquid	972	not liquid	$ 178.65	$ 173,623	$ 173,623	$ 39,065
Montague WPCF	Synagro Waterbury CT incinerator	not liquid	24	not liquid	$ 178.65	$ 4,245	$ 4,245	$ 955
Montague WPCF	Synagro in Woonsocket, RI incinerator	not liquid	124	not liquid	$ 178.65	$ 22,176	$ 22,176	$ 4,990
MWRA Clinton WWTP	Town of Clinton Recycling Center	not liquid	1,464	not liquid	$ 156.00	$ 228,350	$ 228,350	$ 51,379
Nantucket Sewer Dept. - Siasconset		-	-	$ 0.16	liquid	$ -	$ -	$ -
Nantucket Sewer Dept. - Surfside		not liquid	-	not liquid	$ 156.00	$ -	$ -	$ -
New Bedford WWTP	Synagro in Woonsocket, RI incinerator	26,053,293	108,642	$ 0.19	liquid	$ 4,942,657	$ 4,942,657	$ 1,112,098
North Attleborough WPCF	Synagro in Woonsocket, RI incinerator	3,603,805	15,028	$ 0.11	liquid	$ 407,230	$ 407,230	$ 91,627
North Attleborough WPCF	Lowell Regional WW Utility	585,784	2,443	$ 0.11	liquid	$ 66,194	$ 66,194	$ 14,894
North Brookfield WWTP	Synagro Waterbury CT incinerator	not liquid	985	not liquid	$ 203.01	$ 199,951	$ 199,951	$ 44,989
Northampton WWTF	Synagro Waterbury CT incinerator	not liquid	4,506	not liquid	$ 157.00	$ 707,394	$ 707,394	$ 159,164
Northbridge WWTF	Cranston WPCF Incinerator	2,759,820	11,508	$ 0.06	liquid	$ 167,132	$ 167,132	$ 37,605
Northfield WPCF	Lowell Regional WW Utility	145,531	607	$ 0.25	liquid	$ 36,048	$ 36,048	$ 8,111
Oak Bluffs WWTP		400,000	1,668	$ 0.30	liquid	$ 119,000	$ 119,000	$ 26,775
Old Deerfield - Historic WWTP	Lowell Regional WW Utility	202,009	842	$ 0.25	liquid	$ 51,452	$ 51,452	$ 11,577
Orange WWTP	Lowell Regional WW Utility	313,571	1,308	$ 0.22	liquid	$ 67,582	$ 67,582	$ 15,206
Orange WWTP	Montague WPCF	107,211	447	$ 0.22	liquid	$ 23,106	$ 23,106	$ 5,199
Otis DPW		-	-	$ 0.16	liquid	$ -	$ -	$ -
Oxford-Rochdale SD WPCP	Synagro in Woonsocket, RI incinerator	671,325	2,799	$ 0.08	liquid	$ 54,122	$ 54,122	$ 12,178
Palmer WWTF	MDC Hartford Connecticut Incinerator	not liquid	2,921	not liquid	$ 160.07	$ 467,584	$ 467,584	$ 105,206
Pepperell WWTF		not liquid	1,047	not liquid	$ 156.00	$ 163,332	$ 163,332	$ 36,750
Pittsfield WWTP	Casella composting Grasslands NY	not liquid	6,022	not liquid	$ 161.00	$ 969,536	$ 969,536	$ 218,146
Plymouth WWTF	Cranston WPCF Incinerator	6,344,891	26,458	$ 0.16	liquid	$ 1,015,183	$ 1,015,183	$ 228,416
Provincetown Public Works	Cranston WPCF Incinerator	888,700	3,706	$ 0.17	liquid	$ 147,042	$ 147,042	$ 33,084
Rockland WWTP	Synagro in Woonsocket, RI incinerator	not liquid	1,315	not liquid	$ 190.00	$ 249,877	$ 249,877	$ 56,222
Royalston WWTF		-	-	$ 0.16	liquid	$ -	$ -	$ -
Russell Village WWTF	Westfield WPCP	70,519	294	$ 0.21	liquid	$ 15,000	$ 15,000	$ 3,375
Salisbury WWTF		-	-	$ 0.16	liquid	$ -	$ -	$ -
Scituate WWTF	Middleborough MSW Landfill	not liquid	1,895	not liquid	$ 172.00	$ 325,917	$ 325,917	$ 73,331
Somerset WWTF	Synagro in Woonsocket, RI incinerator	2,050,609	8,551	$ 0.14	liquid	$ 288,245	$ 288,245	$ 64,855
South Deerfield	Lowell Regional WW Utility	1,303,836	5,437	$ 0.18	liquid	$ 238,870	$ 238,870	$ 53,746
South Hadley WWTP	Synagro Waterbury CT incinerator	not liquid	4,217	not liquid	$ 143.00	$ 603,037	$ 603,037	$ 135,683
Spencer WWTP	Synagro in Woonsocket, RI incinerator	1,147,537	4,785	$ 0.14	liquid	$ 160,511	$ 160,511	$ 36,115
Springfield WWTP - Bondi's Island	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	4,344	not liquid	$ 142.57	$ 619,278	$ 619,278	$ 139,337

Table H-1D: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (22.5%)**
Springfield WWTP - Bondi's Island	Bethleham MSW Landfill NH	not liquid	1,479	not liquid	$ 142.57	$ 210,905	$ 210,905	$ 47,454
Springfield WWTP - Bondi's Island	Ontario County MSW LF NY	not liquid	3,598	not liquid	$ 142.57	$ 512,949	$ 512,949	$ 115,414
Springfield WWTP - Bondi's Island	Casella composting Grasslands NY	not liquid	17,547	not liquid	$ 142.57	$ 2,501,648	$ 2,501,648	$ 562,871
Springfield WWTP - Bondi's Island	Synagro in Woonsocket, RI incinerator	not liquid	2,545	not liquid	$ 142.57	$ 362,803	$ 362,803	$ 81,631
Springfield WWTP - Bondi's Island	Synagro Waterbury CT incinerator	not liquid	1,627	not liquid	$ 142.57	$ 231,937	$ 231,937	$ 52,186
Springfield WWTP - Bondi's Island	Chemung MSW Landfill NY	not liquid	6,397	not liquid	$ 142.57	$ 911,974	$ 911,974	$ 205,194
Stockbridge WWTP	Cranston WPCF Incinerator	282,280	1,177	$ 0.09	liquid	$ 25,405	$ 25,405	$ 5,716
Sturbridge WPCF	Cranston WPCF Incinerator	1,815,155	7,569	$ 0.13	liquid	$ 241,597	$ 241,597	$ 54,359
Sunderland WWTP	Lowell Regional WW Utility	56,463	235	$ 0.24	liquid	$ 13,345	$ 13,345	$ 3,003
Sunderland WWTP	Montague WPCF	282,739	1,179	$ 0.24	liquid	$ 66,825	$ 66,825	$ 15,036
Taunton WWTP	Veolia Naugatuck, CT	not liquid	7,430	not liquid	$ 133.25	$ 990,051	$ 990,051	$ 222,761
Tisbury Public Works		-	-	$ 0.16	liquid	$ -	$ -	$ -
Upton WWTP	Cranston WPCF Incinerator	324,000	1,351	$ 0.08	liquid	$ 24,927	$ 24,927	$ 5,609
Uxbridge WWTF	Cranston WPCF Incinerator	2,997,369	12,499	$ 0.16	liquid	$ 479,579	$ 479,579	$ 107,905
Ware WWTP	Cranston WPCF Incinerator	2,713,568	11,316	$ 0.08	liquid	$ 230,596	$ 230,596	$ 51,884
Wareham WPCF		-	-	$ 0.16	liquid	$ -	$ -	$ -
Warren WWTP	Cranston WPCF Incinerator	314,568	1,312	$ 0.12	liquid	$ 37,479	$ 37,479	$ 8,433
Wayland WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Webster WWTF	Synagro in Woonsocket, RI incinerator	3,185,671	13,284	$ 0.11	liquid	$ 342,460	$ 342,460	$ 77,053
West Stockbridge	Cranston WPCF Incinerator	103,002	430	$ 0.17	liquid	$ 17,407	$ 17,407	$ 3,917
Westborough WWTF	Cranston WPCF Incinerator	204,866	854	$ 0.16	liquid	$ 32,779	$ 32,779	$ 7,375
Westborough WWTF	Upper Blackstone Clean Water	12,026,379	50,150	$ 0.16	liquid	$ 1,924,221	$ 1,924,221	$ 432,950
Westfield WPCP	Veolia Naugatuck, CT	not liquid	5,151	not liquid	$ 135.00	$ 695,421	$ 695,421	$ 156,470
Winchendon WPCF	Cranston WPCF Incinerator	1,282,214	5,347	$ 0.07	liquid	$ 87,581	$ 87,581	$ 19,706
							Total	**$ 10,374,000**

Table H-2A: Plants Directly Impacted in Scenario 2			
Regional/national land application restrictions with regional impact			
Plant	**DEP "region"**	**Permitted or design flow (MGD)**	**Notes**
Acton Wastewater Collection	Central	0.30	
Amesbury WWTP	Northeast	2.40	
Billerica WWTP	Northeast	5.55	
Chatham WPCF	Southeast	1.50	
Concord WWTF	Northeast	1.20	Some sludge streams indirectly impacted
Gloucester WPCF	Northeast	5.15	
Greater Lawrence Sanitary District	Northeast	52.00	
Hoosac WQD	West	6.50	
Ipswich WWTP	Northeast	1.80	
Lowell Regional WW Utility	Northeast	32.00	Some sludge streams indirectly impacted
Maynard WWTP	Central	1.45	Some sludge streams indirectly impacted
Merrimac WWTP	Northeast	0.45	
Monroe WWTP	West	0.02	
MWRA Deer Island WWTP	Northeast	361.00	
Newburyport WWTP	Northeast	3.40	
Rockport WWTP	Northeast	0.80	
South Essex Sewerage District	Northeast	29.70	Some sludge streams indirectly impacted
	Total # of Plants	17	

Calculation approach
Total Annual Solids Handling Costs were estimated
For facilities hauling liquid, Column A was multipled by Column C to get Column E (eg, for Acton, 236,361 gal/yr * $0.11/gal = $25,031/yr). Numbers will not be exact due to rounding errors.
For facilities hauling cake, Column B was multipled by Column D to get Column E (eg, for Amesbury, 2,120 wt/yr * $156/wt = $330,739/yr)
This provided the total annual solids handling costs for each facility BEFORE price increases
To determine the proportion of those annual costs that would be subject to DIRECT price impacts, the annual cost was multipled by the % of biosolids land applied in Connecticut, New Hampshire, or Vermont, out of the entirety of biosolids land applied
For example, for Acton, they pay $25,031 per year to haul their liquid sludge to GLSD, which then land applies it. Since 23% of what GLSD land applies is applied in Connecticut, New Hampshire, or Vermont, 23% of Acton's hauling costs would be subject to DIRECT price increases due to land app bans in those states (CT, NH, or VT).
To calculate the portion of hauling costs that are subject to direct price increases, Column E was multiplied by Column F to get Column G (eg, for Acton, $25,031 * 23% = $5,807)
The remainder of their annual costs are subject to INDIRECT price increases - here, Column E minus Column G equals Column H. (eg, for Action, $25,031 - $5,807 = $19,224)
Next, to determine the INCREASE in annual sludge handling costs, the proportion of annual sludge handling costs that would be directly impacted are multiplied by the percent increase associated with direct impacts for this Scenario.
According to Table 5-1, since Scenario 2 affects between 10,000 and 15,000 dt/yr, the DIRECT price increase percentage is 30%.
Column G was multiplied by 30% to get the direct price increase shown in Column I (eg for Acton, $5,807 * 30% = $1,742)
Indirect price increases are 15% (see Table 5-1) - Column H was multiplied by 15% to get the indirect price increase shown in Column J (eg, for Acton, $19,224 * 15% = $2,884)

For four plants (Concord, Lowell, Maynard, and South Essex), some of their sludge goes to a plant which land applies in CT, NH, or VT, and some goes elsewhere and would not be directly affected by a land app ban in CT, NH, or VT. For example, Concord sends sludge BOTH to GLSD (which would be DIRECTLY impacted), and to a landfill in VT (which would be INDIRECTLY impacted). For this portion that is indirectly impacted, this is noted in Column F by indicating the % Sludge Land Applied in CT, NH, or VT as 0%.
For clarity, these plants which have biosolids that are directly impacted and biosolids or sludge that is indirectly impacted are included in this table.
For clarity of calculations, results for individual plants or sludge loads are not rounded. When values are totaled for Column I and Column J (total direct impacts and total indirect impacts), these totals are rounded.

Table H-2B: Direct and Indirect Cost Increases for Facilities Sending Biosolids to Land Application in CT, NH, or VT

		A	B	C	D	E	F	G	H	I	J
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**% Biosolids Land Applied in CT, NH, or VT**	**Direct Impacts - Base Cost**	**Indirect Impacts - Base Cost**	**Direct Impacts - Increased Cost (30%)**	**Indirect Impacts - Increased Cost (15%)**
Acton Wastewater Collection	Greater Lawrence Sanitary District	236,361	986	$ 0.11	liquid	$ 25,031	23%	$ 5,807	$ 19,224	$ 1,742	$ 2,884
Amesbury WWTP	Agresource/Ipswich Compost Facility	not liquid	2,120	not liquid	$ 156.00	$ 330,739	5%	$ 16,459	$ 314,279	$ 4,938	$ 47,142
Billerica WWTP	Hawk Ridge Compost Facility	not liquid	7,003	not liquid	$ 146.70	$ 1,027,369	35%	$ 359,046	$ 668,323	$ 107,714	$ 100,248
Chatham WPCF	Hawk Ridge Compost Facility	not liquid	271	not liquid	$ 156.00	$ 42,336	35%	$ 14,796	$ 27,540	$ 4,439	$ 4,131
Concord WWTF	Greater Lawrence Sanitary District	978,417	4,080	$ 0.06	liquid	$ 59,058	23%	$ 13,701	$ 45,357	$ 4,110	$ 6,804
Concord WWTF	New England Waste Services of VT Landfill (Waste USA Landfill)	31,175	130	$ 0.06	liquid	$ 1,882	0%	$ -	$ 1,882	$ -	$ 282.26
Gloucester WPCF	Hawk Ridge Compost Facility	not liquid	2,604	not liquid	$ 156.00	$ 406,256	35%	$ 141,979	$ 264,277	$ 42,594	$ 39,642
Greater Lawrence Sanitary District	Greater Lawrence Sanitary District	not liquid	6,480	not liquid	$ 366.90	$ 2,377,408	23%	$ 551,535	$ 1,825,872	$ 165,461	$ 273,881
Hoosac WQD	Hoosac WQD	not liquid	465	not liquid	$ 195.15	$ 90,705	5%	$ 90,705	$ -	$ 27,212	$ -
Ipswich WWTP	Agresource/Ipswich Compost Facility	not liquid	2,364	not liquid	$ 156.00	$ 368,759	5%	$ 18,352	$ 350,408	$ 5,505	$ 52,561
Lowell Regional WW Utility	Hawk Ridge Compost Facility	not liquid	11,211	not liquid	$ 190.37	$ 2,134,202	35%	$ 745,864	$ 1,388,339	$ 223,759	$ 208,251
Lowell Regional WW Utility	Bethleham MSW Landfill NH	not liquid	7,648	not liquid	$ 190.37	$ 1,456,002	0%	$ -	$ 1,456,002	$ -	$ 218,400.29
Lowell Regional WW Utility	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	2,448	not liquid	$ 190.37	$ 466,073	0%	$ -	$ 466,073	$ -	$ 69,910.90
Lowell Regional WW Utility	Synagro in Woonsocket, RI incinerator	not liquid	64	not liquid	$ 190.37	$ 12,165	0%	$ -	$ 12,165	$ -	$ 1,824.75
Lowell Regional WW Utility	Envirem Organics (NB)	not liquid	5,751	not liquid	$ 190.37	$ 1,094,853	0%	$ -	$ 1,094,853	$ -	$ 164,227.89
Maynard WWTP	Greater Lawrence Sanitary District	2,798,422	11,669	$ 1.00	liquid	$ 2,798,422	23%	$ 649,207	$ 2,149,216	$ 194,762	$ 322,382
Maynard WWTP	Cranston WPCF Incinerator	35,246	147	$ 1.00	liquid	$ 35,246	0%	$ -	$ 35,246	$ -	$ 5,286.86
Merrimac WWTP	Agresource/Ipswich Compost Facility	678,068	2,828	$ 0.16	liquid	$ 108,491	5%	$ 5,399	$ 103,092	$ 1,620	$ 15,464
Monroe WWTP	Hoosac WQD	488,109	2,035	$ 0.16	liquid	$ 78,098	5%	$ 3,905	$ 74,193	$ 1,171	$ 11,129
MWRA Deer Island WWTP	Massachusetts Water Resources Authority thermal drying facility	not liquid	35,373	not liquid	$ 156.00	$ 5,518,161	18%	$ 993,269	$ 4,524,892	$ 297,981	$ 678,734
Newburyport WWTP	Agresource/Ipswich Compost Facility	not liquid	2,729	not liquid	$ 156.00	$ 425,666	5%	$ 21,184	$ 404,483	$ 6,355	$ 60,672
Rockport WWTP	Agresource/Ipswich Compost Facility	not liquid	473	not liquid	$ 156.00	$ 73,840	5%	$ 3,675	$ 70,165	$ 1,102	$ 10,525
South Essex Sewerage District	Hawk Ridge Compost Facility	not liquid	19,646	not liquid	$ 135.08	$ 2,653,817	35%	$ 927,460	$ 1,726,358	$ 278,238	$ 258,954
South Essex Sewerage District	Bethleham MSW Landfill NH	not liquid	1,389	not liquid	$ 135.08	$ 187,687	0%	$ -	$ 187,687	$ -	$ 28,153.09

Table H-2B: Direct and Indirect Cost Increases for Facilities Sending Biosolids to Land Application in CT, NH, or VT

		A	B	C	D	E	F	G	H	I	J
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**% Biosolids Land Applied in CT, NH, or VT**	**Direct Impacts - Base Cost**	**Indirect Impacts - Base Cost**	**Direct Impacts - Increased Cost (30%)**	**Indirect Impacts - Increased Cost (15%)**
South Essex Sewerage District	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	5,020	not liquid	$ 135.08	$ 678,091	0%	$ -	$ 678,091	$ -	$ 101,713.61
South Essex Sewerage District	Synagro in Woonsocket, RI incinerator	not liquid	5,680	not liquid	$ 135.08	$ 767,319	0%	$ -	$ 767,319	$ -	$ 115,097.86
South Essex Sewerage District	Synagro Waterbury CT incinerator	not liquid	2,538	not liquid	$ 135.08	$ 342,788	0%	$ -	$ 342,788	$ -	$ 51,418.15
									Total	**$ 1,369,000**	**$ 2,850,000**

Calculation approach
Total Annual Solids Handling Costs were estimated
For facilities hauling liquid, Column A was multipled by Column C to get Column E (eg, for Amherst, 3,448,975 gal/yr * $0.19/gal = $661,600/yr). Numbers will not be exact due to rounding errors.
For facilities hauling cake, Column B was multipled by Column D to get Column E (eg, for Adams, 983 wt/yr * $170/wt = $167,193/yr)
This provided the total annual solids handling costs for each facility BEFORE price increases
The entirety of these annual costs would be subjected to indirect price increase, therefore Column F is identical to Column E
Next, to determine the INCREASE in annual sludge handling costs, the annual solids handling costs that would be indirectly impacted are multiplied by the percent increase associated with indirect impacts for this Scenario.
According to Table 5-1, since Scenario 2 affects between 10,000 and 15,000 dt/yr, INDIRECT price increase percentage is 15%.
Multiply Column F by 15% to get the indirect price increase, shown in Column G (eg, for Adams, $167,193 * 15% = $25,079)
Lynn has some sludge that is INDIRECTLY impacted, and some sludge that is incinerated on-site (and is thus unaffected by direct or indirect impacts).
Note: data on annual solids handling costs were not available for all plants; these were deemed negligible and not considered.
For clarity of calculations, results for individual plants or sludge loads are not rounded. When values are totaled for Column G (total indirect impacts), this total is rounded.

Table H-2C: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (15%)**
Adams WWTP	Synagro Waterbury CT incinerator	not liquid	983	not liquid	$ 170.00	$ 167,193	$ 167,193	$ 25,079
Amherst WWTP	MDC Hartford Connecticut Incinerator	3,448,975	14,382	$ 0.19	liquid	$ 661,600	$ 661,600	$ 99,240
Ashfield	Lowell Regional WW Utility	20,869	87	$ 0.24	liquid	$ 5,044	$ 5,044	$ 757
Athol WWTP	Cranston WPCF Incinerator	303,029	1,264	$ 0.26	liquid	$ 78,636	$ 78,636	$ 11,795
Athol WWTP	Upper Blackstone Clean Water	1,804,657	7,525	$ 0.26	liquid	$ 468,308	$ 468,308	$ 70,246
Attleboro WWTP	Attleboro Monofill	not liquid	9,521	not liquid	$ 156.00	$ 1,485,246	$ 1,485,246	$ 222,787
Ayer WWTP	Cranston WPCF Incinerator	1,964,446	8,192	$ 0.14	liquid	$ 267,496	$ 267,496	$ 40,124
Barnstable WWTP WPCD - DPW	Cranston WPCF Incinerator	4,731,738	19,731	$ 0.18	liquid	$ 859,073	$ 859,073	$ 128,861
Barnstable WWTP WPCD - DPW	Upper Blackstone Clean Water	248,482	1,036	$ 0.18	liquid	$ 45,113	$ 45,113	$ 6,767
Barre WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Belchertown WWTP	Cranston WPCF Incinerator	570,594	2,379	$ 0.17	liquid	$ 94,252	$ 94,252	$ 14,138
Brockton WWTP	Veolia Naugatuck, CT	not liquid	17,335	not liquid	$ 148.52	$ 2,574,569	$ 2,574,569	$ 386,185
Charlemont Sewer District		-	-	$ 0.16	liquid	$ -	$ -	$ -
Charles River PCD	Cranston WPCF Incinerator	532,573	2,221	$ 0.15	liquid	$ 78,237	$ 78,237	$ 11,735
Charles River PCD	Upper Blackstone Clean Water	6,247,045	26,050	$ 0.15	liquid	$ 917,709	$ 917,709	$ 137,656
Charlton WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Chicopee WWTP	Synagro Waterbury CT incinerator	not liquid	412	not liquid	$ 140.17	$ 57,796	$ 57,796	$ 8,669
Chicopee WWTP	Cranston WPCF Incinerator	not liquid	366	not liquid	$ 140.17	$ 51,363	$ 51,363	$ 7,705
Chicopee WWTP	Casella composting Grasslands NY	not liquid	3,443	not liquid	$ 140.17	$ 482,629	$ 482,629	$ 72,394
Cohasset WWTF	Cranston WPCF Incinerator	524,258	2,186	$ 0.16	liquid	$ 83,881	$ 83,881	$ 12,582
Devens WWTP	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	3,844	not liquid	$ 170.00	$ 653,421	$ 653,421	$ 98,013
Douglas WWTP	Upper Blackstone Clean Water	1,236,248	5,155	$ 0.10	liquid	$ 125,000	$ 125,000	$ 18,750
Easthampton WWTP	Synagro Waterbury CT incinerator	not liquid	2,539	not liquid	$ 118.17	$ 300,000	$ 300,000	$ 45,000
Edgartown WWTP	Synagro in Woonsocket, RI incinerator	not liquid	1,011	not liquid	$ 119.00	$ 120,271	$ 120,271	$ 18,041
Erving POTW #1	Lowell Regional WW Utility	192,970	805	$ 0.20	liquid	$ 38,451	$ 38,451	$ 5,768
Erving POTW #3	Erving POTW #1	4,958	21	$ 0.16	liquid	$ 793	$ 793	$ 119

Table H-2C: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (15%)**
Fairhaven WPCF	Synagro in Woonsocket, RI incinerator	4,650,730	19,394	$ 0.09	liquid	$ 410,178	$ 410,178	$ 61,527
Fall River Regional WWF	Cranston WPCF Incinerator	33,968,066	141,647	$ 0.05	liquid	$ 1,863,588	$ 1,863,588	$ 279,538
Falmouth WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Fitchburg East WWTP	Resource Control, Inc. – RCI Fitchburg Landfill	not liquid	8,748	not liquid	$ 37.59	$ 328,849	$ 328,849	$ 49,327
Gardner WPCF	City of Gardner West St. Sludge Landfill	not liquid	3,276	not liquid	$ 2.72	$ 8,925	$ 8,925	$ 1,339
Grafton WWTP	Upper Blackstone Clean Water	2,769,789	11,550	$ 0.11	liquid	$ 301,245	$ 301,245	$ 45,187
Great Barrington WWTP	Synagro Waterbury CT incinerator	not liquid	937	not liquid	$ 151.00	$ 141,446	$ 141,446	$ 21,217
Greenfield WPCF	Lowell Regional WW Utility	3,138,258	13,087	$ 0.23	liquid	$ 730,183	$ 730,183	$ 109,527
Hadley WWTP	Lowell Regional WW Utility	1,039,319	4,334	$ 0.23	liquid	$ 243,928	$ 243,928	$ 36,589
Hardwick-Gilbertville WPCF	Cranston WPCF Incinerator	238,609	995	$ 0.11	liquid	$ 25,800	$ 25,800	$ 3,870
Hardwick-Wheelwright WPCF	Cranston WPCF Incinerator	148,681	620	$ 0.08	liquid	$ 12,000	$ 12,000	$ 1,800
Hatfield WWTP	Lowell Regional WW Utility	328,759	1,371	$ 0.24	liquid	$ 78,398	$ 78,398	$ 11,760
Haverhill WWTP	Crossroads Landfill in Maine	not liquid	14,583	not liquid	$ 175.00	$ 2,552,052	$ 2,552,052	$ 382,808
Holyoke WWTP	Veolia Naugatuck, CT	not liquid	428	not liquid	$ 140.00	$ 59,920	$ 59,920	$ 8,988
Holyoke WWTP	Cranston WPCF Incinerator	not liquid	312	not liquid	$ 140.00	$ 43,680	$ 43,680	$ 6,552
Holyoke WWTP	Ontario County MSW LF NY	not liquid	3,639	not liquid	$ 140.00	$ 509,390	$ 509,390	$ 76,409
Holyoke WWTP	Casella composting Grasslands NY	not liquid	5,229	not liquid	$ 140.00	$ 732,060	$ 732,060	$ 109,809
Hopedale WWTF	Synagro in Woonsocket, RI incinerator	1,223,998	5,104	$ 0.09	liquid	$ 110,000	$ 110,000	$ 16,500
Hudson WWTF	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	2,133	not liquid	$ 156.00	$ 332,773	$ 332,773	$ 49,916
Hull WWTF	Cranston WPCF Incinerator	1,211,484	5,052	$ 0.16	liquid	$ 193,837	$ 193,837	$ 29,076
Huntington WWTP	Westfield WPCP	72,000	300	$ 0.34	liquid	$ 24,480	$ 24,480	$ 3,672
Kingston Sewer Commission	Cranston WPCF Incinerator	937,999	3,911	$ 0.16	liquid	$ 150,010	$ 150,010	$ 22,501
Lee WWTP	Cranston WPCF Incinerator	1,153,383	4,810	$ 0.19	liquid	$ 224,000	$ 224,000	$ 33,600
Leicester WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Lenox Center WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Leominster WPCF	Upper Blackstone Clean Water	6,370,102	26,563	$ 0.06	liquid	$ 379,114	$ 379,114	$ 56,867
Lynn Regional WF	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	3,306	not liquid	$ 225.00	$ 743,959	$ 743,959	$ 111,594
Lynn Regional WF	Lynn WWTF	not liquid	1,415	not liquid	$ 225.00	$ 318,271	Exception - not directly or indirectly impacted in this scenario	
Manchester By the Sea WWTP	Cranston WPCF Incinerator	111,964	467	$ 0.16	liquid	$ 17,914	$ 17,914	$ 2,687
Manchester By the Sea WWTP	Upper Blackstone Clean Water	129,822	541	$ 0.16	liquid	$ 20,771	$ 20,771	$ 3,116
Mansfield WWTP (MFN)	Synagro in Woonsocket, RI incinerator	4,759,417	19,847	$ 0.11	liquid	$ 541,356	$ 541,356	$ 81,203
Mansfield WWTP (MFN)	Lowell Regional WW Utility	85,106	355	$ 0.11	liquid	$ 9,680	$ 9,680	$ 1,452
Marlborough East WWTP	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	5,598	not liquid	$ 163.75	$ 916,704	$ 916,704	$ 137,506
Marlborough West WWTP	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	3,345	not liquid	$ 156.00	$ 521,814	$ 521,814	$ 78,272
Marshfield WWTF	Cranston WPCF Incinerator	536,735	2,238	$ 0.17	liquid	$ 88,659	$ 88,659	$ 13,299
Marshfield WWTF	Upper Blackstone Clean Water	656,197	2,736	$ 0.17	liquid	$ 108,392	$ 108,392	$ 16,259
MCI Bridgewater	New Bedford WWTP	379,521	1,583	$ 0.19	liquid	$ 70,591	$ 70,591	$ 10,589

Table H-2C: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (15%)**
MCI Concord		1,216,199	5,072	$ 0.05	liquid	$ 58,515	$ 58,515	$ 8,777
MCI Norfolk	New Bedford WWTP	366,013	1,526	$ 0.13	liquid	$ 48,497	$ 48,497	$ 7,275
Medfield WWTP	Cranston WPCF Incinerator	2,415,888	10,074	$ 0.13	liquid	$ 306,201	$ 306,201	$ 45,930
Middleborough WWTP	Middleborough MSW Landfill	not liquid	2,195	not liquid	$ 156.00	$ 342,407	$ 342,407	$ 51,361
Milford WWTP	Synagro in Woonsocket, RI incinerator	4,777,199	19,921	$ 0.16	liquid	$ 764,352	$ 764,352	$ 114,653
Montague WPCF	Veolia Naugatuck, CT	not liquid	972	not liquid	$ 178.65	$ 173,623	$ 173,623	$ 26,043
Montague WPCF	Synagro Waterbury CT incinerator	not liquid	24	not liquid	$ 178.65	$ 4,245	$ 4,245	$ 637
Montague WPCF	Synagro in Woonsocket, RI incinerator	not liquid	124	not liquid	$ 178.65	$ 22,176	$ 22,176	$ 3,326
MWRA Clinton WWTP	Town of Clinton Recycling Center	not liquid	1,464	not liquid	$ 156.00	$ 228,350	$ 228,350	$ 34,252
Nantucket Sewer Dept. - Siasconset		-	-	$ 0.16	liquid	$ -	$ -	$ -
Nantucket Sewer Dept. - Surfside		not liquid	-	not liquid	$ 156.00	$ -	$ -	$ -
New Bedford WWTP	Synagro in Woonsocket, RI incinerator	26,053,293	108,642	$ 0.19	liquid	$ 4,942,657	$ 4,942,657	$ 741,398
North Attleborough WPCF	Synagro in Woonsocket, RI incinerator	3,603,805	15,028	$ 0.11	liquid	$ 407,230	$ 407,230	$ 61,084
North Attleborough WPCF	Lowell Regional WW Utility	585,784	2,443	$ 0.11	liquid	$ 66,194	$ 66,194	$ 9,929
North Brookfield WWTP	Synagro Waterbury CT incinerator	not liquid	985	not liquid	$ 203.01	$ 199,951	$ 199,951	$ 29,993
Northampton WWTF	Synagro Waterbury CT incinerator	not liquid	4,506	not liquid	$ 157.00	$ 707,394	$ 707,394	$ 106,109
Northbridge WWTF	Cranston WPCF Incinerator	2,759,820	11,508	$ 0.06	liquid	$ 167,132	$ 167,132	$ 25,070
Northfield WPCF	Lowell Regional WW Utility	145,531	607	$ 0.25	liquid	$ 36,048	$ 36,048	$ 5,407
Oak Bluffs WWTP		400,000	1,668	$ 0.30	liquid	$ 119,000	$ 119,000	$ 17,850
Old Deerfield - Historic WWTP	Lowell Regional WW Utility	202,009	842	$ 0.25	liquid	$ 51,452	$ 51,452	$ 7,718
Orange WWTP	Lowell Regional WW Utility	313,571	1,308	$ 0.22	liquid	$ 67,582	$ 67,582	$ 10,137
Orange WWTP	Montague WPCF	107,211	447	$ 0.22	liquid	$ 23,106	$ 23,106	$ 3,466
Otis DPW		-	-	$ 0.16	liquid	$ -	$ -	$ -
Oxford-Rochdale SD WPCP	Synagro in Woonsocket, RI incinerator	671,325	2,799	$ 0.08	liquid	$ 54,122	$ 54,122	$ 8,118
Palmer WWTF	MDC Hartford Connecticut Incinerator	not liquid	2,921	not liquid	$ 160.07	$ 467,584	$ 467,584	$ 70,138
Pepperell WWTF		not liquid	1,047	not liquid	$ 156.00	$ 163,332	$ 163,332	$ 24,500
Pittsfield WWTP	Casella composting Grasslands NY	not liquid	6,022	not liquid	$ 161.00	$ 969,536	$ 969,536	$ 145,430
Plymouth WWTF	Cranston WPCF Incinerator	6,344,891	26,458	$ 0.16	liquid	$ 1,015,183	$ 1,015,183	$ 152,277
Provincetown Public Works	Cranston WPCF Incinerator	888,700	3,706	$ 0.17	liquid	$ 147,042	$ 147,042	$ 22,056
Rockland WWTP	Synagro in Woonsocket, RI incinerator	not liquid	1,315	not liquid	$ 190.00	$ 249,877	$ 249,877	$ 37,482
Royalston WWTF		-	-	$ 0.16	liquid	$ -	$ -	$ -
Russell Village WWTF	Westfield WPCP	70,519	294	$ 0.21	liquid	$ 15,000	$ 15,000	$ 2,250
Salisbury WWTF		-	-	$ 0.16	liquid	$ -	$ -	$ -
Scituate WWTF	Middleborough MSW Landfill	not liquid	1,895	not liquid	$ 172.00	$ 325,917	$ 325,917	$ 48,887
Somerset WWTF	Synagro in Woonsocket, RI incinerator	2,050,609	8,551	$ 0.14	liquid	$ 288,245	$ 288,245	$ 43,237
South Deerfield	Lowell Regional WW Utility	1,303,836	5,437	$ 0.18	liquid	$ 238,870	$ 238,870	$ 35,830
South Hadley WWTP	Synagro Waterbury CT incinerator	not liquid	4,217	not liquid	$ 143.00	$ 603,037	$ 603,037	$ 90,456
Spencer WWTP	Synagro in Woonsocket, RI incinerator	1,147,537	4,785	$ 0.14	liquid	$ 160,511	$ 160,511	$ 24,077

Table H-2C: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (15%)**
Springfield WWTP - Bondi's Island	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	4,344	not liquid	$ 142.57	$ 619,278	$ 619,278	$ 92,892
Springfield WWTP - Bondi's Island	Bethleham MSW Landfill NH	not liquid	1,479	not liquid	$ 142.57	$ 210,905	$ 210,905	$ 31,636
Springfield WWTP - Bondi's Island	Ontario County MSW LF NY	not liquid	3,598	not liquid	$ 142.57	$ 512,949	$ 512,949	$ 76,942
Springfield WWTP - Bondi's Island	Casella composting Grasslands NY	not liquid	17,547	not liquid	$ 142.57	$ 2,501,648	$ 2,501,648	$ 375,247
Springfield WWTP - Bondi's Island	Synagro in Woonsocket, RI incinerator	not liquid	2,545	not liquid	$ 142.57	$ 362,803	$ 362,803	$ 54,420
Springfield WWTP - Bondi's Island	Synagro Waterbury CT incinerator	not liquid	1,627	not liquid	$ 142.57	$ 231,937	$ 231,937	$ 34,791
Springfield WWTP - Bondi's Island	Chemung MSW Landfill NY	not liquid	6,397	not liquid	$ 142.57	$ 911,974	$ 911,974	$ 136,796
Stockbridge WWTP	Cranston WPCF Incinerator	282,280	1,177	$ 0.09	liquid	$ 25,405	$ 25,405	$ 3,811
Sturbridge WPCF	Cranston WPCF Incinerator	1,815,155	7,569	$ 0.13	liquid	$ 241,597	$ 241,597	$ 36,240
Sunderland WWTP	Lowell Regional WW Utility	56,463	235	$ 0.24	liquid	$ 13,345	$ 13,345	$ 2,002
Sunderland WWTP	Montague WPCF	282,739	1,179	$ 0.24	liquid	$ 66,825	$ 66,825	$ 10,024
Taunton WWTP	Veolia Naugatuck, CT	not liquid	7,430	not liquid	$ 133.25	$ 990,051	$ 990,051	$ 148,508
Tisbury Public Works		-	-	$ 0.16	liquid	$ -	$ -	$ -
Upton WWTP	Cranston WPCF Incinerator	324,000	1,351	$ 0.08	liquid	$ 24,927	$ 24,927	$ 3,739
Uxbridge WWTF	Cranston WPCF Incinerator	2,997,369	12,499	$ 0.16	liquid	$ 479,579	$ 479,579	$ 71,937
Ware WWTP	Cranston WPCF Incinerator	2,713,568	11,316	$ 0.08	liquid	$ 230,596	$ 230,596	$ 34,589
Wareham WPCF		-	-	$ 0.16	liquid	$ -	$ -	$ -
Warren WWTP	Cranston WPCF Incinerator	314,568	1,312	$ 0.12	liquid	$ 37,479	$ 37,479	$ 5,622
Wayland WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Webster WWTF	Synagro in Woonsocket, RI incinerator	3,185,671	13,284	$ 0.11	liquid	$ 342,460	$ 342,460	$ 51,369
West Stockbridge	Cranston WPCF Incinerator	103,002	430	$ 0.17	liquid	$ 17,407	$ 17,407	$ 2,611
Westborough WWTF	Cranston WPCF Incinerator	204,866	854	$ 0.16	liquid	$ 32,779	$ 32,779	$ 4,917
Westborough WWTF	Upper Blackstone Clean Water	12,026,379	50,150	$ 0.16	liquid	$ 1,924,221	$ 1,924,221	$ 288,633
Westfield WPCP	Veolia Naugatuck, CT	not liquid	5,151	not liquid	$ 135.00	$ 695,421	$ 695,421	$ 104,313
Winchendon WPCF	Cranston WPCF Incinerator	1,282,214	5,347	$ 0.07	liquid	$ 87,581	$ 87,581	$ 13,137
							Total	**$ 6,916,000**

Table H-3A: Plant Directly Impacted in Scenario 3		
Landfill restrictions in Massachusetts		
POTW name	**DEP "region"**	**Permitted or design flow (MGD)**
Fitchburg East WWTP	Central	12.40

Calculation approach
Total Annual Solids Handling Costs were estimated
Column B was multipled by Column D to get Column E (8,748 wt/yr * $37.59/wt = $328,849/yr)
This provided the total annual solids handling costs for Fitchburg East BEFORE price increases
To determine the proportion of those annual costs that would be subject to DIRECT price impacts, the annual cost was multipled by the % of sludge that would no longer be accepted at Resource Control Inc's (RCI), landfill, out of the entirety of sludge landfilled
Fitchburg pays $328,849 per year to haul their sludge to Resource Control, Inc's landfill. Since 50% of what Fitchburg sends to RCI is impacted (because RCI is restricting 50% of incoming sludge), 50% of Fitchburg's hauling costs would be subject to DIRECT price increases.
To calculate the dollar value of directly impacted sludge, Column E is multiplied by Column F to get Column G ($328,849 * 50% = $164,424)
The dollar value of indirectly impacted sludge is the result of Column E minus Column G, and shown in Column H ($328,849 - $164,424 = $164,424)
Next, to determine the INCREASE in annual sludge handling costs, the proportion of annual solids handling costs that would be directly impacted, are multiplied by the percent increase associated with direct impacts for this Scenario.
According to Table 5-1, since Scenario 3 affects less than 10,000 dt/yr, the DIRECT price increase percentage is 15%.
Multiply Column G by 15% to get the direct price increase, shown in Column I ($164,424 * 15% = $24,664)
Indirect price increases are 7.5% (see Table 5-1) - Multiply Column H by 7.5% to get the indirect price increase, shown in Column J ($164,424 * 7.5% = $12,332)
For clarity, sludge that is directly impacted and sludge that is indirectly impacted are included in this table.
For clarity of calculations, results for individual sludge loads are not rounded. When values are totaled for Column I and Column J (total direct impacts and total indirect impacts), these totals are rounded.

Table H-3B: Direct and Indirect Cost Increases for Facility Sending Sludge to Resource Control, Inc Landfill

		A	B	C	D	E	F	G	H	I	J
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**% Sludge no Longer Accepted at Resource Control Inc's Landfill**	**Direct Impacts - Base Cost**	**Indirect Impacts - Base Cost**	**Direct Impacts - Increased Cost (15%)**	**Indirect Impacts - Increased Cost (7.5%)**
Fitchburg East WWTP	Resource Control, Inc. – RCI Fitchburg Landfill	not liquid	8,748	not liquid	$ 37.59	$ 328,849	50%	$ 164,424	$ 164,424	$ 24,664	$ 12,332
									Total	**$ 25,000**	**$ 12,000**

Calculation approach
Total Annual Solids Handling Costs were estimated
For facilities hauling liquid, Column A was multipled by Column C to get Column E (eg, for Acton, 236,361 gal/yr * $0.11/gal = $25,031/yr). Numbers will not be exact due to rounding errors.
For facilities hauling cake, Column B was multipled by Column D to get Column E (eg, for Adams, 983 wt/yr * $170/wt = $167,193/yr)
This provided the total annual solids handling costs for each facility BEFORE price increases
The entirety of these annual costs would be subjected to indirect price increases, therefore Column F is identical to Column E
Next, to determine the INCREASE in annual sludge handling costs, the annual solids handling costs that would be indirectly impacted are multiplied by the percent increase associated with indirect impacts for this Scenario.
According to Table 5-1, since Scenario 3 affects less than 10,000 dt/yr, INDIRECT price increase percentage is 7.5%.
Multiply Column F by 7.5% to get the indirect price increase, shown in Column G (eg, for Adams, $167,193 * 7.5% = $12,540)
Lynn has some sludge that is INDIRECTLY impacted, and some sludge that is incinerated on-site (and is thus unaffected by direct or indirect impacts).
Note: data on annual solids handling costs were not available for all plants; these were deemed negligible and not considered.
For clarity of calculations, results for individual plants or sludge loads are not rounded. When values are totaled for Column G (total indirect impacts), this total is rounded.

Table H-3C: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (7.5%)**
Acton Wastewater Collection	Greater Lawrence Sanitary District	236,361	986	$ 0.11	liquid	$ 25,031	$ 25,031	$ 1,877
Adams WWTP	Synagro Waterbury CT incinerator	not liquid	983	not liquid	$ 170.00	$ 167,193	$ 167,193	$ 12,540
Amesbury WWTP	Agresource/Ipswich Compost Facility	not liquid	2,120	not liquid	$ 156.00	$ 330,739	$ 330,739	$ 24,805
Amherst WWTP	MDC Hartford Connecticut Incinerator	3,448,975	14,382	$ 0.19	liquid	$ 661,600	$ 661,600	$ 49,620
Ashfield	Lowell Regional WW Utility	20,869	87	$ 0.24	liquid	$ 5,044	$ 5,044	$ 378
Athol WWTP	Cranston WPCF Incinerator	303,029	1,264	$ 0.26	liquid	$ 78,636	$ 78,636	$ 5,898
Athol WWTP	Upper Blackstone Clean Water	1,804,657	7,525	$ 0.26	liquid	$ 468,308	$ 468,308	$ 35,123
Attleboro WWTP	Attleboro Monofill	not liquid	9,521	not liquid	$ 156.00	$ 1,485,246	$ 1,485,246	$ 111,393
Ayer WWTP	Cranston WPCF Incinerator	1,964,446	8,192	$ 0.14	liquid	$ 267,496	$ 267,496	$ 20,062
Barnstable WWTP WPCD - DPW	Cranston WPCF Incinerator	4,731,738	19,731	$ 0.18	liquid	$ 859,073	$ 859,073	$ 64,431
Barnstable WWTP WPCD - DPW	Upper Blackstone Clean Water	248,482	1,036	$ 0.18	liquid	$ 45,113	$ 45,113	$ 3,384
Barre WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Belchertown WWTP	Cranston WPCF Incinerator	570,594	2,379	$ 0.17	liquid	$ 94,252	$ 94,252	$ 7,069
Billerica WWTP	Hawk Ridge Compost Facility	not liquid	7,003	not liquid	$ 146.70	$ 1,027,369	$ 1,027,369	$ 77,053
Brockton WWTP	Veolia Naugatuck, CT	not liquid	17,335	not liquid	$ 148.52	$ 2,574,569	$ 2,574,569	$ 193,093
Charlemont Sewer District		-	-	$ 0.16	liquid	$ -	$ -	$ -
Charles River PCD	Cranston WPCF Incinerator	532,573	2,221	$ 0.15	liquid	$ 78,237	$ 78,237	$ 5,868
Charles River PCD	Upper Blackstone Clean Water	6,247,045	26,050	$ 0.15	liquid	$ 917,709	$ 917,709	$ 68,828
Charlton WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Chatham WPCF	Hawk Ridge Compost Facility	not liquid	271	not liquid	$ 156.00	$ 42,336	$ 42,336	$ 3,175
Chicopee WWTP	Synagro Waterbury CT incinerator	not liquid	412	not liquid	$ 140.17	$ 57,796	$ 57,796	$ 4,335
Chicopee WWTP	Cranston WPCF Incinerator	not liquid	366	not liquid	$ 140.17	$ 51,363	$ 51,363	$ 3,852
Chicopee WWTP	Casella composting Grasslands NY	not liquid	3,443	not liquid	$ 140.17	$ 482,629	$ 482,629	$ 36,197
Cohasset WWTF	Cranston WPCF Incinerator	524,258	2,186	$ 0.16	liquid	$ 83,881	$ 83,881	$ 6,291
Concord WWTF	New England Waste Services of VT Landfill (Waste USA Landfill)	31,175	130	$ 0.06	liquid	$ 1,882	$ 1,882	$ 141
Concord WWTF	Greater Lawrence Sanitary District	978,417	4,080	$ 0.06	liquid	$ 59,058	$ 59,058	$ 4,429

Table H-3C: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (7.5%)**
Devens WWTP	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	3,844	not liquid	$ 170.00	$ 653,421	$ 653,421	$ 49,007
Douglas WWTP	Upper Blackstone Clean Water	1,236,248	5,155	$ 0.10	liquid	$ 125,000	$ 125,000	$ 9,375
Easthampton WWTP	Synagro Waterbury CT incinerator	not liquid	2,539	not liquid	$ 118.17	$ 300,000	$ 300,000	$ 22,500
Edgartown WWTP	Synagro in Woonsocket, RI incinerator	not liquid	1,011	not liquid	$ 119.00	$ 120,271	$ 120,271	$ 9,020
Erving POTW #1	Lowell Regional WW Utility	192,970	805	$ 0.20	liquid	$ 38,451	$ 38,451	$ 2,884
Erving POTW #3	Erving POTW #1	4,958	21	$ 0.16	liquid	$ 793	$ 793	$ 59
Fairhaven WPCF	Synagro in Woonsocket, RI incinerator	4,650,730	19,394	$ 0.09	liquid	$ 410,178	$ 410,178	$ 30,763
Fall River Regional WWF	Cranston WPCF Incinerator	33,968,066	141,647	$ 0.05	liquid	$ 1,863,588	$ 1,863,588	$ 139,769
Falmouth WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Gardner WPCF	City of Gardner West St. Sludge Landfill	not liquid	3,276	not liquid	$ 2.72	$ 8,925	$ 8,925	$ 669
Gloucester WPCF	Hawk Ridge Compost Facility	not liquid	2,604	not liquid	$ 156.00	$ 406,256	$ 406,256	$ 30,469
Grafton WWTP	Upper Blackstone Clean Water	2,769,789	11,550	$ 0.11	liquid	$ 301,245	$ 301,245	$ 22,593
Great Barrington WWTP	Synagro Waterbury CT incinerator	not liquid	937	not liquid	$ 151.00	$ 141,446	$ 141,446	$ 10,608
Greenfield WPCF	Lowell Regional WW Utility	3,138,258	13,087	$ 0.23	liquid	$ 730,183	$ 730,183	$ 54,764
Hadley WWTP	Lowell Regional WW Utility	1,039,319	4,334	$ 0.23	liquid	$ 243,928	$ 243,928	$ 18,295
Hardwick-Gilbertville WPCF	Cranston WPCF Incinerator	238,609	995	$ 0.11	liquid	$ 25,800	$ 25,800	$ 1,935
Hardwick-Wheelwright WPCF	Cranston WPCF Incinerator	148,681	620	$ 0.08	liquid	$ 12,000	$ 12,000	$ 900
Hatfield WWTP	Lowell Regional WW Utility	328,759	1,371	$ 0.24	liquid	$ 78,398	$ 78,398	$ 5,880
Haverhill WWTP	Crossroads Landfill in Maine	not liquid	14,583	not liquid	$ 175.00	$ 2,552,052	$ 2,552,052	$ 191,404
Holyoke WWTP	Veolia Naugatuck, CT	not liquid	428	not liquid	$ 140.00	$ 59,920	$ 59,920	$ 4,494
Holyoke WWTP	Cranston WPCF Incinerator	not liquid	312	not liquid	$ 140.00	$ 43,680	$ 43,680	$ 3,276
Holyoke WWTP	Ontario County MSW LF NY	not liquid	3,639	not liquid	$ 140.00	$ 509,390	$ 509,390	$ 38,204
Holyoke WWTP	Casella composting Grasslands NY	not liquid	5,229	not liquid	$ 140.00	$ 732,060	$ 732,060	$ 54,905
Hopedale WWTF	Synagro in Woonsocket, RI incinerator	1,223,998	5,104	$ 0.09	liquid	$ 110,000	$ 110,000	$ 8,250
Hudson WWTF	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	2,133	not liquid	$ 156.00	$ 332,773	$ 332,773	$ 24,958
Hull WWTF	Cranston WPCF Incinerator	1,211,484	5,052	$ 0.16	liquid	$ 193,837	$ 193,837	$ 14,538
Huntington WWTP	Westfield WPCP	72,000	300	$ 0.34	liquid	$ 24,480	$ 24,480	$ 1,836
Ipswich WWTP	Agresource/Ipswich Compost Facility	not liquid	2,364	not liquid	$ 156.00	$ 368,759	$ 368,759	$ 27,657
Kingston Sewer Commission	Cranston WPCF Incinerator	937,999	3,911	$ 0.16	liquid	$ 150,010	$ 150,010	$ 11,251
Lee WWTP	Cranston WPCF Incinerator	1,153,383	4,810	$ 0.19	liquid	$ 224,000	$ 224,000	$ 16,800
Leicester WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Lenox Center WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Leominster WPCF	Upper Blackstone Clean Water	6,370,102	26,563	$ 0.06	liquid	$ 379,114	$ 379,114	$ 28,434
Lowell Regional WW Utility	Bethleham MSW Landfill NH	not liquid	7,648	not liquid	$ 190.37	$ 1,456,002	$ 1,456,002	$ 109,200
Lowell Regional WW Utility	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	2,448	not liquid	$ 190.37	$ 466,073	$ 466,073	$ 34,955
Lowell Regional WW Utility	Hawk Ridge Compost Facility	not liquid	11,211	not liquid	$ 190.37	$ 2,134,202	$ 2,134,202	$ 160,065
Lowell Regional WW Utility	Synagro in Woonsocket, RI incinerator	not liquid	64	not liquid	$ 190.37	$ 12,165	$ 12,165	$ 912
Lowell Regional WW Utility	Envirem Organics (NB)	not liquid	5,751	not liquid	$ 190.37	$ 1,094,853	$ 1,094,853	$ 82,114

Table H-3C: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (7.5%)**
Lynn Regional WF	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	3,306	not liquid	$ 225.00	$ 743,959	$ 743,959	$ 55,797
Lynn Regional WF	Lynn WWTF	not liquid	1,415	not liquid	$ 225.00	$ 318,271	Exception - not directly or indirectly impacted in this scenario	
Manchester By the Sea WWTP	Cranston WPCF Incinerator	111,964	467	$ 0.16	liquid	$ 17,914	$ 17,914	$ 1,344
Manchester By the Sea WWTP	Upper Blackstone Clean Water	129,822	541	$ 0.16	liquid	$ 20,771	$ 20,771	$ 1,558
Mansfield WWTP (MFN)	Synagro in Woonsocket, RI incinerator	4,759,417	19,847	$ 0.11	liquid	$ 541,356	$ 541,356	$ 40,602
Mansfield WWTP (MFN)	Lowell Regional WW Utility	85,106	355	$ 0.11	liquid	$ 9,680	$ 9,680	$ 726
Marlborough East WWTP	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	5,598	not liquid	$ 163.75	$ 916,704	$ 916,704	$ 68,753
Marlborough West WWTP	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	3,345	not liquid	$ 156.00	$ 521,814	$ 521,814	$ 39,136
Marshfield WWTF	Cranston WPCF Incinerator	536,735	2,238	$ 0.17	liquid	$ 88,659	$ 88,659	$ 6,649
Marshfield WWTF	Upper Blackstone Clean Water	656,197	2,736	$ 0.17	liquid	$ 108,392	$ 108,392	$ 8,129
Maynard WWTP	Cranston WPCF Incinerator	35,246	147	$ 1.00	liquid	$ 35,246	$ 35,246	$ 2,643
Maynard WWTP	Greater Lawrence Sanitary District	2,798,422	11,669	$ 1.00	liquid	$ 2,798,422	$ 2,798,422	$ 209,882
MCI Bridgewater	New Bedford WWTP	379,521	1,583	$ 0.19	liquid	$ 70,591	$ 70,591	$ 5,294
MCI Concord		1,216,199	5,072	$ 0.05	liquid	$ 58,515	$ 58,515	$ 4,389
MCI Norfolk	New Bedford WWTP	366,013	1,526	$ 0.13	liquid	$ 48,497	$ 48,497	$ 3,637
Medfield WWTP	Cranston WPCF Incinerator	2,415,888	10,074	$ 0.13	liquid	$ 306,201	$ 306,201	$ 22,965
Merrimac WWTP	Agresource/Ipswich Compost Facility	678,068	2,828	$ 0.16	liquid	$ 108,491	$ 108,491	$ 8,137
Middleborough WWTP	Middleborough MSW Landfill	not liquid	2,195	not liquid	$ 156.00	$ 342,407	$ 342,407	$ 25,681
Milford WWTP	Synagro in Woonsocket, RI incinerator	4,777,199	19,921	$ 0.16	liquid	$ 764,352	$ 764,352	$ 57,326
Monroe WWTP	Hoosac WQD	488,109	2,035	$ 0.16	liquid	$ 78,098	$ 78,098	$ 5,857
Montague WPCF	Veolia Naugatuck, CT	not liquid	972	not liquid	$ 178.65	$ 173,623	$ 173,623	$ 13,022
Montague WPCF	Synagro Waterbury CT incinerator	not liquid	24	not liquid	$ 178.65	$ 4,245	$ 4,245	$ 318
Montague WPCF	Synagro in Woonsocket, RI incinerator	not liquid	124	not liquid	$ 178.65	$ 22,176	$ 22,176	$ 1,663
MWRA Clinton WWTP	Town of Clinton Recycling Center	not liquid	1,464	not liquid	$ 156.00	$ 228,350	$ 228,350	$ 17,126
Nantucket Sewer Dept. - Siasconset		-	-	$ 0.16	liquid	$ -	$ -	$ -
Nantucket Sewer Dept. - Surfside		not liquid	-	not liquid	$ 156.00	$ -	$ -	$ -
New Bedford WWTP	Synagro in Woonsocket, RI incinerator	26,053,293	108,642	$ 0.19	liquid	$ 4,942,657	$ 4,942,657	$ 370,699
Newburyport WWTP	Agresource/Ipswich Compost Facility	not liquid	2,729	not liquid	$ 156.00	$ 425,666	$ 425,666	$ 31,925
North Attleborough WPCF	Synagro in Woonsocket, RI incinerator	3,603,805	15,028	$ 0.11	liquid	$ 407,230	$ 407,230	$ 30,542
North Attleborough WPCF	Lowell Regional WW Utility	585,784	2,443	$ 0.11	liquid	$ 66,194	$ 66,194	$ 4,965
North Brookfield WWTP	Synagro Waterbury CT incinerator	not liquid	985	not liquid	$ 203.01	$ 199,951	$ 199,951	$ 14,996
Northampton WWTF	Synagro Waterbury CT incinerator	not liquid	4,506	not liquid	$ 157.00	$ 707,394	$ 707,394	$ 53,055
Northbridge WWTF	Cranston WPCF Incinerator	2,759,820	11,508	$ 0.06	liquid	$ 167,132	$ 167,132	$ 12,535
Northfield WPCF	Lowell Regional WW Utility	145,531	607	$ 0.25	liquid	$ 36,048	$ 36,048	$ 2,704
Oak Bluffs WWTP		400,000	1,668	$ 0.30	liquid	$ 119,000	$ 119,000	$ 8,925
Old Deerfield - Historic WWTP	Lowell Regional WW Utility	202,009	842	$ 0.25	liquid	$ 51,452	$ 51,452	$ 3,859
Orange WWTP	Lowell Regional WW Utility	313,571	1,308	$ 0.22	liquid	$ 67,582	$ 67,582	$ 5,069

Table H-3C: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (7.5%)**
Orange WWTP	Montague WPCF	107,211	447	$ 0.22	liquid	$ 23,106	$ 23,106	$ 1,733
Otis DPW		-	-	$ 0.16	liquid	$ -	$ -	$ -
Oxford-Rochdale SD WPCP	Synagro in Woonsocket, RI incinerator	671,325	2,799	$ 0.08	liquid	$ 54,122	$ 54,122	$ 4,059
Palmer WWTF	MDC Hartford Connecticut Incinerator	not liquid	2,921	not liquid	$ 160.07	$ 467,584	$ 467,584	$ 35,069
Pepperell WWTF		not liquid	1,047	not liquid	$ 156.00	$ 163,332	$ 163,332	$ 12,250
Pittsfield WWTP	Casella composting Grasslands NY	not liquid	6,022	not liquid	$ 161.00	$ 969,536	$ 969,536	$ 72,715
Plymouth WWTF	Cranston WPCF Incinerator	6,344,891	26,458	$ 0.16	liquid	$ 1,015,183	$ 1,015,183	$ 76,139
Provincetown Public Works	Cranston WPCF Incinerator	888,700	3,706	$ 0.17	liquid	$ 147,042	$ 147,042	$ 11,028
Rockland WWTP	Synagro in Woonsocket, RI incinerator	not liquid	1,315	not liquid	$ 190.00	$ 249,877	$ 249,877	$ 18,741
Rockport WWTP	Agresource/Ipswich Compost Facility	not liquid	473	not liquid	$ 156.00	$ 73,840	$ 73,840	$ 5,538
Royalston WWTF		-	-	$ 0.16	liquid	$ -	$ -	$ -
Russell Village WWTF	Westfield WPCP	70,519	294	$ 0.21	liquid	$ 15,000	$ 15,000	$ 1,125
Salisbury WWTF		-	-	$ 0.16	liquid	$ -	$ -	$ -
Scituate WWTF	Middleborough MSW Landfill	not liquid	1,895	not liquid	$ 172.00	$ 325,917	$ 325,917	$ 24,444
Somerset WWTF	Synagro in Woonsocket, RI incinerator	2,050,609	8,551	$ 0.14	liquid	$ 288,245	$ 288,245	$ 21,618
South Deerfield	Lowell Regional WW Utility	1,303,836	5,437	$ 0.18	liquid	$ 238,870	$ 238,870	$ 17,915
South Essex Sewerage District	Hawk Ridge Compost Facility	not liquid	19,646	not liquid	$ 135.08	$ 2,653,817	$ 2,653,817	$ 199,036
South Essex Sewerage District	Bethleham MSW Landfill NH	not liquid	1,389	not liquid	$ 135.08	$ 187,687	$ 187,687	$ 14,077
South Essex Sewerage District	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	5,020	not liquid	$ 135.08	$ 678,091	$ 678,091	$ 50,857
South Essex Sewerage District	Synagro in Woonsocket, RI incinerator	not liquid	5,680	not liquid	$ 135.08	$ 767,319	$ 767,319	$ 57,549
South Essex Sewerage District	Synagro Waterbury CT incinerator	not liquid	2,538	not liquid	$ 135.08	$ 342,788	$ 342,788	$ 25,709
South Hadley WWTP	Synagro Waterbury CT incinerator	not liquid	4,217	not liquid	$ 143.00	$ 603,037	$ 603,037	$ 45,228
Spencer WWTP	Synagro in Woonsocket, RI incinerator	1,147,537	4,785	$ 0.14	liquid	$ 160,511	$ 160,511	$ 12,038
Springfield WWTP - Bondi's Island	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	4,344	not liquid	$ 142.57	$ 619,278	$ 619,278	$ 46,446
Springfield WWTP - Bondi's Island	Bethleham MSW Landfill NH	not liquid	1,479	not liquid	$ 142.57	$ 210,905	$ 210,905	$ 15,818
Springfield WWTP - Bondi's Island	Ontario County MSW LF NY	not liquid	3,598	not liquid	$ 142.57	$ 512,949	$ 512,949	$ 38,471
Springfield WWTP - Bondi's Island	Casella composting Grasslands NY	not liquid	17,547	not liquid	$ 142.57	$ 2,501,648	$ 2,501,648	$ 187,624
Springfield WWTP - Bondi's Island	Synagro in Woonsocket, RI incinerator	not liquid	2,545	not liquid	$ 142.57	$ 362,803	$ 362,803	$ 27,210
Springfield WWTP - Bondi's Island	Synagro Waterbury CT incinerator	not liquid	1,627	not liquid	$ 142.57	$ 231,937	$ 231,937	$ 17,395
Springfield WWTP - Bondi's Island	Chemung MSW Landfill NY	not liquid	6,397	not liquid	$ 142.57	$ 911,974	$ 911,974	$ 68,398
Stockbridge WWTP	Cranston WPCF Incinerator	282,280	1,177	$ 0.09	liquid	$ 25,405	$ 25,405	$ 1,905
Sturbridge WPCF	Cranston WPCF Incinerator	1,815,155	7,569	$ 0.13	liquid	$ 241,597	$ 241,597	$ 18,120
Sunderland WWTP	Lowell Regional WW Utility	56,463	235	$ 0.24	liquid	$ 13,345	$ 13,345	$ 1,001
Sunderland WWTP	Montague WPCF	282,739	1,179	$ 0.24	liquid	$ 66,825	$ 66,825	$ 5,012
Taunton WWTP	Veolia Naugatuck, CT	not liquid	7,430	not liquid	$ 133.25	$ 990,051	$ 990,051	$ 74,254
Tisbury Public Works		-	-	$ 0.16	liquid	$ -	$ -	$ -
Upton WWTP	Cranston WPCF Incinerator	324,000	1,351	$ 0.08	liquid	$ 24,927	$ 24,927	$ 1,870
Uxbridge WWTF	Cranston WPCF Incinerator	2,997,369	12,499	$ 0.16	liquid	$ 479,579	$ 479,579	$ 35,968

Table H-3C: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (7.5%)**
Ware WWTP	Cranston WPCF Incinerator	2,713,568	11,316	$ 0.08	liquid	$ 230,596	$ 230,596	$ 17,295
Wareham WPCF		-	-	$ 0.16	liquid	$ -	$ -	$ -
Warren WWTP	Cranston WPCF Incinerator	314,568	1,312	$ 0.12	liquid	$ 37,479	$ 37,479	$ 2,811
Wayland WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Webster WWTF	Synagro in Woonsocket, RI incinerator	3,185,671	13,284	$ 0.11	liquid	$ 342,460	$ 342,460	$ 25,684
West Stockbridge	Cranston WPCF Incinerator	103,002	430	$ 0.17	liquid	$ 17,407	$ 17,407	$ 1,306
Westborough WWTF	Cranston WPCF Incinerator	204,866	854	$ 0.16	liquid	$ 32,779	$ 32,779	$ 2,458
Westborough WWTF	Upper Blackstone Clean Water	12,026,379	50,150	$ 0.16	liquid	$ 1,924,221	$ 1,924,221	$ 144,317
Westfield WPCP	Veolia Naugatuck, CT	not liquid	5,151	not liquid	$ 135.00	$ 695,421	$ 695,421	$ 52,157
Winchendon WPCF	Cranston WPCF Incinerator	1,282,214	5,347	$ 0.07	liquid	$ 87,581	$ 87,581	$ 6,569
							Total	**$ 4,601,000**

Table H-4A: Plants Directly Impacted in Scenario 4

Regional/national landfill restrictions with regional impact

POTW name	DEP "region"	Permitted or design flow (MGD)	Notes
Concord WWTF	Northeast	1.20	Some sludge streams indirectly impacted
Devens WWTP	Central	4.65	
Holyoke WWTP	West	17.50	Some sludge streams indirectly impacted
Hudson WWTF	Central	3.05	
Lowell Regional WW Utility	Northeast	32.00	Some sludge streams indirectly impacted
Lynn Regional WF	Northeast	25.80	Some sludge not directly or indirectly impacted
Marlborough East WWTP	Central	5.50	
Marlborough West WWTP	Central	2.89	
South Essex Sewerage District	Northeast	29.70	Some sludge streams indirectly impacted
Springfield WWTP - Bondi's Island	West	67.00	Some sludge streams indirectly impacted
	Total # of Plants	10	

Calculation approach
Total Annual Solids Handling Costs were estimated
For facilities hauling liquid, Column A was multipled by Column C to get Column E (eg, for Concord, 31,175 gal/yr * $0.06/gal = $1,882/yr). Numbers will not be exact due to rounding errors.
For facilities hauling cake, Column B was multipled by Column D to get Column E (eg, for Devens, 3,844 wt/yr * $170/wt = $653,421/yr)
This provided the total annual solids handling costs for each facility
To determine the proportion of those annual costs that would be subject to DIRECT price impacts, the annual cost was multipled by the % of sludge landfilled in New Hampshire, New York, or Vermont, out of the entirety of sludge landfilled
For example, for Concord, they pay $1,882 per year to haul their liquid sludge to a landfill in VT. Since 100% of what Concord sends to Vermont is impacted (because Vermont is banning all sludge from being landfilled), 100% of Concord's hauling costs to this destination would be subject to DIRECT price increases due to landfill bans in those states (NH, NY, or VT).
Column E is multiplied by Column F to get Column G (for Concord, $1,882 * 100% = $1,882)
For Holyoke, they pay $509,390 per year to haul their sludge to a landfill in NY. Since 50% of what Holyoke sends to New York is impacted (because New York is only accepting 50% of sludge for landfilling), 50% of Holyoke's hauling costs would be subject to DIRECT price increases due to landfill bans in those states (NH, NY, or VT).
Column E is multiplied by Column F to get Column G (for Holyoke, $509,390 * 50% = $254,695)
Costs that are indirectly impacted are calculated by subtracting Column G from Column E to get Column H (for Holyoke, this is $509,390 - $254,695 = $254,695)
Next, to determine the INCREASE in annual sludge handling costs, the proportion of annual solids handling costs that would be directly impacted, are multiplied by the percent increase associated with direct impacts for this Scenario.
According to Table 5-1, since Scenario 4 affects between 10,000 and 15,000 dt/yr, the DIRECT price increase percentage is 30%.
Multiply Column G by 30% to get the direct price increase (eg for Holyoke, $254,695 * 30% = $76,409)
Indirect price increases are 15% (see Table 5-1) - Multiply Column H by 15% to get the indirect price increase shown in Column J (eg, for Holyoke, $254,695 * 15% = $38,204)
For five plants (Concord, Holyoke, Lowell, South Essex, and Springfield), some of their sludge goes to a landfill in NH, NY, or VT, and some goes elsewhere and would not be directly affected by a landfill ban in NH, NY, or VT. For example, Concord sends sludge BOTH to a landfill in VT (which would be DIRECTLY impacted), and to GLSD (which would be INDIRECTLY impacted). For the sludge that is indirectly impacted, this is noted in Column F by indicating the % Sludge Land Applied in CT, NH, or VT as 0%.
For clarity, these plants which have sludge that is directly impacted and sludge that is indirectly impacted are included in this table.
Lynn has some sludge that goes to a landfill in VT (and is DIRECTLY impacted), and some sludge that is incinerated on-site (and is thus unaffected by direct or indirect impacts).
For clarity of calculations, results for individual plants or sludge loads are not rounded. When values are totaled for Column I and Column J (total direct impacts and total indirect impacts), these totals are rounded.

Table H-4B: Direct and Indirect Costs for Facilities Sending Sludge to Landfills in NH, NY, or VT

		A	B	C	D	E	F	G	H	I	J
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**% Sludge Landfilled in NH, NY or VT**	**Direct Impacts - Base Cost**	**Indirect Impacts - Base Cost**	**Direct Impacts - Increased Cost (30%)**	**Indirect Impacts - Increased Cost (15%)**
Concord WWTF	New England Waste Services of VT Landfill (Waste USA Landfill)	31,175	130	$ 0.06	liquid	$ 1,882	100%	$ 1,882	$ -	$ 565	$ -
Concord WWTF	Greater Lawrence Sanitary District	978,417	4,080	$ 0.06	liquid	$ 59,058	0%	$ -	$ 59,058	$ -	$ 8,859
Devens WWTP	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	3,844	not liquid	$ 170.00	$ 653,421	100%	$ 653,421	$ -	$ 196,026	$ -
Holyoke WWTP	Ontario County MSW LF NY	not liquid	3,639	not liquid	$ 140.00	$ 509,390	50%	$ 254,695	$ 254,695	$ 76,409	$ 38,204
Holyoke WWTP	Veolia Naugatuck, CT	428	not liquid	$ 140.00	$ 59,920	$ 59,920	0%	$ -	$ 59,920	$ -	$ 8,988
Holyoke WWTP	Cranston WPCF Incinerator	312	not liquid	$ 140.00	$ 43,680	$ 43,680	0%	$ -	$ 43,680	$ -	$ 6,552
Holyoke WWTP	Casella composting Grasslands NY	5,229	not liquid	$ 140.00	$ 732,060	$ 732,060	0%	$ -	$ 732,060	$ -	$ 109,809
Hudson WWTF	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	2,133	not liquid	$ 156.00	$ 332,773	100%	$ 332,773	$ -	$ 99,832	$ -
Lowell Regional WW Utility	Bethleham MSW Landfill NH	not liquid	7,648	not liquid	$ 190.37	$ 1,456,002	100%	$ 1,456,002	$ -	$ 436,801	$ -
Lowell Regional WW Utility	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	2,448	not liquid	$ 190.37	$ 466,073	100%	$ 466,073	$ -	$ 139,822	$ -
Lowell Regional WW Utility	Hawk Ridge Compost Facility	11,211	not liquid	$ 190.37	$ 2,134,202	$ 2,134,202	0%	$ -	$ 2,134,202	$ -	$ 320,130
Lowell Regional WW Utility	Synagro in Woonsocket, RI incinerator	64	not liquid	$ 190.37	$ 12,165	$ 12,165	0%	$ -	$ 12,165	$ -	$ 1,825
Lowell Regional WW Utility	Envirem Organics (NB)	5,751	not liquid	$ 190.37	$ 1,094,853	$ 1,094,853	0%	$ -	$ 1,094,853	$ -	$ 164,228
Lynn Regional WF	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	3,306	not liquid	$ 225.00	$ 743,959	100%	$ 743,959	$ -	$ 223,188	$ -
Lynn Regional WF	Lynn WWTF	not liquid	1,415	not liquid	$ 225.00	$ 318,271	Exception - not directly or indirectly impacted in this scenario				
Marlborough East WWTP	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	5,598	not liquid	$ 163.75	$ 916,704	100%	$ 916,704	$ -	$ 275,011	$ -
Marlborough West WWTP	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	3,345	not liquid	$ 156.00	$ 521,814	100%	$ 521,814	$ -	$ 156,544	$ -
South Essex Sewerage District	Bethleham MSW Landfill NH	not liquid	1,389	not liquid	$ 135.08	$ 187,687	100%	$ 187,687	$ -	$ 56,306	$ -
South Essex Sewerage District	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	5,020	not liquid	$ 135.08	$ 678,091	100%	$ 678,091	$ -	$ 203,427	$ -
South Essex Sewerage District	Hawk Ridge Compost Facility	19,646	not liquid	$ 135.08	$ 2,653,817	$ 2,653,817	0%	$ -	$ 2,653,817	$ -	$ 398,073
South Essex Sewerage District	Synagro in Woonsocket, RI incinerator	5,680	not liquid	$ 135.08	$ 767,319	$ 767,319	0%	$ -	$ 767,319	$ -	$ 115,098

Table H-4B: Direct and Indirect Costs for Facilities Sending Sludge to Landfills in NH, NY, or VT

		A	B	C	D	E	F	G	H	I	J
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**% Sludge Landfilled in NH, NY or VT**	**Direct Impacts - Base Cost**	**Indirect Impacts - Base Cost**	**Direct Impacts - Increased Cost (30%)**	**Indirect Impacts - Increased Cost (15%)**
South Essex Sewerage District	Synagro Waterbury CT incinerator	2,538	not liquid	$ 135.08	$ 342,788	$ 342,788	0%	$ -	$ 342,788	$ -	$ 51,418
Springfield WWTP - Bondi's Island	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	4,344	not liquid	$ 142.57	$ 619,278	100%	$ 619,278	$ -	$ 185,783	$ -
Springfield WWTP - Bondi's Island	Bethleham MSW Landfill NH	not liquid	1,479	not liquid	$ 142.57	$ 210,905	100%	$ 210,905	$ -	$ 63,271	$ -
Springfield WWTP - Bondi's Island	Ontario County MSW LF NY	not liquid	3,598	not liquid	$ 142.57	$ 512,949	50%	$ 256,474	$ 256,474	$ 76,942	$ 38,471
Springfield WWTP - Bondi's Island	Chemung MSW Landfill NY	not liquid	6,397	not liquid	$ 142.57	$ 911,974	50%	$ 455,987	$ 455,987	$ 136,796	$ 68,398
Springfield WWTP - Bondi's Island	Casella composting Grasslands NY	17,547	not liquid	$ 142.57	$ 2,501,648	$ 2,501,648	0%	$ -	$ 2,501,648	$ -	$ 375,247
Springfield WWTP - Bondi's Island	Synagro in Woonsocket, RI incinerator	2,545	not liquid	$ 142.57	$ 362,803	$ 362,803	0%	$ -	$ 362,803	$ -	$ 54,420
Springfield WWTP - Bondi's Island	Synagro Waterbury CT incinerator	1,627	not liquid	$ 142.57	$ 231,937	$ 231,937	0%	$ -	$ 231,937	$ -	$ 34,791
									Total	**$ 2,327,000**	**$ 1,795,000**

Calculation approach
Total Annual Solids Handling Costs were estimated
For facilities hauling liquid, Column A was multipled by Column C to get Column E (eg, for Acton, 236,361 gal/yr * $0.11/gal = $25,031/yr). Numbers will not be exact due to rounding errors.
For facilities hauling cake, Column B was multipled by Column D to get Column E (eg, for Adams, 983 wt/yr * $170/wt = $167,193/yr)
This provided the total annual solids handling costs for each facility BEFORE price increases
The entirety of these annual costs would be subjected to indirect price increases, therefore Column F is identical to Column E
Next, to determine the INCREASE in annual sludge handling costs, the annual solids handling costs that would be indirectly impacted are multiplied by the percent increase associated with indirect impacts for this Scenario.
According to Table 5-1, since Scenario 4 affects between 10,000 and 15,000 dt/yr, INDIRECT price increase percentage is 15%.
Multiply Column F by 15% to get the indirect price increase shown in Column G (eg, for Adams, $167,193 * 15% = $25,079)
Note: data on annual solids handling costs were not available for all plants; these were deemed negligible and not considered.
For clarity of calculations, results for individual plants or sludge loads are not rounded. When values are totaled for Column G (total indirect impacts), this total is rounded.

Table H-4C: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (15%)**
Acton Wastewater Collection	Greater Lawrence Sanitary District	236,361	986	$ 0.11	liquid	$ 25,031	$ 25,031	$ 3,755
Adams WWTP	Synagro Waterbury CT incinerator	not liquid	983	not liquid	$ 170.00	$ 167,193	$ 167,193	$ 25,079
Amesbury WWTP	Agresource/Ipswich Compost Facility	not liquid	2,120	not liquid	$ 156.00	$ 330,739	$ 330,739	$ 49,611
Amherst WWTP	MDC Hartford Connecticut Incinerator	3,448,975	14,382	$ 0.19	liquid	$ 661,600	$ 661,600	$ 99,240
Ashfield	Lowell Regional WW Utility	20,869	87	$ 0.24	liquid	$ 5,044	$ 5,044	$ 757
Athol WWTP	Cranston WPCF Incinerator	303,029	1,264	$ 0.26	liquid	$ 78,636	$ 78,636	$ 11,795
Athol WWTP	Upper Blackstone Clean Water	1,804,657	7,525	$ 0.26	liquid	$ 468,308	$ 468,308	$ 70,246
Attleboro WWTP	Attleboro Monofill	not liquid	9,521	not liquid	$ 156.00	$ 1,485,246	$ 1,485,246	$ 222,787
Ayer WWTP	Cranston WPCF Incinerator	1,964,446	8,192	$ 0.14	liquid	$ 267,496	$ 267,496	$ 40,124
Barnstable WWTP WPCD - DPW	Cranston WPCF Incinerator	4,731,738	19,731	$ 0.18	liquid	$ 859,073	$ 859,073	$ 128,861
Barnstable WWTP WPCD - DPW	Upper Blackstone Clean Water	248,482	1,036	$ 0.18	liquid	$ 45,113	$ 45,113	$ 6,767
Barre WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Belchertown WWTP	Cranston WPCF Incinerator	570,594	2,379	$ 0.17	liquid	$ 94,252	$ 94,252	$ 14,138
Billerica WWTP	Hawk Ridge Compost Facility	not liquid	7,003	not liquid	$ 146.70	$ 1,027,369	$ 1,027,369	$ 154,105
Brockton WWTP	Veolia Naugatuck, CT	not liquid	17,335	not liquid	$ 148.52	$ 2,574,569	$ 2,574,569	$ 386,185
Charlemont Sewer District		-	-	$ 0.16	liquid	$ -	$ -	$ -
Charles River PCD	Cranston WPCF Incinerator	532,573	2,221	$ 0.15	liquid	$ 78,237	$ 78,237	$ 11,735
Charles River PCD	Upper Blackstone Clean Water	6,247,045	26,050	$ 0.15	liquid	$ 917,709	$ 917,709	$ 137,656
Charlton WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Chatham WPCF	Hawk Ridge Compost Facility	not liquid	271	not liquid	$ 156.00	$ 42,336	$ 42,336	$ 6,350
Chicopee WWTP	Synagro Waterbury CT incinerator	not liquid	412	not liquid	$ 140.17	$ 57,796	$ 57,796	$ 8,669
Chicopee WWTP	Cranston WPCF Incinerator	not liquid	366	not liquid	$ 140.17	$ 51,363	$ 51,363	$ 7,705
Chicopee WWTP	Casella composting Grasslands NY	not liquid	3,443	not liquid	$ 140.17	$ 482,629	$ 482,629	$ 72,394
Cohasset WWTF	Cranston WPCF Incinerator	524,258	2,186	$ 0.16	liquid	$ 83,881	$ 83,881	$ 12,582
Douglas WWTP	Upper Blackstone Clean Water	1,236,248	5,155	$ 0.10	liquid	$ 125,000	$ 125,000	$ 18,750
Easthampton WWTP	Synagro Waterbury CT incinerator	not liquid	2,539	not liquid	$ 118.17	$ 300,000	$ 300,000	$ 45,000
Edgartown WWTP	Synagro in Woonsocket, RI incinerator	not liquid	1,011	not liquid	$ 119.00	$ 120,271	$ 120,271	$ 18,041

Table H-4C: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (15%)**
Erving POTW #1	Lowell Regional WW Utility	192,970	805	$ 0.20	liquid	$ 38,451	$ 38,451	$ 5,768
Erving POTW #3	Erving POTW #1	4,958	21	$ 0.16	liquid	$ 793	$ 793	$ 119
Fairhaven WPCF	Synagro in Woonsocket, RI incinerator	4,650,730	19,394	$ 0.09	liquid	$ 410,178	$ 410,178	$ 61,527
Fall River Regional WWF	Cranston WPCF Incinerator	33,968,066	141,647	$ 0.05	liquid	$ 1,863,588	$ 1,863,588	$ 279,538
Falmouth WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Fitchburg East WWTP	Resource Control, Inc. – RCI Fitchburg Landfill	not liquid	8,748	not liquid	$ 37.59	$ 328,849	$ 328,849	$ 49,327
Gardner WPCF	City of Gardner West St. Sludge Landfill	not liquid	3,276	not liquid	$ 2.72	$ 8,925	$ 8,925	$ 1,339
Gloucester WPCF	Hawk Ridge Compost Facility	not liquid	2,604	not liquid	$ 156.00	$ 406,256	$ 406,256	$ 60,938
Grafton WWTP	Upper Blackstone Clean Water	2,769,789	11,550	$ 0.11	liquid	$ 301,245	$ 301,245	$ 45,187
Great Barrington WWTP	Synagro Waterbury CT incinerator	not liquid	937	not liquid	$ 151.00	$ 141,446	$ 141,446	$ 21,217
Greenfield WPCF	Lowell Regional WW Utility	3,138,258	13,087	$ 0.23	liquid	$ 730,183	$ 730,183	$ 109,527
Hadley WWTP	Lowell Regional WW Utility	1,039,319	4,334	$ 0.23	liquid	$ 243,928	$ 243,928	$ 36,589
Hardwick-Gilbertville WPCF	Cranston WPCF Incinerator	238,609	995	$ 0.11	liquid	$ 25,800	$ 25,800	$ 3,870
Hardwick-Wheelwright WPCF	Cranston WPCF Incinerator	148,681	620	$ 0.08	liquid	$ 12,000	$ 12,000	$ 1,800
Hatfield WWTP	Lowell Regional WW Utility	328,759	1,371	$ 0.24	liquid	$ 78,398	$ 78,398	$ 11,760
Haverhill WWTP	Crossroads Landfill in Maine	not liquid	14,583	not liquid	$ 175.00	$ 2,552,052	$ 2,552,052	$ 382,808
Hopedale WWTF	Synagro in Woonsocket, RI incinerator	1,223,998	5,104	$ 0.09	liquid	$ 110,000	$ 110,000	$ 16,500
Hull WWTF	Cranston WPCF Incinerator	1,211,484	5,052	$ 0.16	liquid	$ 193,837	$ 193,837	$ 29,076
Huntington WWTP	Westfield WPCP	72,000	300	$ 0.34	liquid	$ 24,480	$ 24,480	$ 3,672
Ipswich WWTP	Agresource/Ipswich Compost Facility	not liquid	2,364	not liquid	$ 156.00	$ 368,759	$ 368,759	$ 55,314
Kingston Sewer Commission	Cranston WPCF Incinerator	937,999	3,911	$ 0.16	liquid	$ 150,010	$ 150,010	$ 22,501
Lee WWTP	Cranston WPCF Incinerator	1,153,383	4,810	$ 0.19	liquid	$ 224,000	$ 224,000	$ 33,600
Leicester WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Lenox Center WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Leominster WPCF	Upper Blackstone Clean Water	6,370,102	26,563	$ 0.06	liquid	$ 379,114	$ 379,114	$ 56,867
Manchester By the Sea WWTP	Cranston WPCF Incinerator	111,964	467	$ 0.16	liquid	$ 17,914	$ 17,914	$ 2,687
Manchester By the Sea WWTP	Upper Blackstone Clean Water	129,822	541	$ 0.16	liquid	$ 20,771	$ 20,771	$ 3,116
Mansfield WWTP (MFN)	Synagro in Woonsocket, RI incinerator	4,759,417	19,847	$ 0.11	liquid	$ 541,356	$ 541,356	$ 81,203
Mansfield WWTP (MFN)	Lowell Regional WW Utility	85,106	355	$ 0.11	liquid	$ 9,680	$ 9,680	$ 1,452
Marshfield WWTF	Cranston WPCF Incinerator	536,735	2,238	$ 0.17	liquid	$ 88,659	$ 88,659	$ 13,299
Marshfield WWTF	Upper Blackstone Clean Water	656,197	2,736	$ 0.17	liquid	$ 108,392	$ 108,392	$ 16,259
Maynard WWTP	Cranston WPCF Incinerator	35,246	147	$ 1.00	liquid	$ 35,246	$ 35,246	$ 5,287
Maynard WWTP	Greater Lawrence Sanitary District	2,798,422	11,669	$ 1.00	liquid	$ 2,798,422	$ 2,798,422	$ 419,763
MCI Bridgewater	New Bedford WWTP	379,521	1,583	$ 0.19	liquid	$ 70,591	$ 70,591	$ 10,589
MCI Concord		1,216,199	5,072	$ 0.05	liquid	$ 58,515	$ 58,515	$ 8,777
MCI Norfolk	New Bedford WWTP	366,013	1,526	$ 0.13	liquid	$ 48,497	$ 48,497	$ 7,275
Medfield WWTP	Cranston WPCF Incinerator	2,415,888	10,074	$ 0.13	liquid	$ 306,201	$ 306,201	$ 45,930
Merrimac WWTP	Agresource/Ipswich Compost Facility	678,068	2,828	$ 0.16	liquid	$ 108,491	$ 108,491	$ 16,274

Table H-4C: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (15%)**
Middleborough WWTP	Middleborough MSW Landfill	not liquid	2,195	not liquid	$ 156.00	$ 342,407	$ 342,407	$ 51,361
Milford WWTP	Synagro in Woonsocket, RI incinerator	4,777,199	19,921	$ 0.16	liquid	$ 764,352	$ 764,352	$ 114,653
Monroe WWTP	Hoosac WQD	488,109	2,035	$ 0.16	liquid	$ 78,098	$ 78,098	$ 11,715
Montague WPCF	Veolia Naugatuck, CT	not liquid	972	not liquid	$ 178.65	$ 173,623	$ 173,623	$ 26,043
Montague WPCF	Synagro Waterbury CT incinerator	not liquid	24	not liquid	$ 178.65	$ 4,245	$ 4,245	$ 637
Montague WPCF	Synagro in Woonsocket, RI incinerator	not liquid	124	not liquid	$ 178.65	$ 22,176	$ 22,176	$ 3,326
MWRA Clinton WWTP	Town of Clinton Recycling Center	not liquid	1,464	not liquid	$ 156.00	$ 228,350	$ 228,350	$ 34,252
Nantucket Sewer Dept. - Siasconset		-	-	$ 0.16	liquid	$ -	$ -	$ -
Nantucket Sewer Dept. - Surfside		not liquid	-	not liquid	$ 156.00	$ -	$ -	$ -
New Bedford WWTP	Synagro in Woonsocket, RI incinerator	26,053,293	108,642	$ 0.19	liquid	$ 4,942,657	$ 4,942,657	$ 741,398
Newburyport WWTP	Agresource/Ipswich Compost Facility	not liquid	2,729	not liquid	$ 156.00	$ 425,666	$ 425,666	$ 63,850
North Attleborough WPCF	Synagro in Woonsocket, RI incinerator	3,603,805	15,028	$ 0.11	liquid	$ 407,230	$ 407,230	$ 61,084
North Attleborough WPCF	Lowell Regional WW Utility	585,784	2,443	$ 0.11	liquid	$ 66,194	$ 66,194	$ 9,929
North Brookfield WWTP	Synagro Waterbury CT incinerator	not liquid	985	not liquid	$ 203.01	$ 199,951	$ 199,951	$ 29,993
Northampton WWTF	Synagro Waterbury CT incinerator	not liquid	4,506	not liquid	$ 157.00	$ 707,394	$ 707,394	$ 106,109
Northbridge WWTF	Cranston WPCF Incinerator	2,759,820	11,508	$ 0.06	liquid	$ 167,132	$ 167,132	$ 25,070
Northfield WPCF	Lowell Regional WW Utility	145,531	607	$ 0.25	liquid	$ 36,048	$ 36,048	$ 5,407
Oak Bluffs WWTP		400,000	1,668	$ 0.30	liquid	$ 119,000	$ 119,000	$ 17,850
Old Deerfield - Historic WWTP	Lowell Regional WW Utility	202,009	842	$ 0.25	liquid	$ 51,452	$ 51,452	$ 7,718
Orange WWTP	Lowell Regional WW Utility	313,571	1,308	$ 0.22	liquid	$ 67,582	$ 67,582	$ 10,137
Orange WWTP	Montague WPCF	107,211	447	$ 0.22	liquid	$ 23,106	$ 23,106	$ 3,466
Otis DPW		-	-	$ 0.16	liquid	$ -	$ -	$ -
Oxford-Rochdale SD WPCP	Synagro in Woonsocket, RI incinerator	671,325	2,799	$ 0.08	liquid	$ 54,122	$ 54,122	$ 8,118
Palmer WWTF	MDC Hartford Connecticut Incinerator	not liquid	2,921	not liquid	$ 160.07	$ 467,584	$ 467,584	$ 70,138
Pepperell WWTF		not liquid	1,047	not liquid	$ 156.00	$ 163,332	$ 163,332	$ 24,500
Pittsfield WWTP	Casella composting Grasslands NY	not liquid	6,022	not liquid	$ 161.00	$ 969,536	$ 969,536	$ 145,430
Plymouth WWTF	Cranston WPCF Incinerator	6,344,891	26,458	$ 0.16	liquid	$ 1,015,183	$ 1,015,183	$ 152,277
Provincetown Public Works	Cranston WPCF Incinerator	888,700	3,706	$ 0.17	liquid	$ 147,042	$ 147,042	$ 22,056
Rockland WWTP	Synagro in Woonsocket, RI incinerator	not liquid	1,315	not liquid	$ 190.00	$ 249,877	$ 249,877	$ 37,482
Rockport WWTP	Agresource/Ipswich Compost Facility	not liquid	473	not liquid	$ 156.00	$ 73,840	$ 73,840	$ 11,076
Royalston WWTF		-	-	$ 0.16	liquid	$ -	$ -	$ -
Russell Village WWTF	Westfield WPCP	70,519	294	$ 0.21	liquid	$ 15,000	$ 15,000	$ 2,250
Salisbury WWTF		-	-	$ 0.16	liquid	$ -	$ -	$ -
Scituate WWTF	Middleborough MSW Landfill	not liquid	1,895	not liquid	$ 172.00	$ 325,917	$ 325,917	$ 48,887
Somerset WWTF	Synagro in Woonsocket, RI incinerator	2,050,609	8,551	$ 0.14	liquid	$ 288,245	$ 288,245	$ 43,237
South Deerfield	Lowell Regional WW Utility	1,303,836	5,437	$ 0.18	liquid	$ 238,870	$ 238,870	$ 35,830
South Hadley WWTP	Synagro Waterbury CT incinerator	not liquid	4,217	not liquid	$ 143.00	$ 603,037	$ 603,037	$ 90,456
Spencer WWTP	Synagro in Woonsocket, RI incinerator	1,147,537	4,785	$ 0.14	liquid	$ 160,511	$ 160,511	$ 24,077

Table H-4C: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (15%)**
Stockbridge WWTP	Cranston WPCF Incinerator	282,280	1,177	$ 0.09	liquid	$ 25,405	$ 25,405	$ 3,811
Sturbridge WPCF	Cranston WPCF Incinerator	1,815,155	7,569	$ 0.13	liquid	$ 241,597	$ 241,597	$ 36,240
Sunderland WWTP	Lowell Regional WW Utility	56,463	235	$ 0.24	liquid	$ 13,345	$ 13,345	$ 2,002
Sunderland WWTP	Montague WPCF	282,739	1,179	$ 0.24	liquid	$ 66,825	$ 66,825	$ 10,024
Taunton WWTP	Veolia Naugatuck, CT	not liquid	7,430	not liquid	$ 133.25	$ 990,051	$ 990,051	$ 148,508
Tisbury Public Works		-	-	$ 0.16	liquid	$ -	$ -	$ -
Upton WWTP	Cranston WPCF Incinerator	324,000	1,351	$ 0.08	liquid	$ 24,927	$ 24,927	$ 3,739
Uxbridge WWTF	Cranston WPCF Incinerator	2,997,369	12,499	$ 0.16	liquid	$ 479,579	$ 479,579	$ 71,937
Ware WWTP	Cranston WPCF Incinerator	2,713,568	11,316	$ 0.08	liquid	$ 230,596	$ 230,596	$ 34,589
Wareham WPCF		-	-	$ 0.16	liquid	$ -	$ -	$ -
Warren WWTP	Cranston WPCF Incinerator	314,568	1,312	$ 0.12	liquid	$ 37,479	$ 37,479	$ 5,622
Wayland WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Webster WWTF	Synagro in Woonsocket, RI incinerator	3,185,671	13,284	$ 0.11	liquid	$ 342,460	$ 342,460	$ 51,369
West Stockbridge	Cranston WPCF Incinerator	103,002	430	$ 0.17	liquid	$ 17,407	$ 17,407	$ 2,611
Westborough WWTF	Cranston WPCF Incinerator	204,866	854	$ 0.16	liquid	$ 32,779	$ 32,779	$ 4,917
Westborough WWTF	Upper Blackstone Clean Water	12,026,379	50,150	$ 0.16	liquid	$ 1,924,221	$ 1,924,221	$ 288,633
Westfield WPCP	Veolia Naugatuck, CT	not liquid	5,151	not liquid	$ 135.00	$ 695,421	$ 695,421	$ 104,313
Winchendon WPCF	Cranston WPCF Incinerator	1,282,214	5,347	$ 0.07	liquid	$ 87,581	$ 87,581	$ 13,137
							Total	**$ 6,294,000**

| | | | | | | | **Total** | **$ 6,294,000** |

Table H-5A: Plants Directly Impacted in Scenario 5			
Incineration capacity reduction in Massachusetts			
POTW name	**DEP "region"**	**Permitted or design flow (MGD)**	**Notes**
Athol WWTP	West	1.75	Some sludge streams indirectly impacted; continues hauling
Barnstable WWTP WPCD - DPW	Southeast	4.20	Some sludge streams indirectly impacted; installs dewatering
Charles River PCD	Central	5.70	Some sludge streams indirectly impacted; continues hauling
Douglas WWTP	Central	0.60	Installs dewatering
Grafton WWTP	Central	2.40	Installs dewatering
Leominster WPCF	Central	9.30	Installs dewatering
Manchester By the Sea WWTP	Northeast	0.67	Some sludge streams indirectly impacted; continues hauling
Marshfield WWTF	Southeast	2.10	Some sludge streams indirectly impacted; continues hauling
Upper Blackstone WPAD (Worcester area)	Central	56.00	
Westborough WWTF	Central	7.68	Some sludge streams indirectly impacted; installs dewatering
	Total # of Plants	10	

This sheet outlines the cost approach for calculating the cost increases UBCW would see if they had to haul their cake elsewhere (since they could no longer incinerate it under Scenario 5). First, quantities that UBCW will produce over the next 20 years are calculated, using a 0.5% population growth rate. Since UBCW does not haul cake, they would see an increase of $156 (avg cost of solids handling determined in Part 1) plus an assumed $20/wt increase representing the constricted solids market. Costs were calculated by multiplying the price and sludge quantity for a given year. These were then discounted at 2.2% to present dollars, summed, and converted to an annual cost. For clarity of calculations, results for individual calculations were not rounded. Only the final result was rounded.

Table H-5B: UBCW Hauling Calculations

POTW name	Solid Unit Costs ($/wet ton)	Destination Facility	Destination Facility State	Destination Facility Type	volume, for liquid (gal/yr)	Quantity (wet US tons/year)	
Upper Blackstone WPAD (Worcester area)	$156	Upper Blackstone Clean Water	MA	Incinerator	not liquid	52,035	
Increase quantities of liquid sludge by 0.5% per year to match population growth	**Sludge Quantity Increases**						
Present Quantity of Liquid Sludge, wet tons/yr	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
52,035	52,296	52,557	52,820	53,084	53,349	53,616	53,884
Add $20 to statewide avg cost of $156/wet ton	**Price increases with step increase**						
Step Increase	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
$ 176.00	$ 186.91	$ 198.50	$ 210.81	$ 223.88	$ 237.76	$ 252.50	$ 268.15
UBCW does not currently pay to haul sludge. Costs to handle ash assumed negligible.	**Cost increases with step increase**						
	2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
	$ 9,774,659	$ 10,432,592	$ 11,134,809	$ 11,884,293	$ 12,684,225	$ 13,538,000	$ 14,449,243

Present worth from future cost	**$ 9,774,659**	**$ 10,208,015**	**$ 10,660,584**	**$ 11,133,217**	**$ 11,626,804**	**$ 12,142,274**	**$ 12,680,598**
	Sludge Quantity Increases						
	2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
	54,154	54,424	54,696	54,970	55,245	55,521	55,799
	Price increases with step increase						
	2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
	$ 284.78	$ 302.44	$ 321.19	$ 341.10	$ 362.25	$ 384.71	$ 408.56
	Cost increases with step increase						
	2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
	$ 15,421,822	$ 16,459,865	$ 17,567,778	$ 18,750,265	$ 20,012,345	$ 21,359,376	$ 22,797,076
Present worth from future cost	**$ 13,242,787**	**$ 13,829,902**	**$ 14,443,045**	**$ 15,083,372**	**$ 15,752,088**	**$ 16,450,451**	**$ 17,179,776**
	Sludge Quantity Increases						
	2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
	56,078	56,358	56,640	56,923	57,208	57,494	57,781
	Price increases with step increase						
	2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
	$ 433.89	$ 460.79	$ 489.36	$ 519.70	$ 551.92	$ 586.14	$ 622.48
	Cost increases with step increase						
	2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
	$ 24,331,547	$ 25,969,304	$ 27,717,298	$ 29,582,949	$ 31,574,177	$ 33,699,435	$ 35,967,744
Present worth from future cost	**$ 17,941,435**	**$ 18,736,862**	**$ 19,567,554**	**$ 20,435,075**	**$ 21,341,057**	**$ 22,287,205**	**$ 23,275,300**

Table H-5B: UBCW Hauling Calculations

Sum of cost increases with step increase	$ 327,792,063						
How much more UBCW needs to pay to haul cake:	$ 327,792,063						
Equivalent Annual Cost	$ 25,637,985						
Direct Costs to UBCW Haulers, annually	$ 25,638,000						

To determine cost increases for plants that would continue hauling in Scenario 5, the following approach was taken. Sludge quantity increases, at 0.5% per year to follow population growth, and price increases, increasing at 6.2% per year to match the average rate determined in Part 1, were calculated. The resulting costs were determined by multiplying quantity by price. This provided the cost of hauling the plants would see before a 45% increase (owing to the difficulty of finding outlets for sludge). Next, these calculations were repeated, but including the 45% increase in prices (as well as escalation and population growth). The difference between the two was found, which provided the overall increase in solids hauling costs that would have to be paid over 20 years, and converted to an annual cost. For clarity of calculations, results for individual calculations were not rounded. Only the final result was rounded.

Table H-5C: Hauling Cost Calculations

POTW name	Liquid - unit cost ($/gal)	Destination Facility	Destination Facility State	Destination Facility Type	volume, for liquid (gal/yr)	Quantity (wet US tons/year)		
Athol WWTP	$ 0.26	Upper Blackstone Clean Water	MA	POTW	1,804,657	7,525		
Charles River PCD	$ 0.15	Upper Blackstone Clean Water	MA	POTW	6,247,045	26,050		
Manchester By the Sea WWTP	Assume average cost as determined in Part 1 - $0.16	Upper Blackstone Clean Water	MA	POTW	129,822	541		
Marshfield WWTF	$ 0.17	Upper Blackstone Clean Water	MA	Incinerator	656,197	2,736		
		Sludge Quantity Increases						
		Increase quantities of liquid sludge by 0.5% per year to match population growth						
	Present Quantity of Liquid Sludge, gal/yr (assume 3.7% solids)	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Athol WWTP	1,804,657	1,813,680	1,822,748	1,831,862	1,841,021	1,850,226	1,859,477	1,868,775
Charles River PCD	6,247,045	6,278,281	6,309,672	6,341,220	6,372,926	6,404,791	6,436,815	6,468,999
Manchester By the Sea WWTP	129,822	130,471	131,123	131,779	132,438	133,100	133,765	134,434
Marshfield WWTF	656,197	659,478	662,776	666,090	669,420	672,767	676,131	679,512
		Price increases without 45% step increase						
		Escalate unit cost by 6.2% per year (following sludge mgmt price increase trends)						
	Present Price of Hauling per gallon	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Athol WWTP	$ 0.26	$ 0.28	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.40
Charles River PCD	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.22
Manchester By the Sea WWTP	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24
Marshfield WWTF	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.22	$ 0.24	$ 0.25
		Cost increases without 45% step increase						
		2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
	Athol WWTP	$ 499,830	$ 533,474	$ 569,382	$ 607,707	$ 648,612	$ 692,270	$ 738,866
	Charles River PCD	$ 979,481	$ 1,045,409	$ 1,115,776	$ 1,190,879	$ 1,271,037	$ 1,356,590	$ 1,447,902
	Manchester By the Sea WWTP	$ 22,170	$ 23,662	$ 25,255	$ 26,954	$ 28,769	$ 30,705	$ 32,772
	Marshfield WWTF	$ 115,688	$ 123,475	$ 131,786	$ 140,657	$ 150,124	$ 160,229	$ 171,014
	Sum increased annual costs for all plants that will haul - WITHOUT step increase							
	Sum	$ 1,617,168	$ 1,726,020	$ 1,842,198	$ 1,966,197	$ 2,098,541	$ 2,239,794	$ 2,390,555
	Convert to present worth using 2.2% discount rate							
	Present worth from future cost	**$ 1,617,168**	**$ 1,688,865**	**$ 1,763,740**	**$ 1,841,935**	**$ 1,923,596**	**$ 2,008,878**	**$ 2,097,941**
		Sludge Quantity Increases						
		2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
	Athol WWTP	1,878,119	1,887,509	1,896,947	1,906,432	1,915,964	1,925,544	1,935,171
	Charles River PCD	6,501,344	6,533,851	6,566,520	6,599,353	6,632,349	6,665,511	6,698,839
	Manchester By the Sea WWTP	135,106	135,782	136,461	137,143	137,829	138,518	139,211
	Marshfield WWTF	682,909	686,324	689,755	693,204	696,670	700,154	703,654
		Price increases without 45% step increase						

Table H-5C: Hauling Cost Calculations

		2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
	Athol WWTP	$ 0.42	$ 0.45	$ 0.47	$ 0.50	$ 0.53	$ 0.57	$ 0.60
	Charles River PCD	$ 0.24	$ 0.25	$ 0.27	$ 0.28	$ 0.30	$ 0.32	$ 0.34
	Manchester By the Sea WWTP	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
	Marshfield WWTF	$ 0.27	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.38
		Cost increases without 45% step increase						
		2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
	Athol WWTP	$ 788,600	$ 841,680	$ 898,334	$ 958,801	$ 1,023,337	$ 1,092,218	$ 1,165,735
	Charles River PCD	$ 1,545,361	$ 1,649,379	$ 1,760,399	$ 1,878,891	$ 2,005,359	$ 2,140,340	$ 2,284,406
	Manchester By the Sea WWTP	$ 34,978	$ 37,332	$ 39,845	$ 42,527	$ 45,389	$ 48,445	$ 51,705
	Marshfield WWTF	$ 182,525	$ 194,811	$ 207,924	$ 221,919	$ 236,856	$ 252,799	$ 269,815
	Sum increased annual costs for all plants that will haul - WITHOUT step increase							
	Sum	$ 2,551,463	$ 2,723,202	$ 2,906,501	$ 3,102,137	$ 3,310,942	$ 3,533,802	$ 3,771,662
	Convert to present worth using 2.2% discount rate							
	Present worth from future cost	**$ 2,190,953**	**$ 2,288,088**	**$ 2,389,529**	**$ 2,495,468**	**$ 2,606,104**	**$ 2,721,645**	**$ 2,842,308**
		Sludge Quantity Increases						
		2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
	Athol WWTP	1,944,847	1,954,571	1,964,344	1,974,166	1,984,037	1,993,957	2,003,927
	Charles River PCD	6,732,333	6,765,995	6,799,825	6,833,824	6,867,993	6,902,333	6,936,844
	Manchester By the Sea WWTP	139,907	140,606	141,309	142,016	142,726	143,439	144,157
	Marshfield WWTF	707,173	710,708	714,262	717,833	721,423	725,030	728,655
		Price increases without 45% step increase						
		2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
	Athol WWTP	$ 0.64	$ 0.68	$ 0.72	$ 0.77	$ 0.81	$ 0.86	$ 0.92
	Charles River PCD	$ 0.36	$ 0.38	$ 0.41	$ 0.43	$ 0.46	$ 0.49	$ 0.52
	Manchester By the Sea WWTP	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.57
	Marshfield WWTF	$ 0.41	$ 0.43	$ 0.46	$ 0.49	$ 0.52	$ 0.55	$ 0.58
		Cost increases without 45% step increase						
		2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
	Athol WWTP	$ 1,244,201	$ 1,327,948	$ 1,417,333	$ 1,512,733	$ 1,614,555	$ 1,723,231	$ 1,839,222
	Charles River PCD	$ 2,438,170	$ 2,602,283	$ 2,777,442	$ 2,964,392	$ 3,163,925	$ 3,376,889	$ 3,604,187
	Manchester By the Sea WWTP	$ 55,186	$ 58,900	$ 62,865	$ 67,096	$ 71,612	$ 76,433	$ 81,577
	Marshfield WWTF	$ 287,976	$ 307,360	$ 328,048	$ 350,129	$ 373,696	$ 398,850	$ 425,697
	Sum increased annual costs for all plants that will haul - WITHOUT step increase							
	Sum	$ 4,025,533	$ 4,296,491	$ 4,585,688	$ 4,894,351	$ 5,223,789	$ 5,575,403	$ 5,950,683
	Convert to present worth using 2.2% discount rate							
	Present worth from future cost	**$ 2,968,321**	**$ 3,099,920**	**$ 3,237,354**	**$ 3,380,881**	**$ 3,530,771**	**$ 3,687,306**	**$ 3,850,782**
	Sum the total present worth							
	Sum of cost increases WITHOUT step increase	**$ 54,231,554**						
		Price increases with step increase						

Table H-5C: Hauling Cost Calculations

	Increased cost of hauling by 45% due to direct impacts	Escalate unit cost by 6.2% per year (following sludge mgmt price increase trends)						
Present Price of Hauling per gallon	Step Increase	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
$ 0.26	$ 0.38	$ 0.40	$ 0.42	$ 0.45	$ 0.48	$ 0.51	$ 0.54	$ 0.57
$ 0.15	$ 0.21	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.32
$ 0.16	$ 0.23	$ 0.25	$ 0.26	$ 0.28	$ 0.30	$ 0.31	$ 0.33	$ 0.35
$ 0.17	$ 0.24	$ 0.25	$ 0.27	$ 0.29	$ 0.30	$ 0.32	$ 0.34	$ 0.36
		Cost increases with step increase						
		Multiply quantity of liquid sludge by escalated mgmt prices						
		2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
	Athol WWTP	$ 724,754	$ 773,537	$ 825,604	$ 881,175	$ 940,487	$ 1,003,791	$ 1,071,356
	Charles River PCD	$ 1,420,247	$ 1,515,844	$ 1,617,875	$ 1,726,774	$ 1,843,003	$ 1,967,056	$ 2,099,458
	Manchester By the Sea WWTP	$ 32,146	$ 34,310	$ 36,619	$ 39,084	$ 41,715	$ 44,522	$ 47,519
	Marshfield WWTF	$ 167,748	$ 179,039	$ 191,090	$ 203,952	$ 217,680	$ 232,332	$ 247,971
	Sum increased annual costs for all plants that will haul - WITH step increase							
	SUM of hauling sites	$ 2,344,894	$ 2,502,729	$ 2,671,188	$ 2,850,985	$ 3,042,885	$ 3,247,702	$ 3,466,305
	Convert to present worth using 2.2% discount rate							
	Present worth from future cost	**$ 2,344,894**	**$ 2,448,854**	**$ 2,557,423**	**$ 2,670,806**	**$ 2,789,215**	**$ 2,912,874**	**$ 3,042,015**
		Price increases with step increase						
		2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
	Athol WWTP	$ 0.61	$ 0.65	$ 0.69	$ 0.73	$ 0.77	$ 0.82	$ 0.87
	Charles River PCD	$ 0.34	$ 0.37	$ 0.39	$ 0.41	$ 0.44	$ 0.47	$ 0.49
	Manchester By the Sea WWTP	$ 0.38	$ 0.40	$ 0.42	$ 0.45	$ 0.48	$ 0.51	$ 0.54
	Marshfield WWTF	$ 0.39	$ 0.41	$ 0.44	$ 0.46	$ 0.49	$ 0.52	$ 0.56
		Cost increases with step increase						
		2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
	Athol WWTP	$ 1,143,469	$ 1,220,436	$ 1,302,584	$ 1,390,261	$ 1,483,839	$ 1,583,716	$ 1,690,316
	Charles River PCD	$ 2,240,773	$ 2,391,599	$ 2,552,578	$ 2,724,392	$ 2,907,771	$ 3,103,493	$ 3,312,389
	Manchester By the Sea WWTP	$ 50,718	$ 54,132	$ 57,775	$ 61,664	$ 65,815	$ 70,245	$ 74,973
	Marshfield WWTF	$ 264,661	$ 282,476	$ 301,489	$ 321,782	$ 343,442	$ 366,559	$ 391,232
	Sum increased annual costs for all plants that will haul - WITH step increase							
	SUM of hauling sites	$ 3,699,622	$ 3,948,643	$ 4,214,426	$ 4,498,099	$ 4,800,866	$ 5,124,013	$ 5,468,910
	Convert to present worth using 2.2% discount rate							
	Present worth from future cost	**$ 3,176,882**	**$ 3,317,727**	**$ 3,464,818**	**$ 3,618,429**	**$ 3,778,851**	**$ 3,946,385**	**$ 4,121,346**
		Price increases with step increase						
		2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
	Athol WWTP	$ 0.93	$ 0.99	$ 1.05	$ 1.11	$ 1.18	$ 1.25	$ 1.33

Table H-5C: Hauling Cost Calculations

	Charles River PCD	$ 0.53	$ 0.56	$ 0.59	$ 0.63	$ 0.67	$ 0.71	$ 0.75
	Manchester By the Sea WWTP	$ 0.57	$ 0.61	$ 0.65	$ 0.69	$ 0.73	$ 0.77	$ 0.82
	Marshfield WWTF	$ 0.59	$ 0.63	$ 0.67	$ 0.71	$ 0.75	$ 0.80	$ 0.85
		Cost increases with step increase						
		2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
	Athol WWTP	$ 1,804,092	$ 1,925,525	$ 2,055,132	$ 2,193,463	$ 2,341,105	$ 2,498,685	$ 2,666,871
	Charles River PCD	$ 3,535,346	$ 3,773,310	$ 4,027,291	$ 4,298,368	$ 4,587,692	$ 4,896,489	$ 5,226,072
	Manchester By the Sea WWTP	$ 80,019	$ 85,405	$ 91,154	$ 97,289	$ 103,838	$ 110,827	$ 118,287
	Marshfield WWTF	$ 417,566	$ 445,672	$ 475,670	$ 507,687	$ 541,860	$ 578,332	$ 617,260
	Sum increased annual costs for all plants that will haul - WITH step increase							
	SUM of hauling sites	$ 5,837,022	$ 6,229,912	$ 6,649,248	$ 7,096,808	$ 7,574,495	$ 8,084,334	$ 8,628,490
	Convert to present worth using 2.2% discount rate							
	Present worth from future cost	**$ 4,304,065**	**$ 4,494,884**	**$ 4,694,163**	**$ 4,902,277**	**$ 5,119,618**	**$ 5,346,594**	**$ 5,583,633**
	Sum the total present worth							
	Sum of cost increases WITH step increase	**$ 78,635,754**						
	INCREASE due to step increase	**$ 24,404,199**						
	How much MORE haulers need to pay from 2024-2044:	**$ 24,404,199**						
	Equivalent annual cost	**$ 1,909,000**						

To determine cost increases for plants that would install dewatering in Scenario 5, the following approach was taken. Sludge quantity increases, at 0.5% per year to follow population growth, and price increases, including a 45% step increase and increasing at 6.2% per year to match the average rate determined in Part 1, were calculated. The resulting costs were determined by multiplying quantity by price. This provided the cost of hauling liquid sludge that these plants would avoid by installing dewatering. Next, an equivalent amount of wet tons produced per year was calculated, assuming 3.7% solids content in the liquid sludge and 22.8% in the cake (these are average values of the plants studied). Then the costs the plants would have to bear to haul the cake produced at their dewatering facilities, starting with the average cost of $156/wt and including the 45% increase in prices (as well as escalation and population growth), was determined.
Estimated solids growth in dry tons per year was calculated through 2044. This allowed calculation of capital cost in 2044 for screw presses and centrifuges, using cost curves developed in Part 2. O&M costs were also calculated per plant based on the solids produced in a given year. Annual O&M costs and capital costs were incorporated to calculate the net present cost and equivalent annual rate. Finally, the resulting annual cost to these facilities was determined by considering the cost savings by not hauling liquid, the additional cost to haul cake, and the cost of capital cost and O&M for the facilities.
For clarity of calculations, results for individual calculations were not rounded. Only the final result was rounded.

Table H-5D: Dewatering Cost Calculations

POTW name	Liquid - unit cost ($/gal)	Destination Facility	Destination Facility State	Destination Facility Type	volume, for liquid (gal/yr)	Quantity (wet US tons/year)			
Barnstable WWTP WPCD - DPW	$ 0.18	Upper Blackstone Clean Water	MA	POTW	248,482	1,036			
Douglas WWTP	$ 0.10	Upper Blackstone Clean Water	MA	Incinerator	1,236,248	5,155			
Grafton WWTP	$ 0.11	Upper Blackstone Clean Water	MA	POTW	2,769,789	11,550			
Leominster WPCF	$ 0.06	Upper Blackstone Clean Water	MA	POTW	6,370,102	26,563			
Westborough WWTF	Assume average - $0.16	Upper Blackstone Clean Water	MA	POTW	12,026,379	50,150			
			Sludge Quantity Increases						
			Increase quantities of liquid sludge by 0.5% per year to match population growth						
Scenario 5 Group		**Present Quantity of Liquid Sludge, gal/yr (assume 3.7% solids)**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Installs Dewatering		248,482	249,725	250,973	252,228	253,489	254,757	256,031	257,311
		1,236,248	1,242,429	1,248,642	1,254,885	1,261,159	1,267,465	1,273,802	1,280,171
		2,769,789	2,783,638	2,797,556	2,811,544	2,825,602	2,839,730	2,853,928	2,868,198
		6,370,102	6,401,953	6,433,962	6,466,132	6,498,463	6,530,955	6,563,610	6,596,428
		12,026,379	12,086,511	12,146,943	12,207,678	12,268,716	12,330,060	12,391,710	12,453,669
			Price increases WITH step increase						
		Increased cost of hauling by 45% due to direct impacts	Escalate unit cost by 6.2% per year (following sludge mgmt price increase trends)						
	Present Price of Hauling per gallon	Step Increase	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Barnstable WWTP WPCD - DPW	$ 0.18	$ 0.26	$ 0.28	$ 0.30	$ 0.32	$ 0.33	$ 0.36	$ 0.38	$ 0.40
Douglas WWTP	$ 0.10	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.22
Grafton WWTP	$ 0.11	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.23	$ 0.24
Leominster WPCF	$ 0.06	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.11	$ 0.12	$ 0.12	$ 0.13
Westborough WWTF	$ 0.16	$ 0.23	$ 0.25	$ 0.26	$ 0.28	$ 0.30	$ 0.31	$ 0.33	$ 0.35
			Cost increases WITH step increase						
			Multiply quantity of liquid sludge by escalated mgmt prices						
			2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
		Barnstable WWTP WPCD - DPW	$ 69,817	$ 74,517	$ 79,533	$ 84,886	$ 90,600	$ 96,698	$ 103,207
		Douglas WWTP	$ 193,450	$ 206,471	$ 220,368	$ 235,201	$ 251,033	$ 267,930	$ 285,964
		Grafton WWTP	$ 466,206	$ 497,587	$ 531,079	$ 566,826	$ 604,979	$ 645,700	$ 689,162
		Leominster WPCF	$ 586,717	$ 626,209	$ 668,359	$ 713,346	$ 761,361	$ 812,609	$ 867,305
		Westborough WWTF	$ 2,977,923	$ 3,178,367	$ 3,392,303	$ 3,620,639	$ 3,864,344	$ 4,124,453	$ 4,402,070
		Sum increased annual costs for all plants that will haul - WITH step increase							
		Sum	$ 4,294,113	$ 4,583,150	$ 4,891,642	$ 5,220,898	$ 5,572,317	$ 5,947,389	$ 6,347,708
		Convert to present worth using 2.2% discount rate							
		Present worth from future cost	**$ 4,294,113**	**$ 4,484,491**	**$ 4,683,309**	**$ 4,890,942**	**$ 5,107,780**	**$ 5,334,232**	**$ 5,570,723**
			Sludge Quantity Increases						
			2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
		Barnstable WWTP WPCD - DPW	258,597	259,890	261,190	262,496	263,808	265,127	266,453
		Douglas WWTP	1,286,572	1,293,005	1,299,470	1,305,967	1,312,497	1,319,060	1,325,655
		Grafton WWTP	2,882,539	2,896,952	2,911,436	2,925,993	2,940,623	2,955,327	2,970,103
		Leominster WPCF	6,629,410	6,662,557	6,695,870	6,729,349	6,762,996	6,796,811	6,830,795
		Westborough WWTF	12,515,937	12,578,517	12,641,410	12,704,617	12,768,140	12,831,980	12,896,140
			Price increases WITH step increase						
			2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
		Barnstable WWTP WPCD - DPW	$ 0.43	$ 0.45	$ 0.48	$ 0.51	$ 0.54	$ 0.58	$ 0.61
		Douglas WWTP	$ 0.24	$ 0.25	$ 0.27	$ 0.28	$ 0.30	$ 0.32	$ 0.34

Table H-5D: Dewatering Cost Calculations

		Grafton WWTP	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.32	$ 0.34	$ 0.37
		Leominster WPCF	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20
		Westborough WWTF	$ 0.38	$ 0.40	$ 0.42	$ 0.45	$ 0.48	$ 0.51	$ 0.54
			Cost increases WITH step increase						
			2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
		Barnstable WWTP WPCD - DPW	$ 110,153	$ 117,568	$ 125,481	$ 133,927	$ 142,942	$ 152,563	$ 162,833
		Douglas WWTP	$ 305,212	$ 325,756	$ 347,683	$ 371,085	$ 396,063	$ 422,722	$ 451,176
		Grafton WWTP	$ 735,550	$ 785,060	$ 837,902	$ 894,301	$ 954,497	$ 1,018,744	$ 1,087,316
		Leominster WPCF	$ 925,684	$ 987,991	$ 1,054,493	$ 1,125,471	$ 1,201,226	$ 1,282,081	$ 1,368,378
		Westborough WWTF	$ 4,698,373	$ 5,014,621	$ 5,352,155	$ 5,712,408	$ 6,096,910	$ 6,507,293	$ 6,945,299
		Sum increased annual costs for all plants that will haul - WITH step increase							
		Sum	$ 6,774,972	$ 7,230,996	$ 7,717,714	$ 8,237,193	$ 8,791,639	$ 9,383,404	$ 10,015,001
		Convert to present worth using 2.2% discount rate							
		Present worth from future cost	**$ 5,817,699**	**$ 6,075,625**	**$ 6,344,985**	**$ 6,626,288**	**$ 6,920,062**	**$ 7,226,860**	**$ 7,547,261**
			Sludge Quantity Increases						
			2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
		Barnstable WWTP WPCD - DPW	267,785	269,124	270,470	271,822	273,181	274,547	275,920
		Douglas WWTP	1,332,283	1,338,945	1,345,639	1,352,368	1,359,130	1,365,925	1,372,755
		Grafton WWTP	2,984,954	2,999,878	3,014,878	3,029,952	3,045,102	3,060,328	3,075,629
		Leominster WPCF	6,864,949	6,899,274	6,933,770	6,968,439	7,003,281	7,038,298	7,073,489
		Westborough WWTF	12,960,621	13,025,424	13,090,551	13,156,004	13,221,784	13,287,893	13,354,332
			Price increases WITH step increase						
			2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
		Barnstable WWTP WPCD - DPW	$ 0.65	$ 0.69	$ 0.73	$ 0.78	$ 0.83	$ 0.88	$ 0.93
		Douglas WWTP	$ 0.36	$ 0.38	$ 0.41	$ 0.43	$ 0.46	$ 0.49	$ 0.52
		Grafton WWTP	$ 0.39	$ 0.41	$ 0.44	$ 0.47	$ 0.49	$ 0.53	$ 0.56
		Leominster WPCF	$ 0.21	$ 0.23	$ 0.24	$ 0.25	$ 0.27	$ 0.29	$ 0.31
		Westborough WWTF	$ 0.57	$ 0.61	$ 0.65	$ 0.69	$ 0.73	$ 0.77	$ 0.82
			Cost increases WITH step increase						
			2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
		Barnstable WWTP WPCD - DPW	$ 173,793	$ 185,491	$ 197,976	$ 211,302	$ 225,525	$ 240,705	$ 256,907
		Douglas WWTP	$ 481,544	$ 513,957	$ 548,551	$ 585,474	$ 624,883	$ 666,944	$ 711,835
		Grafton WWTP	$ 1,160,503	$ 1,238,616	$ 1,321,987	$ 1,410,970	$ 1,505,943	$ 1,607,308	$ 1,715,496
		Leominster WPCF	$ 1,460,483	$ 1,558,788	$ 1,663,710	$ 1,775,695	$ 1,895,217	$ 2,022,784	$ 2,158,937
		Westborough WWTF	$ 7,412,787	$ 7,911,742	$ 8,444,281	$ 9,012,666	$ 9,619,309	$ 10,266,784	$ 10,957,842
		Sum increased annual costs for all plants that will haul - WITH step increase							
		Sum	$ 10,689,110	$ 11,408,594	$ 12,176,507	$ 12,996,108	$ 13,870,876	$ 14,804,524	$ 15,801,017
		Convert to present worth using 2.2% discount rate							
		Present worth from future cost	**$ 7,881,866**	**$ 8,231,305**	**$ 8,596,237**	**$ 8,977,348**	**$ 9,375,356**	**$ 9,791,009**	**$ 10,225,090**
		How much dewaterers are saving by not hauling liquid, 2024-2044	**$ 144,002,579**						
		Equivalent Annual Cost	**$ 11,263,042**						
		Calculate cost to haul wet cake after dewatering	**Sludge Quantity Increases**						
		Convert liquid sludge (avg 3.7% solids) to cake (avg 22.8% solids)							
		Present Quantity of Dewatered Cake, WTPY (assume 22.8% solids)	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
	Barnstable WWTP WPCD - DP	169	169	170	171	172	173	174	175
	Douglas WWTP	839	843	847	851	856	860	864	869
	Grafton WWTP	1,879	1,889	1,898	1,908	1,917	1,927	1,937	1,946
	Leominster WPCF	4,322	4,344	4,366	4,388	4,409	4,432	4,454	4,476
	Westborough WWTF	8,160	8,201	8,242	8,283	8,325	8,366	8,408	8,450

Table H-5D: Dewatering Cost Calculations

			Price Increases						
	Average cost to haul cake	Step Increase	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
	$ 156.00	$ 226.20	$ 240.22	$ 255.12	$ 270.94	$ 287.73	$ 305.57	$ 324.52	$ 344.64
			Cost Increases						
			2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
		Barnstable WWTP WPCD - DPW	$ 40,706	$ 43,445	$ 46,370	$ 49,491	$ 52,822	$ 56,378	$ 60,172
		Douglas WWTP	$ 202,518	$ 216,150	$ 230,699	$ 246,227	$ 262,801	$ 280,490	$ 299,369
		Grafton WWTP	$ 453,738	$ 484,279	$ 516,876	$ 551,667	$ 588,799	$ 628,431	$ 670,731
		Leominster WPCF	$ 1,043,529	$ 1,113,769	$ 1,188,737	$ 1,268,751	$ 1,354,151	$ 1,445,299	$ 1,542,582
		Westborough WWTF	$ 1,970,122	$ 2,102,731	$ 2,244,266	$ 2,395,328	$ 2,556,557	$ 2,728,639	$ 2,912,304
		Sum increased annual costs for all plants that will haul - WITH step increase							
		Sum	$ 3,710,613	$ 3,960,375	$ 4,226,947	$ 4,511,463	$ 4,815,130	$ 5,139,236	$ 5,485,158
		Convert to present worth using 2.2% discount rate							
		Present worth from future cost	**$ 3,710,613**	**$ 3,875,122**	**$ 4,046,924**	**$ 4,226,343**	**$ 4,413,716**	**$ 4,609,397**	**$ 4,813,753**
			Sludge Quantity Increases						
			2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
		Barnstable WWTP WPCD - DPW	175	176	177	178	179	180	181
		Douglas WWTP	873	877	882	886	891	895	900
		Grafton WWTP	1,956	1,966	1,976	1,985	1,995	2,005	2,015
		Leominster WPCF	4,498	4,521	4,543	4,566	4,589	4,612	4,635
		Westborough WWTF	8,493	8,535	8,578	8,621	8,664	8,707	8,751
			Price Increases						
			2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
			$ 366.01	$ 388.70	$ 412.80	$ 438.39	$ 465.57	$ 494.44	$ 525.09
			Cost Increases						
			2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
		Barnstable WWTP WPCD - DPW	$ 64,223	$ 68,545	$ 73,159	$ 78,084	$ 83,339	$ 88,949	$ 94,936
		Douglas WWTP	$ 319,520	$ 341,027	$ 363,981	$ 388,481	$ 414,630	$ 442,538	$ 472,326
		Grafton WWTP	$ 715,878	$ 764,064	$ 815,493	$ 870,384	$ 928,969	$ 991,498	$ 1,058,236
		Leominster WPCF	$ 1,646,413	$ 1,757,233	$ 1,875,512	$ 2,001,753	$ 2,136,491	$ 2,280,298	$ 2,433,785
		Westborough WWTF	$ 3,108,331	$ 3,317,553	$ 3,540,857	$ 3,779,192	$ 4,033,569	$ 4,305,069	$ 4,594,843
		Sum increased annual costs for all plants that will haul - WITH step increase							
		Sum	$ 5,854,364	$ 6,248,421	$ 6,669,003	$ 7,117,893	$ 7,596,999	$ 8,108,353	$ 8,654,126
		Convert to present worth using 2.2% discount rate							
		Present worth from future cost	**$ 5,027,169**	**$ 5,250,046**	**$ 5,482,805**	**$ 5,725,884**	**$ 5,979,739**	**$ 6,244,848**	**$ 6,521,711**
			Sludge Quantity Increases						
		Barnstable WWTP WPCD - DPW	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
		Douglas WWTP	182	183	184	184	185	186	187
		Grafton WWTP	904	909	913	918	922	927	931
		Leominster WPCF	2,025	2,036	2,046	2,056	2,066	2,077	2,087
		Westborough WWTF	4,658	4,681	4,705	4,728	4,752	4,776	4,800
			8,794	8,838	8,882	8,927	8,972	9,016	9,061
			Price Increases						
			2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
			$ 557.65	$ 592.22	$ 628.94	$ 667.93	$ 709.35	$ 753.33	$ 800.03
			Cost Increases						
			2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
		Barnstable WWTP WPCD - DPW	$ 101,326	$ 108,147	$ 115,426	$ 123,195	$ 131,487	$ 140,338	$ 149,784
		Douglas WWTP	$ 504,118	$ 538,050	$ 574,266	$ 612,920	$ 654,176	$ 698,208	$ 745,205

Table H-5D: Dewatering Cost Calculations

		Grafton WWTP	$ 1,129,466	$ 1,205,490	$ 1,286,632	$ 1,373,235	$ 1,465,667	$ 1,564,321	$ 1,669,616
		Leominster WPCF	$ 2,597,603	$ 2,772,448	$ 2,959,061	$ 3,158,236	$ 3,370,816	$ 3,597,706	$ 3,839,868
		Westborough WWTF	$ 4,904,122	$ 5,234,219	$ 5,586,534	$ 5,962,563	$ 6,363,904	$ 6,792,258	$ 7,249,445
		Sum increased annual costs for all plants that will haul - WITH step increase							
		Sum	$ 9,236,635	$ 9,858,353	$ 10,521,919	$ 11,230,149	$ 11,986,050	$ 12,792,831	$ 13,653,917
		Convert to present worth using 2.2% discount rate							
		Present worth from future cost	**$ 6,810,849**	**$ 7,112,805**	**$ 7,428,149**	**$ 7,757,473**	**$ 8,101,398**	**$ 8,460,571**	**$ 8,835,667**
		How much dewaterers still have to pay to haul cake, 2024-2044	**$ 124,434,982**						
		Equivalent Annual Cost	**$ 9,732,579**						
			% population growth rate	0.50%					
			Starting Year	2023					
			Increase in sludge due to population growth						
			Increase quantities of sludge by 0.5% per year to match population growth						
		Present Quantity of Sludge, dt/yr	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
	Barnstable WWTP WPCD - DP	52	52	52	53	53	53	53	54
	Douglas WWTP	64	64	65	65	65	66	66	66
	Grafton WWTP	489	491	493	496	498	501	503	506
	Leominster WPCF	1,248	1,255	1,261	1,267	1,274	1,280	1,286	1,293
	Westborough WWTF	2,006	2,016	2,026	2,036	2,046	2,057	2,067	2,077
			2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
		Barnstable WWTP WPCD - DPW	54	54	54	55	55	55	56
		Douglas WWTP	67	67	67	68	68	68	69
		Grafton WWTP	508	511	514	516	519	521	524
		Leominster WPCF	1,299	1,306	1,312	1,319	1,325	1,332	1,339
		Westborough WWTF	2,088	2,098	2,109	2,119	2,130	2,140	2,151
			2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
		Barnstable WWTP WPCD - DPW	56	56	56	57	57	57	58
		Douglas WWTP	69	69	70	70	70	71	71
		Grafton WWTP	527	529	532	534	537	540	543
		Leominster WPCF	1,345	1,352	1,359	1,366	1,373	1,379	1,386
		Westborough WWTF	2,162	2,173	2,184	2,194	2,205	2,216	2,228
		Use cost curves to calculate Capital and O&M costs	**Capital Cost of buildout facility, Screw Press**		**Capital Cost of buildout facility, Centrifuge**				
		Barnstable WWTP WPCD - DPW	$ 9,211,439		$ 9,067,057				
		Douglas WWTP	$ 9,355,522		$ 9,139,166				
		Grafton WWTP	$ 14,405,617		$ 11,666,571				
		Leominster WPCF	$ 23,442,928		$ 16,189,446				
		Westborough WWTF	$ 32,451,853		$ 20,698,114				
		Cost for all 5 plants to install given dewatering facilities	**$ 88,867,359**		**$ 66,760,354**				
		Average cost of facilities		**$ 77,813,856**					
			Screw Press Cost of O&M per year, 2023 dollars						
		Calculate Annual O&M cost, by year, per plant, for screw presses	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
		Barnstable WWTP WPCD - DPW	$ 181,561	$ 181,795	$ 182,031	$ 182,267	$ 182,505	$ 182,744	$ 182,984
		Douglas WWTP	$ 192,519	$ 192,808	$ 193,099	$ 193,391	$ 193,684	$ 193,979	$ 194,276
		Grafton WWTP	$ 576,608	$ 578,817	$ 581,038	$ 583,270	$ 585,512	$ 587,767	$ 590,032
		Leominster WPCF	$ 1,263,947	$ 1,269,593	$ 1,275,268	$ 1,280,970	$ 1,286,702	$ 1,292,462	$ 1,298,251
		Westborough WWTF	$ 1,949,127	$ 1,958,199	$ 1,967,317	$ 1,976,480	$ 1,985,689	$ 1,994,944	$ 2,004,245
		Capital cost of screw press	**$ 88,867,359**						
		Capital and O&M cost, per year	$ 93,031,120	$ 4,181,213	$ 4,198,752	$ 4,216,378	$ 4,234,092	$ 4,251,895	$ 4,269,787

Table H-5D: Dewatering Cost Calculations

		Escalated at 4.7% per year	$	93,031,120	$	4,377,730	$	4,602,709	$	4,839,267	$	5,087,999	$	5,349,534	$	5,624,531
		Discounted at 2.2% per year	$	93,031,120	$	4,283,493	$	4,406,682	$	4,533,430	$	4,663,838	$	4,798,014	$	4,936,066
				2031		**2032**		**2033**		**2034**		**2035**		**2036**		**2037**
		Barnstable WWTP WPCD - DPW	$	183,226	$	183,468	$	183,712	$	183,957	$	184,204	$	184,451	$	184,700
		Douglas WWTP	$	194,573	$	194,873	$	195,174	$	195,476	$	195,780	$	196,085	$	196,392
		Grafton WWTP	$	592,309	$	594,597	$	596,896	$	599,207	$	601,530	$	603,864	$	606,210
		Leominster WPCF	$	1,304,068	$	1,309,915	$	1,315,791	$	1,321,697	$	1,327,632	$	1,333,596	$	1,339,591
		Westborough WWTF	$	2,013,592	$	2,022,987	$	2,032,428	$	2,041,917	$	2,051,453	$	2,061,037	$	2,070,669
		Capital and O&M cost, per year	$	4,287,769	$	4,305,840	$	4,324,002	$	4,342,254	$	4,360,598	$	4,379,033	$	4,397,561
		Escalated at 4.7% per year	$	5,913,684	$	6,217,722	$	6,537,414	$	6,873,565	$	7,227,025	$	7,598,685	$	7,989,484
		Discounted at 2.2% per year	$	5,078,107	$	5,224,253	$	5,374,622	$	5,529,337	$	5,688,525	$	5,852,315	$	6,020,840
				2038		**2039**		**2040**		**2041**		**2042**		**2043**		**2044**
		Barnstable WWTP WPCD - DPW	$	184,950	$	185,201	$	185,454	$	185,707	$	185,962	$	186,219	$	186,476
		Douglas WWTP	$	196,701	$	197,011	$	197,322	$	197,635	$	197,950	$	198,266	$	198,584
		Grafton WWTP	$	608,567	$	610,936	$	613,318	$	615,711	$	618,116	$	620,533	$	622,962
		Leominster WPCF	$	1,345,615	$	1,351,670	$	1,357,755	$	1,363,870	$	1,370,016	$	1,376,192	$	1,382,400
		Westborough WWTF	$	2,080,348	$	2,090,077	$	2,099,854	$	2,109,679	$	2,119,554	$	2,129,478	$	2,139,452
		Capital and O&M cost, per year	$	4,416,181	$	4,434,895	$	4,453,702	$	4,472,603	$	4,491,598	$	4,510,689	$	4,529,875
		Escalated at 4.7% per year	$	8,400,409	$	8,832,498	$	9,286,842	$	9,764,588	$	10,266,944	$	10,795,178	$	11,350,626
		Discounted at 2.2% per year	$	6,194,238	$	6,372,651	$	6,556,223	$	6,745,105	$	6,939,450	$	7,139,418	$	7,345,171
		NPC, Screw Press	**$**	**206,712,896**												
		O&M only	$	117,845,537												
			Centrifuge Cost of O&M per year, 2023 dollars													
		Calculate Annual O&M cost, by year, per plant, for centrifuges		**2024**		**2025**		**2026**		**2027**		**2028**		**2029**		**2030**
		Barnstable WWTP WPCD - DPW	$	96,588	$	96,926	$	97,266	$	97,608	$	97,952	$	98,297	$	98,644
		Douglas WWTP	$	112,417	$	112,834	$	113,254	$	113,676	$	114,100	$	114,526	$	114,954
		Grafton WWTP	$	667,211	$	670,403	$	673,610	$	676,834	$	680,074	$	683,329	$	686,602
		Leominster WPCF	$	1,660,034	$	1,668,190	$	1,676,386	$	1,684,624	$	1,692,902	$	1,701,222	$	1,709,584
		Westborough WWTF	$	2,649,739	$	2,662,843	$	2,676,013	$	2,689,248	$	2,702,550	$	2,715,918	$	2,729,354
		Capital cost of centrifuge	**$**	**66,760,354**												
		Capital and O&M cost, per year	$	71,946,343	$	5,211,197	$	5,236,530	$	5,261,990	$	5,287,578	$	5,313,293	$	5,339,137
		Escalated at 4.7% per year	$	71,946,343	$	5,456,123	$	5,740,331	$	6,039,348	$	6,353,945	$	6,684,935	$	7,033,171
		Discounted at 2.2% per year	$	71,946,343	$	5,338,672	$	5,495,854	$	5,657,667	$	5,824,249	$	5,995,739	$	6,172,282
				2031		**2032**		**2033**		**2034**		**2035**		**2036**		**2037**
		Barnstable WWTP WPCD - DPW	$	98,993	$	99,343	$	99,695	$	100,049	$	100,405	$	100,763	$	101,122
		Douglas WWTP	$	115,384	$	115,816	$	116,251	$	116,688	$	117,127	$	117,568	$	118,011
		Grafton WWTP	$	689,890	$	693,195	$	696,517	$	699,855	$	703,209	$	706,581	$	709,969
		Leominster WPCF	$	1,717,988	$	1,726,433	$	1,734,921	$	1,743,451	$	1,752,023	$	1,760,639	$	1,769,298
		Westborough WWTF	$	2,742,856	$	2,756,426	$	2,770,063	$	2,783,769	$	2,797,543	$	2,811,387	$	2,825,299
		Capital and O&M cost, per year	$	5,365,110	$	5,391,213	$	5,417,447	$	5,443,811	$	5,470,308	$	5,496,937	$	5,523,699
		Escalated at 4.7% per year	$	7,399,552	$	7,785,024	$	8,190,582	$	8,617,274	$	9,066,200	$	9,538,519	$	10,035,451
		Discounted at 2.2% per year	$	6,354,028	$	6,541,130	$	6,733,746	$	6,932,038	$	7,136,174	$	7,346,326	$	7,562,672
				2038		**2039**		**2040**		**2041**		**2042**		**2043**		**2044**
		Barnstable WWTP WPCD - DPW	$	101,483	$	101,846	$	102,211	$	102,577	$	102,946	$	103,316	$	103,688
		Douglas WWTP	$	118,457	$	118,904	$	119,354	$	119,807	$	120,261	$	120,718	$	121,177
		Grafton WWTP	$	713,375	$	716,797	$	720,237	$	723,693	$	727,167	$	730,659	$	734,167
		Leominster WPCF	$	1,778,000	$	1,786,745	$	1,795,534	$	1,804,368	$	1,813,245	$	1,822,167	$	1,831,133
		Westborough WWTF	$	2,839,281	$	2,853,333	$	2,867,455	$	2,881,648	$	2,895,912	$	2,910,247	$	2,924,653

Table H-5D: Dewatering Cost Calculations

		Capital and O&M cost, per year	$ 5,550,595	$ 5,577,626	$ 5,604,791	$ 5,632,093	$ 5,659,531	$ 5,687,106	$ 5,714,819
		Escalated at 4.7% per year	$ 10,558,278	$ 11,108,351	$ 11,687,089	$ 12,295,987	$ 12,936,616	$ 13,610,631	$ 14,319,772
		Discounted at 2.2% per year	$ 7,785,393	$ 8,014,679	$ 8,250,723	$ 8,493,724	$ 8,743,888	$ 9,001,425	$ 9,266,553
		NPC, Centrifuge	**$ 214,593,304**						
		O&M only	$ 147,832,951						
		Average O&M for Screw Press and Centrifuge	$ 132,839,244						
		Average NPC of centrifuges and screw presses	**$ 210,653,100**						
		Savings from not hauling liquid	**$ 144,002,579**						
		Costs from hauling cake	**$ 124,434,982**						
		Total Cost (NPC of dewatering - liquid sludge hauling savings + cake hauling costs)	**$ 191,085,503**						
		Equivalent Annual Cost	**$ 14,946,000**						

Calculation approach
Total Annual Solids Handling Costs were estimated
For facilities hauling liquid, Column A was multipled by Column C to get Column E (eg, for Acton, 236,631 gal/yr * $0.11/gal = $25,031/yr). Numbers will not be exact due to rounding errors.
For facilities hauling cake, Column B was multipled by Column D to get Column E (eg, for Adams, 983 wt/yr * $170/wt = $167,193/yr)
This provided the total annual solids handling costs for each facility BEFORE price increases
The entirety of these annual costs would be subjected to indirect price increases, therefore Column F is identical to Column E
Next, to determine the INCREASE in annual sludge handling costs, the annual solids handling costs that would be indirectly impacted are multiplied by the percent increase associated with indirect impacts for this Scenario.
According to Table 5-1, since Scenario 5 affects between 15,000 and 20,000 dt/yr, the INDIRECT price increase percentage is 22.5%.
Multiply Column F by 22.5% to get the indirect price increase (eg, for Acton, $25,031 * 22.5% = $5,632)
Lynn has some sludge that is INDIRECTLY impacted, and some sludge that is incinerated on-site (and is thus unaffected by direct or indirect impacts).
For clarity of calculations, the numbers for individual plants or streams are not rounded. However, the total of Column G (total of indirect impacts) is rounded.
Note: data on annual solids handling costs were not available for all plants; these were deemed negligible and not considered.
For clarity of calculations, results for individual plants or sludge loads are not rounded. When values are totaled for Column G (total indirect impacts), this total is rounded.

Table H-5E: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (22.5%)**
Acton Wastewater Collection	Greater Lawrence Sanitary District	236,361	986	$ 0.11	liquid	$ 25,031	$ 25,031	$ 5,632
Adams WWTP	Synagro Waterbury CT incinerator	not liquid	983	not liquid	$ 170.00	$ 167,193	$ 167,193	$ 37,619
Amesbury WWTP	Agresource/Ipswich Compost Facility	not liquid	2,120	not liquid	$ 156.00	$ 330,739	$ 330,739	$ 74,416
Amherst WWTP	MDC Hartford Connecticut Incinerator	3,448,975	14,382	$ 0.19	liquid	$ 661,600	$ 661,600	$ 148,860
Ashfield	Lowell Regional WW Utility	20,869	87	$ 0.24	liquid	$ 5,044	$ 5,044	$ 1,135
Athol WWTP	Cranston WPCF Incinerator	303,029	1,264	$ 0.26	liquid	$ 78,636	$ 78,636	$ 17,693
Attleboro WWTP	Attleboro Monofill	not liquid	9,521	not liquid	$ 156.00	$ 1,485,246	$ 1,485,246	$ 334,180
Ayer WWTP	Cranston WPCF Incinerator	1,964,446	8,192	$ 0.14	liquid	$ 267,496	$ 267,496	$ 60,187
Barnstable WWTP WPCD - DPW	Cranston WPCF Incinerator	4,731,738	19,731	$ 0.18	liquid	$ 859,073	$ 859,073	$ 193,292
Barre WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Belchertown WWTP	Cranston WPCF Incinerator	570,594	2,379	$ 0.17	liquid	$ 94,252	$ 94,252	$ 21,207
Billerica WWTP	Hawk Ridge Compost Facility	not liquid	7,003	not liquid	$ 146.70	$ 1,027,369	$ 1,027,369	$ 231,158
Brockton WWTP	Veolia Naugatuck, CT	not liquid	17,335	not liquid	$ 148.52	$ 2,574,569	$ 2,574,569	$ 579,278
Charlemont Sewer District		-	-	$ 0.16	liquid	$ -	$ -	$ -
Charles River PCD	Cranston WPCF Incinerator	532,573	2,221	$ 0.15	liquid	$ 78,237	$ 78,237	$ 17,603
Charlton WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Chatham WPCF	Hawk Ridge Compost Facility	not liquid	271	not liquid	$ 156.00	$ 42,336	$ 42,336	$ 9,526
Chicopee WWTP	Synagro Waterbury CT incinerator	not liquid	412	not liquid	$ 140.17	$ 57,796	$ 57,796	$ 13,004
Chicopee WWTP	Cranston WPCF Incinerator	not liquid	366	not liquid	$ 140.17	$ 51,363	$ 51,363	$ 11,557
Chicopee WWTP	Casella composting Grasslands NY	not liquid	3,443	not liquid	$ 140.17	$ 482,629	$ 482,629	$ 108,591
Cohasset WWTF	Cranston WPCF Incinerator	524,258	2,186	$ 0.16	liquid	$ 83,881	$ 83,881	$ 18,873
Concord WWTF	New England Waste Services of VT Landfill (Waste USA Landfill)	31,175	130	$ 0.06	liquid	$ 1,882	$ 1,882	$ 423
Concord WWTF	Greater Lawrence Sanitary District	978,417	4,080	$ 0.06	liquid	$ 59,058	$ 59,058	$ 13,288
Devens WWTP	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	3,844	not liquid	$ 170.00	$ 653,421	$ 653,421	$ 147,020
Easthampton WWTP	Synagro Waterbury CT incinerator	not liquid	2,539	not liquid	$ 118.17	$ 300,000	$ 300,000	$ 67,500
Edgartown WWTP	Synagro in Woonsocket, RI incinerator	not liquid	1,011	not liquid	$ 119.00	$ 120,271	$ 120,271	$ 27,061
Erving POTW #1	Lowell Regional WW Utility	192,970	805	$ 0.20	liquid	$ 38,451	$ 38,451	$ 8,652
Erving POTW #3	Erving POTW #1	4,958	21	$ 0.16	liquid	$ 793	$ 793	$ 178
Fairhaven WPCF	Synagro in Woonsocket, RI incinerator	4,650,730	19,394	$ 0.09	liquid	$ 410,178	$ 410,178	$ 92,290
Fall River Regional WWF	Cranston WPCF Incinerator	33,968,066	141,647	$ 0.05	liquid	$ 1,863,588	$ 1,863,588	$ 419,307

Table H-5E: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (22.5%)**
Falmouth WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Fitchburg East WWTP	Resource Control, Inc. – RCI Fitchburg Landfill	not liquid	8,748	not liquid	$ 37.59	$ 328,849	$ 328,849	$ 73,991
Gardner WPCF	City of Gardner West St. Sludge Landfill	not liquid	3,276	not liquid	$ 2.72	$ 8,925	$ 8,925	$ 2,008
Gloucester WPCF	Hawk Ridge Compost Facility	not liquid	2,604	not liquid	$ 156.00	$ 406,256	$ 406,256	$ 91,408
Great Barrington WWTP	Synagro Waterbury CT incinerator	not liquid	937	not liquid	$ 151.00	$ 141,446	$ 141,446	$ 31,825
Greenfield WPCF	Lowell Regional WW Utility	3,138,258	13,087	$ 0.23	liquid	$ 730,183	$ 730,183	$ 164,291
Hadley WWTP	Lowell Regional WW Utility	1,039,319	4,334	$ 0.23	liquid	$ 243,928	$ 243,928	$ 54,884
Hardwick-Gilbertville WPCF	Cranston WPCF Incinerator	238,609	995	$ 0.11	liquid	$ 25,800	$ 25,800	$ 5,805
Hardwick-Wheelwright WPCF	Cranston WPCF Incinerator	148,681	620	$ 0.08	liquid	$ 12,000	$ 12,000	$ 2,700
Hatfield WWTP	Lowell Regional WW Utility	328,759	1,371	$ 0.24	liquid	$ 78,398	$ 78,398	$ 17,640
Haverhill WWTP	Crossroads Landfill in Maine	not liquid	14,583	not liquid	$ 175.00	$ 2,552,052	$ 2,552,052	$ 574,212
Holyoke WWTP	Veolia Naugatuck, CT	not liquid	428	not liquid	$ 140.00	$ 59,920	$ 59,920	$ 13,482
Holyoke WWTP	Cranston WPCF Incinerator	not liquid	312	not liquid	$ 140.00	$ 43,680	$ 43,680	$ 9,828
Holyoke WWTP	Ontario County MSW LF NY	not liquid	3,639	not liquid	$ 140.00	$ 509,390	$ 509,390	$ 114,613
Holyoke WWTP	Casella composting Grasslands NY	not liquid	5,229	not liquid	$ 140.00	$ 732,060	$ 732,060	$ 164,714
Hopedale WWTF	Synagro in Woonsocket, RI incinerator	1,223,998	5,104	$ 0.09	liquid	$ 110,000	$ 110,000	$ 24,750
Hudson WWTF	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	2,133	not liquid	$ 156.00	$ 332,773	$ 332,773	$ 74,874
Hull WWTF	Cranston WPCF Incinerator	1,211,484	5,052	$ 0.16	liquid	$ 193,837	$ 193,837	$ 43,613
Huntington WWTP	Westfield WPCP	72,000	300	$ 0.34	liquid	$ 24,480	$ 24,480	$ 5,508
Ipswich WWTP	Agresource/Ipswich Compost Facility	not liquid	2,364	not liquid	$ 156.00	$ 368,759	$ 368,759	$ 82,971
Kingston Sewer Commission	Cranston WPCF Incinerator	937,999	3,911	$ 0.16	liquid	$ 150,010	$ 150,010	$ 33,752
Lee WWTP	Cranston WPCF Incinerator	1,153,383	4,810	$ 0.19	liquid	$ 224,000	$ 224,000	$ 50,400
Leicester WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Lenox Center WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Lowell Regional WW Utility	Bethleham MSW Landfill NH	not liquid	7,648	not liquid	$ 190.37	$ 1,456,002	$ 1,456,002	$ 327,600
Lowell Regional WW Utility	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	2,448	not liquid	$ 190.37	$ 466,073	$ 466,073	$ 104,866
Lowell Regional WW Utility	Hawk Ridge Compost Facility	not liquid	11,211	not liquid	$ 190.37	$ 2,134,202	$ 2,134,202	$ 480,196
Lowell Regional WW Utility	Synagro in Woonsocket, RI incinerator	not liquid	64	not liquid	$ 190.37	$ 12,165	$ 12,165	$ 2,737
Lowell Regional WW Utility	Envirem Organics (NB)	not liquid	5,751	not liquid	$ 190.37	$ 1,094,853	$ 1,094,853	$ 246,342
Lynn Regional WF	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	3,306	not liquid	$ 225.00	$ 743,959	$ 743,959	$ 167,391
Lynn Regional WF	Lynn WWTF	not liquid	1,415	not liquid	$ 225.00	$ 318,271	Exception - not directly or indirectly impacted in this scenario	
Manchester By the Sea WWTP	Cranston WPCF Incinerator	111,964	467	$ 0.16	liquid	$ 17,914	$ 17,914	$ 4,031
Mansfield WWTP (MFN)	Synagro in Woonsocket, RI incinerator	4,759,417	19,847	$ 0.11	liquid	$ 541,356	$ 541,356	$ 121,805
Mansfield WWTP (MFN)	Lowell Regional WW Utility	85,106	355	$ 0.11	liquid	$ 9,680	$ 9,680	$ 2,178
Marlborough East WWTP	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	5,598	not liquid	$ 163.75	$ 916,704	$ 916,704	$ 206,258
Marlborough West WWTP	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	3,345	not liquid	$ 156.00	$ 521,814	$ 521,814	$ 117,408
Marshfield WWTF	Cranston WPCF Incinerator	536,735	2,238	$ 0.17	liquid	$ 88,659	$ 88,659	$ 19,948
Maynard WWTP	Cranston WPCF Incinerator	35,246	147	$ 1.00	liquid	$ 35,246	$ 35,246	$ 7,930
Maynard WWTP	Greater Lawrence Sanitary District	2,798,422	11,669	$ 1.00	liquid	$ 2,798,422	$ 2,798,422	$ 629,645
MCI Bridgewater	New Bedford WWTP	379,521	1,583	$ 0.19	liquid	$ 70,591	$ 70,591	$ 15,883
MCI Concord		1,216,199	5,072	$ 0.05	liquid	$ 58,515	$ 58,515	$ 13,166
MCI Norfolk	New Bedford WWTP	366,013	1,526	$ 0.13	liquid	$ 48,497	$ 48,497	$ 10,912

Table H-5E: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (22.5%)**
Medfield WWTP	Cranston WPCF Incinerator	2,415,888	10,074	$ 0.13	liquid	$ 306,201	$ 306,201	$ 68,895
Merrimac WWTP	Agresource/Ipswich Compost Facility	678,068	2,828	$ 0.16	liquid	$ 108,491	$ 108,491	$ 24,410
Middleborough WWTP	Middleborough MSW Landfill	not liquid	2,195	not liquid	$ 156.00	$ 342,407	$ 342,407	$ 77,042
Milford WWTP	Synagro in Woonsocket, RI incinerator	4,777,199	19,921	$ 0.16	liquid	$ 764,352	$ 764,352	$ 171,979
Monroe WWTP	Hoosac WQD	488,109	2,035	$ 0.16	liquid	$ 78,098	$ 78,098	$ 17,572
Montague WPCF	Veolia Naugatuck, CT	not liquid	972	not liquid	$ 178.65	$ 173,623	$ 173,623	$ 39,065
Montague WPCF	Synagro Waterbury CT incinerator	not liquid	24	not liquid	$ 178.65	$ 4,245	$ 4,245	$ 955
Montague WPCF	Synagro in Woonsocket, RI incinerator	not liquid	124	not liquid	$ 178.65	$ 22,176	$ 22,176	$ 4,990
MWRA Clinton WWTP	Town of Clinton Recycling Center	not liquid	1,464	not liquid	$ 156.00	$ 228,350	$ 228,350	$ 51,379
Nantucket Sewer Dept. - Siasconset		-	-	$ 0.16	liquid	$ -	$ -	$ -
Nantucket Sewer Dept. - Surfside		not liquid	-	not liquid	$ 156.00	$ -	$ -	$ -
New Bedford WWTP	Synagro in Woonsocket, RI incinerator	26,053,293	108,642	$ 0.19	liquid	$ 4,942,657	$ 4,942,657	$ 1,112,098
Newburyport WWTP	Agresource/Ipswich Compost Facility	not liquid	2,729	not liquid	$ 156.00	$ 425,666	$ 425,666	$ 95,775
North Attleborough WPCF	Synagro in Woonsocket, RI incinerator	3,603,805	15,028	$ 0.11	liquid	$ 407,230	$ 407,230	$ 91,627
North Attleborough WPCF	Lowell Regional WW Utility	585,784	2,443	$ 0.11	liquid	$ 66,194	$ 66,194	$ 14,894
North Brookfield WWTP	Synagro Waterbury CT incinerator	not liquid	985	not liquid	$ 203.01	$ 199,951	$ 199,951	$ 44,989
Northampton WWTF	Synagro Waterbury CT incinerator	not liquid	4,506	not liquid	$ 157.00	$ 707,394	$ 707,394	$ 159,164
Northbridge WWTF	Cranston WPCF Incinerator	2,759,820	11,508	$ 0.06	liquid	$ 167,132	$ 167,132	$ 37,605
Northfield WPCF	Lowell Regional WW Utility	145,531	607	$ 0.25	liquid	$ 36,048	$ 36,048	$ 8,111
Oak Bluffs WWTP		400,000	1,668	$ 0.30	liquid	$ 119,000	$ 119,000	$ 26,775
Old Deerfield - Historic WWTP	Lowell Regional WW Utility	202,009	842	$ 0.25	liquid	$ 51,452	$ 51,452	$ 11,577
Orange WWTP	Lowell Regional WW Utility	313,571	1,308	$ 0.22	liquid	$ 67,582	$ 67,582	$ 15,206
Orange WWTP	Montague WPCF	107,211	447	$ 0.22	liquid	$ 23,106	$ 23,106	$ 5,199
Otis DPW		-	-	$ 0.16	liquid	$ -	$ -	$ -
Oxford-Rochdale SD WPCP	Synagro in Woonsocket, RI incinerator	671,325	2,799	$ 0.08	liquid	$ 54,122	$ 54,122	$ 12,178
Palmer WWTF	MDC Hartford Connecticut Incinerator	not liquid	2,921	not liquid	$ 160.07	$ 467,584	$ 467,584	$ 105,206
Pepperell WWTF		not liquid	1,047	not liquid	$ 156.00	$ 163,332	$ 163,332	$ 36,750
Pittsfield WWTP	Casella composting Grasslands NY	not liquid	6,022	not liquid	$ 161.00	$ 969,536	$ 969,536	$ 218,146
Plymouth WWTF	Cranston WPCF Incinerator	6,344,891	26,458	$ 0.16	liquid	$ 1,015,183	$ 1,015,183	$ 228,416
Provincetown Public Works	Cranston WPCF Incinerator	888,700	3,706	$ 0.17	liquid	$ 147,042	$ 147,042	$ 33,084
Rockland WWTP	Synagro in Woonsocket, RI incinerator	not liquid	1,315	not liquid	$ 190.00	$ 249,877	$ 249,877	$ 56,222
Rockport WWTP	Agresource/Ipswich Compost Facility	not liquid	473	not liquid	$ 156.00	$ 73,840	$ 73,840	$ 16,614
Royalston WWTF		-	-	$ 0.16	liquid	$ -	$ -	$ -
Russell Village WWTF	Westfield WPCP	70,519	294	$ 0.21	liquid	$ 15,000	$ 15,000	$ 3,375
Salisbury WWTF		-	-	$ 0.16	liquid	$ -	$ -	$ -
Scituate WWTF	Middleborough MSW Landfill	not liquid	1,895	not liquid	$ 172.00	$ 325,917	$ 325,917	$ 73,331
Somerset WWTF	Synagro in Woonsocket, RI incinerator	2,050,609	8,551	$ 0.14	liquid	$ 288,245	$ 288,245	$ 64,855
South Deerfield	Lowell Regional WW Utility	1,303,836	5,437	$ 0.18	liquid	$ 238,870	$ 238,870	$ 53,746
South Essex Sewerage District	Hawk Ridge Compost Facility	not liquid	19,646	not liquid	$ 135.08	$ 2,653,817	$ 2,653,817	$ 597,109
South Essex Sewerage District	Bethleham MSW Landfill NH	not liquid	1,389	not liquid	$ 135.08	$ 187,687	$ 187,687	$ 42,230
South Essex Sewerage District	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	5,020	not liquid	$ 135.08	$ 678,091	$ 678,091	$ 152,570
South Essex Sewerage District	Synagro in Woonsocket, RI incinerator	not liquid	5,680	not liquid	$ 135.08	$ 767,319	$ 767,319	$ 172,647
South Essex Sewerage District	Synagro Waterbury CT incinerator	not liquid	2,538	not liquid	$ 135.08	$ 342,788	$ 342,788	$ 77,127

Table H-5E: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (22.5%)**
South Hadley WWTP	Synagro Waterbury CT incinerator	not liquid	4,217	not liquid	$ 143.00	$ 603,037	$ 603,037	$ 135,683
Spencer WWTP	Synagro in Woonsocket, RI incinerator	1,147,537	4,785	$ 0.14	liquid	$ 160,511	$ 160,511	$ 36,115
Springfield WWTP - Bondi's Island	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	4,344	not liquid	$ 142.57	$ 619,278	$ 619,278	$ 139,337
Springfield WWTP - Bondi's Island	Bethleham MSW Landfill NH	not liquid	1,479	not liquid	$ 142.57	$ 210,905	$ 210,905	$ 47,454
Springfield WWTP - Bondi's Island	Ontario County MSW LF NY	not liquid	3,598	not liquid	$ 142.57	$ 512,949	$ 512,949	$ 115,414
Springfield WWTP - Bondi's Island	Casella composting Grasslands NY	not liquid	17,547	not liquid	$ 142.57	$ 2,501,648	$ 2,501,648	$ 562,871
Springfield WWTP - Bondi's Island	Synagro in Woonsocket, RI incinerator	not liquid	2,545	not liquid	$ 142.57	$ 362,803	$ 362,803	$ 81,631
Springfield WWTP - Bondi's Island	Synagro Waterbury CT incinerator	not liquid	1,627	not liquid	$ 142.57	$ 231,937	$ 231,937	$ 52,186
Springfield WWTP - Bondi's Island	Chemung MSW Landfill NY	not liquid	6,397	not liquid	$ 142.57	$ 911,974	$ 911,974	$ 205,194
Stockbridge WWTP	Cranston WPCF Incinerator	282,280	1,177	$ 0.09	liquid	$ 25,405	$ 25,405	$ 5,716
Sturbridge WPCF	Cranston WPCF Incinerator	1,815,155	7,569	$ 0.13	liquid	$ 241,597	$ 241,597	$ 54,359
Sunderland WWTP	Lowell Regional WW Utility	56,463	235	$ 0.24	liquid	$ 13,345	$ 13,345	$ 3,003
Sunderland WWTP	Montague WPCF	282,739	1,179	$ 0.24	liquid	$ 66,825	$ 66,825	$ 15,036
Taunton WWTP	Veolia Naugatuck, CT	not liquid	7,430	not liquid	$ 133.25	$ 990,051	$ 990,051	$ 222,761
Tisbury Public Works		-	-	$ 0.16	liquid	$ -	$ -	$ -
Upton WWTP	Cranston WPCF Incinerator	324,000	1,351	$ 0.08	liquid	$ 24,927	$ 24,927	$ 5,609
Uxbridge WWTF	Cranston WPCF Incinerator	2,997,369	12,499	$ 0.16	liquid	$ 479,579	$ 479,579	$ 107,905
Ware WWTP	Cranston WPCF Incinerator	2,713,568	11,316	$ 0.08	liquid	$ 230,596	$ 230,596	$ 51,884
Wareham WPCF		-	-	$ 0.16	liquid	$ -	$ -	$ -
Warren WWTP	Cranston WPCF Incinerator	314,568	1,312	$ 0.12	liquid	$ 37,479	$ 37,479	$ 8,433
Wayland WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Webster WWTF	Synagro in Woonsocket, RI incinerator	3,185,671	13,284	$ 0.11	liquid	$ 342,460	$ 342,460	$ 77,053
West Stockbridge	Cranston WPCF Incinerator	103,002	430	$ 0.17	liquid	$ 17,407	$ 17,407	$ 3,917
Westborough WWTF	Cranston WPCF Incinerator	204,866	854	$ 0.16	liquid	$ 32,779	$ 32,779	$ 7,375
Westfield WPCP	Veolia Naugatuck, CT	not liquid	5,151	not liquid	$ 135.00	$ 695,421	$ 695,421	$ 156,470
Winchendon WPCF	Cranston WPCF Incinerator	1,282,214	5,347	$ 0.07	liquid	$ 87,581	$ 87,581	$ 19,706
							Total	**$ 12,913,000**

Table H-5F: Summary of Scenario 5 calculations		
Assumptions		
Population increases 0.5% per year		
Sludge mgmt prices increase 6.2% per year		
Directly impacted plants see increase of 45% to sludge mgmt costs in the first year		
Escalation (apart from sludge mgmt) is 4.7% per year		
Discount rate is 2.2% per year		
Half of the plants in scenario 5 will haul further away, half will dewater		
Dewatering facilities are sized for the need in 2044		
UBCW	Annual cost for UBCW to haul dewatered cake, factoring in population growth, escalation, and price increases	$ 25,638,000
Plants that continue to haul	Amount paid due to escalation and population growth ONLY, NPV	$ 54,232,000
	Amount paid due to escalation, population growth AND step increase, NPV	$ 78,636,000
	Net Increase in hauling costs	$ 24,404,000
	Present worth of hauling, converted to annual costs	$ 1,909,000
Plants that install dewatering	Amount that would be paid for hauling liquid sludge if dewatering were not installed	$ 144,003,000
	Amount that still has to be paid to haul dewatered cake	$ 124,435,000
	Capital cost of dewatering, average	$ 77,814,000
	Average NPV of O&M costs	$ 132,839,000
	Total NPV of dewatering	$ 210,653,000
	Dewatering and cake hauling costs, minus liquid hauling savings	$ 191,086,000
	Present worth of dewatering, converted to annual costs	$ 14,946,000
Total annual increase, direct costs to plants (including amortized capital costs)		**$ 42,493,000**

Total annual increase, indirect costs to plants	**$ 12,913,000**

Table H-6A: Plants Directly Impacted in Scenario 6			
Regional/national incineration restrictions with regional impact			
POTW name	**DEP "region"**	**Permitted or design flow (MGD)**	**Notes**
Athol WWTP	West	1.75	Some sludge streams indirectly impacted; continues hauling
Ayer WWTP	Central	1.79	Continues hauling
Barnstable WWTP WPCD - DPW	Southeast	4.20	Some sludge streams indirectly impacted; continues hauling
Belchertown WWTP	West	1.00	Installs dewatering
Charles River PCD	Central	5.70	Some sludge streams indirectly impacted; continues hauling
Chicopee WWTP	West	15.50	Some sludge streams indirectly impacted; hauls cake
Cohasset WWTF	Southeast	0.05	Installs dewatering
Fairhaven WPCF	Southeast	5.00	Installs dewatering
Fall River Regional WWF	Southeast	30.90	Continues hauling
Hardwick-Gilbertville WPCF	West	0.23	Installs dewatering
Hardwick-Wheelwright WPCF	West	0.04	Continues hauling
Holyoke WWTP	West	17.50	Some sludge streams indirectly impacted; hauls cake
Hopedale WWTF	Central	0.59	Continues hauling
Hull WWTF	Southeast	3.07	Installs dewatering
Kingston Sewer Commission	Southeast	0.50	Installs dewatering
Lee WWTP	West	1.25	Installs dewatering
Lowell Regional WW Utility	Northeast	32.00	Some sludge streams indirectly impacted; hauls cake
Manchester By the Sea WWTP	Northeast	0.67	Some sludge streams indirectly impacted; installs dewatering
Mansfield WWTP (MFN)	Southeast	3.14	Some sludge streams indirectly impacted; continues hauling
Marshfield WWTF	Southeast	2.10	Some sludge streams indirectly impacted; installs dewatering
Maynard WWTP	Central	1.45	Some sludge streams indirectly impacted; continues hauling
Medfield WWTP	Central	1.52	Continues hauling
Milford WWTP	Central	4.20	Continues hauling
Montague WPCF	West	1.83	Some sludge streams indirectly impacted; hauls cake
New Bedford WWTP	Southeast	30.00	Installs dewatering
North Attleborough WPCF	Southeast	4.61	Some sludge streams indirectly impacted; continues hauling
Northbridge WWTF	Central	2.00	Installs dewatering

Table H-6A: Plants Directly Impacted in Scenario 6			
Regional/national incineration restrictions with regional impact			
POTW name	**DEP "region"**	**Permitted or design flow (MGD)**	**Notes**
Oxford-Rochdale SD WPCP	Central	0.50	Continues hauling
Plymouth WWTF	Southeast	3.00	Installs dewatering
Rockland WWTP	Southeast	2.50	Hauls cake
Somerset WWTF	Southeast	4.20	Installs dewatering
South Essex Sewerage District	Northeast	29.70	Some sludge streams indirectly impacted; hauls cake
Spencer WWTP	Central	1.08	Continues hauling
Springfield WWTP - Bondi's Island	West	67.00	Some sludge streams indirectly impacted; hauls cake
Stockbridge WWTP	West	0.46	Installs dewatering
Sturbridge WPCF	Central	1.30	Continues hauling
Upton WWTP	Central	0.40	Installs dewatering
Uxbridge WWTF	Central	1.50	Installs dewatering
Ware WWTP	West	1.00	Installs dewatering
Warren WWTP	West	1.50	Continues hauling
Webster WWTF	Central	6.00	Installs dewatering
West Stockbridge	West	0.08	Continues hauling
Westborough WWTF	Central	7.68	Some sludge streams indirectly impacted; continues hauling
Winchendon WPCF	Central	1.10	Installs dewatering
	Total # of Plants	44	

To determine cost increases for plants that would continue hauling in Scenario 6, the following approach was taken (similar to that taken in Scenario 5). Sludge quantity increases, at 0.5% per year to follow population growth, and price increases, increasing at 6.2% per year to match the average rate determined in Part 1, were calculated. The resulting costs were determined by multiplying quantity by price. This provided the cost of hauling the plants would see before a 60% increase (owing to the difficulty of finding outlets for sludge). Next, these calculations were repeated, but including the 60% increase in prices (as well as escalation and population growth). The difference between the two was found, which provided the overall increase in solids hauling costs that would have to be paid over 20 years, and converted to an annual cost.

Table H-6B: Hauling Cost Calculations

POTW name	Liquid - unit cost ($/gal)	Destination Facility	Destination Facility State	Destination Facility Type	volume, for liquid (gal/yr)	Quantity (wet US tons/year)		
Athol WWTP	$ 0.26	Cranston WPCF Incinerator	RI	Incinerator	303,029	1,264		
Ayer WWTP	$ 0.14	Cranston WPCF Incinerator	RI	Incinerator	1,964,446	8,192		
Barnstable WWTP WPCD - DPW	$ 0.18	Cranston WPCF Incinerator	RI	Incinerator	4,731,738	19,731		
Charles River PCD	$ 0.15	Cranston WPCF Incinerator	RI	Incinerator	532,573	2,221		
Fall River Regional WWF	$ 0.05	Cranston WPCF Incinerator	RI	Incinerator	33,968,066	141,647		
Hardwick-Wheelwright WPCF	$ 0.08	Cranston WPCF Incinerator	RI	Incinerator	148,681	620		
Hopedale WWTF	$ 0.09	Synagro in Woonsocket, RI incinerator	RI	Incinerator	1,223,998	5,104		
Mansfield WWTP (MFN)	$ 0.11	Synagro in Woonsocket, RI incinerator	RI	Incinerator	4,759,417	19,847		
Maynard WWTP	$ 1.00	Cranston WPCF Incinerator	RI	Incinerator	35,246	147		
Medfield WWTP	$ 0.13	Cranston WPCF Incinerator	RI	Incinerator	2,415,888	10,074		
Milford WWTP	Assumed $0.16 - Average cost for other plants	Synagro in Woonsocket, RI incinerator	RI	Incinerator	4,777,199	19,921		
North Attleborough WPCF	$ 0.11	Synagro in Woonsocket, RI incinerator	RI	Incinerator	3,603,805	15,028		
Oxford-Rochdale SD WPCP	$ 0.08	Synagro in Woonsocket, RI incinerator	RI	Incinerator	671,325	2,799		
Spencer WWTP	$ 0.14	Synagro in Woonsocket, RI incinerator	RI	Incinerator	1,147,537	4,785		
Sturbridge WPCF	$ 0.13	Cranston WPCF Incinerator	RI	Incinerator	1,815,155	7,569		
Warren WWTP	$ 0.12	Cranston WPCF Incinerator	RI	Incinerator	314,568	1,312		
West Stockbridge	$ 0.17	Cranston WPCF Incinerator	RI	Incinerator	103,002	430		
Westborough WWTF	Assumed $0.16 - Average cost for other plants	Cranston WPCF Incinerator	RI	Incinerator	204,866	854		
		Sludge Quantity Increases						
		Increase quantities of liquid sludge by 0.5% per year to match population growth						
	Present Quantity of Liquid Sludge, gal/yr (assume 3.7% solids)	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Athol WWTP	303,029	304,544	306,067	307,597	309,135	310,681	312,234	313,795
Ayer WWTP	1,964,446	1,974,268	1,984,139	1,994,060	2,004,030	2,014,050	2,024,121	2,034,241
Barnstable WWTP WPCD - DPW	4,731,738	4,755,397	4,779,174	4,803,070	4,827,085	4,851,221	4,875,477	4,899,854
Charles River PCD	532,573	535,236	537,912	540,602	543,305	546,021	548,751	551,495
Fall River Regional WWF	33,968,066	34,137,906	34,308,596	34,480,139	34,652,539	34,825,802	34,999,931	35,174,931
Hardwick-Wheelwright WPCF	148,681	149,424	150,172	150,922	151,677	152,435	153,198	153,964
Hopedale WWTF	1,223,998	1,230,118	1,236,269	1,242,450	1,248,663	1,254,906	1,261,181	1,267,486
Mansfield WWTP (MFN)	4,759,417	4,783,214	4,807,130	4,831,166	4,855,322	4,879,598	4,903,996	4,928,516
Maynard WWTP	35,246	35,422	35,599	35,777	35,956	36,136	36,316	36,498
Medfield WWTP	2,415,888	2,427,967	2,440,107	2,452,308	2,464,569	2,476,892	2,489,276	2,501,723
Milford WWTP	4,777,199	4,801,085	4,825,090	4,849,216	4,873,462	4,897,829	4,922,318	4,946,930
North Attleborough WPCF	3,603,805	3,621,824	3,639,933	3,658,133	3,676,423	3,694,805	3,713,279	3,731,846
Oxford-Rochdale SD WPCP	671,325	674,682	678,055	681,446	684,853	688,277	691,718	695,177
Spencer WWTP	1,147,537	1,153,274	1,159,041	1,164,836	1,170,660	1,176,513	1,182,396	1,188,308
Sturbridge WPCF	1,815,155	1,824,231	1,833,352	1,842,518	1,851,731	1,860,990	1,870,295	1,879,646
Warren WWTP	314,568	316,141	317,722	319,310	320,907	322,511	324,124	325,744
West Stockbridge	103,002	103,517	104,035	104,555	105,078	105,603	106,131	106,662
Westborough WWTF	204,866	205,890	206,920	207,954	208,994	210,039	211,089	212,145
		Price increases without 60% step increase						
		Escalate unit cost by 6.2% per year (following sludge mgmt price increase trends)						
	Present Price of Hauling per gallon	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Athol WWTP	$ 0.26	$ 0.28	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.40

Table H-6B: Hauling Cost Calculations

Ayer WWTP	$ 0.14	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.20	$ 0.21
Barnstable WWTP WPCD - DPW	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.25	$ 0.26	$ 0.28
Charles River PCD	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.22
Fall River Regional WWF	$ 0.05	$ 0.06	$ 0.06	$ 0.07	$ 0.07	$ 0.07	$ 0.08	$ 0.08
Hardwick-Wheelwright WPCF	$ 0.08	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.11	$ 0.12	$ 0.12
Hopedale WWTF	$ 0.09	$ 0.10	$ 0.10	$ 0.11	$ 0.11	$ 0.12	$ 0.13	$ 0.14
Mansfield WWTP (MFN)	$ 0.11	$ 0.12	$ 0.13	$ 0.14	$ 0.14	$ 0.15	$ 0.16	$ 0.17
Maynard WWTP	$ 1.00	$ 1.06	$ 1.13	$ 1.20	$ 1.27	$ 1.35	$ 1.43	$ 1.52
Medfield WWTP	$ 0.13	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19
Milford WWTP	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24
North Attleborough WPCF	$ 0.11	$ 0.12	$ 0.13	$ 0.14	$ 0.14	$ 0.15	$ 0.16	$ 0.17
Oxford-Rochdale SD WPCP	$ 0.08	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.11	$ 0.12	$ 0.12
Spencer WWTP	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21
Sturbridge WPCF	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20
Warren WWTP	$ 0.12	$ 0.13	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18
West Stockbridge	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.23	$ 0.24	$ 0.26
Westborough WWTF	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24
		Cost increases without 60% step increase						
		2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
	Athol WWTP	$ 83,929	$ 89,578	$ 95,608	$ 102,043	$ 108,912	$ 116,242	$ 124,067
	Ayer WWTP	$ 285,501	$ 304,718	$ 325,229	$ 347,120	$ 370,485	$ 395,422	$ 422,038
	Barnstable WWTP WPCD - DPW	$ 916,898	$ 978,614	$ 1,044,485	$ 1,114,789	$ 1,189,825	$ 1,269,912	$ 1,355,390
	Charles River PCD	$ 83,503	$ 89,123	$ 95,122	$ 101,525	$ 108,358	$ 115,652	$ 123,437
	Fall River Regional WWF	$ 1,989,026.28	$ 2,122,907.64	$ 2,265,800.55	$ 2,418,311.58	$ 2,581,088.14	$ 2,754,821.18	$ 2,940,248.19
	Hardwick-Wheelwright WPCF	$ 12,807.72	$ 13,669.81	$ 14,589.92	$ 15,571.97	$ 16,620.12	$ 17,738.82	$ 18,932.82
	Hopedale WWTF	$ 117,403.96	$ 125,306.42	$ 133,740.79	$ 142,742.88	$ 152,350.91	$ 162,605.65	$ 173,550.63
	Mansfield WWTP (MFN)	$ 577,794.67	$ 616,686.03	$ 658,195.17	$ 702,498.29	$ 749,783.44	$ 800,251.37	$ 854,116.29
	Maynard WWTP	$ 37,618.11	$ 40,150.19	$ 42,852.70	$ 45,737.11	$ 48,815.68	$ 52,101.46	$ 55,608.41
	Medfield WWTP	$ 326,811.68	$ 348,809.37	$ 372,287.73	$ 397,346.41	$ 424,091.80	$ 452,637.42	$ 483,104.45
	Milford WWTP	$ 815,800.32	$ 870,711.84	$ 929,319.45	$ 991,871.94	$ 1,058,634.84	$ 1,129,891.56	$ 1,205,944.56
	North Attleborough WPCF	$ 434,640.58	$ 463,896.24	$ 495,121.09	$ 528,447.70	$ 564,017.51	$ 601,981.53	$ 642,500.91
	Oxford-Rochdale SD WPCP	$ 57,765.21	$ 61,653.39	$ 65,803.28	$ 70,232.50	$ 74,959.85	$ 80,005.40	$ 85,390.56
	Spencer WWTP	$ 171,314.91	$ 182,846.12	$ 195,153.49	$ 208,289.28	$ 222,309.23	$ 237,272.86	$ 253,243.70
	Sturbridge WPCF	$ 257,859.00	$ 275,215.49	$ 293,740.24	$ 313,511.90	$ 334,614.38	$ 357,137.28	$ 381,176.19
	Warren WWTP	$ 40,001.22	$ 42,693.70	$ 45,567.42	$ 48,634.56	$ 51,908.15	$ 55,402.09	$ 59,131.20
	West Stockbridge	$ 18,579.09	$ 19,829.65	$ 21,164.38	$ 22,588.95	$ 24,109.42	$ 25,732.22	$ 27,464.26
	Westborough WWTF	$ 34,984.85	$ 37,339.68	$ 39,853.01	$ 42,535.51	$ 45,398.58	$ 48,454.36	$ 51,715.82
	Sum increased annual costs for all plants that will haul - WITHOUT step increase							
	Sum	$ 6,262,238	$ 6,683,749	$ 7,133,633	$ 7,613,797	$ 8,126,282	$ 8,673,262	$ 9,257,059
	Convert to present worth using 2.2% discount rate							
	Present worth from future cost	**$ 6,262,238**	**$ 6,539,872**	**$ 6,829,815**	**$ 7,132,612**	**$ 7,448,834**	**$ 7,779,076**	**$ 8,123,958**
		Sludge Quantity Increases						
		2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
	Athol WWTP	315,364	316,941	318,526	320,118	321,719	323,328	324,944
	Ayer WWTP	2,044,412	2,054,634	2,064,908	2,075,232	2,085,608	2,096,036	2,106,516
	Barnstable WWTP WPCD - DPW	4,924,353	4,948,975	4,973,720	4,998,589	5,023,582	5,048,700	5,073,943

Table H-6B: Hauling Cost Calculations

	Charles River PCD	554,253	557,024	559,809	562,608	565,421	568,248	571,090
	Fall River Regional WWF	35,350,805	35,527,560	35,705,197	35,883,723	36,063,142	36,243,458	36,424,675
	Hardwick-Wheelwright WPCF	154,733	155,507	156,285	157,066	157,851	158,641	159,434
	Hopedale WWTF	1,273,824	1,280,193	1,286,594	1,293,027	1,299,492	1,305,989	1,312,519
	Mansfield WWTP (MFN)	4,953,159	4,977,925	5,002,814	5,027,828	5,052,967	5,078,232	5,103,623
	Maynard WWTP	36,680	36,864	37,048	37,233	37,420	37,607	37,795
	Medfield WWTP	2,514,231	2,526,803	2,539,437	2,552,134	2,564,894	2,577,719	2,590,607
	Milford WWTP	4,971,664	4,996,523	5,021,505	5,046,613	5,071,846	5,097,205	5,122,691
	North Attleborough WPCF	3,750,505	3,769,257	3,788,104	3,807,044	3,826,080	3,845,210	3,864,436
	Oxford-Rochdale SD WPCP	698,653	702,146	705,657	709,185	712,731	716,295	719,876
	Spencer WWTP	1,194,249	1,200,221	1,206,222	1,212,253	1,218,314	1,224,406	1,230,528
	Sturbridge WPCF	1,889,044	1,898,490	1,907,982	1,917,522	1,927,110	1,936,745	1,946,429
	Warren WWTP	327,373	329,010	330,655	332,308	333,970	335,640	337,318
	West Stockbridge	107,195	107,731	108,270	108,811	109,355	109,902	110,452
	Westborough WWTF	213,205	214,271	215,343	216,419	217,501	218,589	219,682
		Price increases without 60% step increase						
		2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
	Athol WWTP	$ 0.42	$ 0.45	$ 0.47	$ 0.50	$ 0.53	$ 0.57	$ 0.60
	Ayer WWTP	$ 0.22	$ 0.23	$ 0.25	$ 0.26	$ 0.28	$ 0.30	$ 0.32
	Barnstable WWTP WPCD - DPW	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.40	$ 0.42
	Charles River PCD	$ 0.24	$ 0.25	$ 0.27	$ 0.28	$ 0.30	$ 0.32	$ 0.34
	Fall River Regional WWF	$ 0.09	$ 0.09	$ 0.10	$ 0.11	$ 0.11	$ 0.12	$ 0.13
	Hardwick-Wheelwright WPCF	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19
	Hopedale WWTF	$ 0.15	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.20	$ 0.21
	Mansfield WWTP (MFN)	$ 0.18	$ 0.20	$ 0.21	$ 0.22	$ 0.23	$ 0.25	$ 0.26
	Maynard WWTP	$ 1.62	$ 1.72	$ 1.82	$ 1.94	$ 2.06	$ 2.19	$ 2.32
	Medfield WWTP	$ 0.21	$ 0.22	$ 0.23	$ 0.25	$ 0.26	$ 0.28	$ 0.29
	Milford WWTP	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
	North Attleborough WPCF	$ 0.18	$ 0.19	$ 0.21	$ 0.22	$ 0.23	$ 0.25	$ 0.26
	Oxford-Rochdale SD WPCP	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19
	Spencer WWTP	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.32
	Sturbridge WPCF	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31
	Warren WWTP	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.25	$ 0.26	$ 0.28
	West Stockbridge	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.39
	Westborough WWTF	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
		Cost increases without 60% step increase						
		2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
	Athol WWTP	$ 132,418	$ 141,331	$ 150,844	$ 160,997	$ 171,834	$ 183,400	$ 195,744
	Ayer WWTP	$ 450,445	$ 480,765	$ 513,125	$ 547,664	$ 584,527	$ 623,871	$ 665,864
	Barnstable WWTP WPCD - DPW	$ 1,446,621	$ 1,543,994	$ 1,647,920	$ 1,758,841	$ 1,877,229	$ 2,003,585	$ 2,138,446
	Charles River PCD	$ 131,745	$ 140,613	$ 150,078	$ 160,179	$ 170,961	$ 182,468	$ 194,750
	Fall River Regional WWF	$ 3,138,156.30	$ 3,349,385.60	$ 3,574,832.74	$ 3,815,454.73	$ 4,072,272.99	$ 4,346,377.69	$ 4,638,932.37
	Hardwick-Wheelwright WPCF	$ 20,207.19	$ 21,567.33	$ 23,019.03	$ 24,568.44	$ 26,222.14	$ 27,987.16	$ 29,870.97
	Hopedale WWTF	$ 185,232.32	$ 197,700.31	$ 211,007.52	$ 225,210.44	$ 240,369.35	$ 256,548.61	$ 273,816.90
	Mansfield WWTP (MFN)	$ 911,606.86	$ 972,967.11	$ 1,038,457.53	$ 1,108,356.11	$ 1,182,959.56	$ 1,262,584.56	$ 1,347,569.13
	Maynard WWTP	$ 59,351.41	$ 63,346.36	$ 67,610.20	$ 72,161.04	$ 77,018.20	$ 82,202.30	$ 87,735.33
	Medfield WWTP	$ 515,622.21	$ 550,328.74	$ 587,371.36	$ 626,907.33	$ 669,104.46	$ 714,141.88	$ 762,210.77
	Milford WWTP	$ 1,287,116.68	$ 1,373,752.51	$ 1,466,219.79	$ 1,564,911.04	$ 1,670,245.21	$ 1,782,669.41	$ 1,902,660.89
	North Attleborough WPCF	$ 685,747.64	$ 731,905.31	$ 781,169.86	$ 833,750.40	$ 889,870.14	$ 949,767.30	$ 1,013,696.14
	Oxford-Rochdale SD WPCP	$ 91,138.20	$ 97,272.71	$ 103,820.14	$ 110,808.27	$ 118,266.77	$ 126,227.31	$ 134,723.67

Table H-6B: Hauling Cost Calculations

	Spencer WWTP	$ 270,289.53	$ 288,482.72	$ 307,900.49	$ 328,625.27	$ 350,745.04	$ 374,353.69	$ 399,551.44
	Sturbridge WPCF	$ 406,833.16	$ 434,217.10	$ 463,444.25	$ 494,638.68	$ 527,932.81	$ 563,467.97	$ 601,395.00
	Warren WWTP	$ 63,111.32	$ 67,359.35	$ 71,893.31	$ 76,732.44	$ 81,897.30	$ 87,409.81	$ 93,293.37
	West Stockbridge	$ 29,312.88	$ 31,285.93	$ 33,391.78	$ 35,639.38	$ 38,038.27	$ 40,598.62	$ 43,331.32
	Westborough WWTF	$ 55,196.81	$ 58,912.11	$ 62,877.49	$ 67,109.77	$ 71,626.93	$ 76,448.14	$ 81,593.86
	Sum increased annual costs for all plants that will haul - WITHOUT step increase							
	Sum	$ 9,880,152	$ 10,545,185	$ 11,254,982	$ 12,012,554	$ 12,821,119	$ 13,684,109	$ 14,605,186
	Convert to present worth using 2.2% discount rate							
	Present worth from future cost	**$ 8,484,131**	**$ 8,860,272**	**$ 9,253,089**	**$ 9,663,321**	**$ 10,091,741**	**$ 10,539,155**	**$ 11,006,404**
		Sludge Quantity Increases						
		2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
	Athol WWTP	326,569	328,202	329,843	331,492	333,150	334,815	336,489
	Ayer WWTP	2,117,049	2,127,634	2,138,272	2,148,964	2,159,709	2,170,507	2,181,360
	Barnstable WWTP WPCD - DPW	5,099,313	5,124,809	5,150,433	5,176,186	5,202,066	5,228,077	5,254,217
	Charles River PCD	573,945	576,815	579,699	582,597	585,510	588,438	591,380
	Fall River Regional WWF	36,606,798	36,789,832	36,973,781	37,158,650	37,344,444	37,531,166	37,718,822
	Hardwick-Wheelwright WPCF	160,231	161,032	161,837	162,647	163,460	164,277	165,098
	Hopedale WWTF	1,319,082	1,325,677	1,332,306	1,338,967	1,345,662	1,352,391	1,359,152
	Mansfield WWTP (MFN)	5,129,142	5,154,787	5,180,561	5,206,464	5,232,496	5,258,659	5,284,952
	Maynard WWTP	37,984	38,174	38,364	38,556	38,749	38,943	39,138
	Medfield WWTP	2,603,561	2,616,578	2,629,661	2,642,810	2,656,024	2,669,304	2,682,650
	Milford WWTP	5,148,305	5,174,046	5,199,916	5,225,916	5,252,046	5,278,306	5,304,697
	North Attleborough WPCF	3,883,758	3,903,177	3,922,693	3,942,306	3,962,018	3,981,828	4,001,737
	Oxford-Rochdale SD WPCP	723,476	727,093	730,729	734,382	738,054	741,744	745,453
	Spencer WWTP	1,236,680	1,242,864	1,249,078	1,255,324	1,261,600	1,267,908	1,274,248
	Sturbridge WPCF	1,956,161	1,965,942	1,975,771	1,985,650	1,995,579	2,005,556	2,015,584
	Warren WWTP	339,005	340,700	342,403	344,115	345,836	347,565	349,303
	West Stockbridge	111,004	111,559	112,117	112,677	113,241	113,807	114,376
	Westborough WWTF	220,780	221,884	222,994	224,109	225,229	226,355	227,487
		Price increases without 60% step increase						
		2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
	Athol WWTP	$ 0.64	$ 0.68	$ 0.72	$ 0.77	$ 0.81	$ 0.86	$ 0.92
	Ayer WWTP	$ 0.34	$ 0.36	$ 0.38	$ 0.40	$ 0.43	$ 0.45	$ 0.48
	Barnstable WWTP WPCD - DPW	$ 0.45	$ 0.48	$ 0.50	$ 0.54	$ 0.57	$ 0.60	$ 0.64
	Charles River PCD	$ 0.36	$ 0.38	$ 0.41	$ 0.43	$ 0.46	$ 0.49	$ 0.52
	Fall River Regional WWF	$ 0.14	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19
	Hardwick-Wheelwright WPCF	$ 0.20	$ 0.21	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.29
	Hopedale WWTF	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.28	$ 0.30	$ 0.32
	Mansfield WWTP (MFN)	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.38	$ 0.40
	Maynard WWTP	$ 2.47	$ 2.62	$ 2.78	$ 2.95	$ 3.14	$ 3.33	$ 3.54
	Medfield WWTP	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.40	$ 0.42	$ 0.45
	Milford WWTP	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.57
	North Attleborough WPCF	$ 0.28	$ 0.30	$ 0.31	$ 0.33	$ 0.35	$ 0.38	$ 0.40
	Oxford-Rochdale SD WPCP	$ 0.20	$ 0.21	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.29
	Spencer WWTP	$ 0.34	$ 0.37	$ 0.39	$ 0.41	$ 0.44	$ 0.47	$ 0.49
	Sturbridge WPCF	$ 0.33	$ 0.35	$ 0.37	$ 0.39	$ 0.42	$ 0.44	$ 0.47

Table H-6B: Hauling Cost Calculations

	Warren WWTP	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.40	$ 0.42
	West Stockbridge	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56	$ 0.60
	Westborough WWTF	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.57
		Cost increases without 60% step increase						
		2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
	Athol WWTP	$ 208,920	$ 222,982	$ 237,991	$ 254,011	$ 271,108	$ 289,356	$ 308,833
	Ayer WWTP	$ 710,683	$ 758,519	$ 809,575	$ 864,068	$ 922,228	$ 984,304	$ 1,050,557
	Barnstable WWTP WPCD - DPW	$ 2,282,385	$ 2,436,013	$ 2,599,981	$ 2,774,985	$ 2,961,770	$ 3,161,126	$ 3,373,902
	Charles River PCD	$ 207,859	$ 221,850	$ 236,783	$ 252,720	$ 269,731	$ 287,887	$ 307,264
	Fall River Regional WWF	$ 4,951,178.91	$ 5,284,442.76	$ 5,640,138.60	$ 6,019,776.33	$ 6,424,967.48	$ 6,857,432.04	$ 7,319,005.79
	Hardwick-Wheelwright WPCF	$ 31,881.59	$ 34,027.54	$ 36,317.93	$ 38,762.49	$ 41,371.59	$ 44,156.31	$ 47,128.48
	Hopedale WWTF	$ 292,247.52	$ 311,918.70	$ 332,913.94	$ 355,322.38	$ 379,239.13	$ 404,765.72	$ 432,010.50
	Mansfield WWTP (MFN)	$ 1,438,274.01	$ 1,535,084.23	$ 1,638,410.75	$ 1,748,692.18	$ 1,866,396.65	$ 1,992,023.81	$ 2,126,106.93
	Maynard WWTP	$ 93,640.80	$ 99,943.76	$ 106,670.97	$ 113,851.00	$ 121,514.31	$ 129,693.44	$ 138,423.10
	Medfield WWTP	$ 813,515.18	$ 868,272.89	$ 926,716.34	$ 989,093.61	$ 1,055,669.50	$ 1,126,726.62	$ 1,202,566.59
	Milford WWTP	$ 2,030,728.99	$ 2,167,417.36	$ 2,313,306.23	$ 2,469,014.87	$ 2,635,204.26	$ 2,812,579.86	$ 3,001,894.61
	North Attleborough WPCF	$ 1,081,928.03	$ 1,154,752.60	$ 1,232,479.00	$ 1,315,437.16	$ 1,403,979.24	$ 1,498,481.08	$ 1,599,343.84
	Oxford-Rochdale SD WPCP	$ 143,791.92	$ 153,470.55	$ 163,800.66	$ 174,826.08	$ 186,593.62	$ 199,153.24	$ 212,558.24
	Spencer WWTP	$ 426,445.24	$ 455,149.27	$ 485,785.37	$ 518,483.58	$ 553,382.71	$ 590,630.90	$ 630,386.27
	Sturbridge WPCF	$ 641,874.90	$ 685,079.50	$ 731,192.20	$ 780,408.74	$ 832,938.06	$ 889,003.12	$ 948,841.92
	Warren WWTP	$ 99,572.94	$ 106,275.20	$ 113,428.58	$ 121,063.46	$ 129,212.24	$ 137,909.52	$ 147,192.21
	West Stockbridge	$ 46,247.95	$ 49,360.90	$ 52,683.38	$ 56,229.50	$ 60,014.31	$ 64,053.87	$ 68,365.34
	Westborough WWTF	$ 87,085.94	$ 92,947.70	$ 99,204.01	$ 105,881.43	$ 113,008.31	$ 120,614.90	$ 128,733.48
	Sum increased annual costs for all plants that will haul - WITHOUT step increase							
	Sum	$ 15,588,261	$ 16,637,507	$ 17,757,378	$ 18,952,627	$ 20,228,328	$ 21,589,897	$ 23,043,113
	Convert to present worth using 2.2% discount rate							
	Present worth from future cost	**$ 11,494,369**	**$ 12,003,968**	**$ 12,536,159**	**$ 13,091,945**	**$ 13,672,372**	**$ 14,278,532**	**$ 14,911,565**
	Sum the total present worth							
	Sum of cost increases WITHOUT step increase	**$ 210,003,429**						
		Price increases with step increase						
	Increased cost of hauling by 60% due to direct impacts	Escalate unit cost by 6.2% per year (following sludge mgmt price increase trends)						
Present Price of Hauling per gallon	Step Increase	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
$ 0.26	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56	$ 0.60	$ 0.63
$ 0.14	$ 0.22	$ 0.23	$ 0.25	$ 0.26	$ 0.28	$ 0.29	$ 0.31	$ 0.33
$ 0.18	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.39	$ 0.42	$ 0.44
$ 0.15	$ 0.24	$ 0.25	$ 0.27	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36
$ 0.05	$ 0.09	$ 0.09	$ 0.10	$ 0.11	$ 0.11	$ 0.12	$ 0.13	$ 0.13
$ 0.08	$ 0.13	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.17	$ 0.19	$ 0.20
$ 0.09	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.21	$ 0.22
$ 0.11	$ 0.18	$ 0.19	$ 0.21	$ 0.22	$ 0.23	$ 0.25	$ 0.26	$ 0.28
$ 1.00	$ 1.60	$ 1.70	$ 1.80	$ 1.92	$ 2.04	$ 2.16	$ 2.30	$ 2.44
$ 0.13	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31
$ 0.16	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.39
$ 0.11	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.28
$ 0.08	$ 0.13	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.17	$ 0.19	$ 0.20

Table H-6B: Hauling Cost Calculations

$ 0.14	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.28	$ 0.30	$ 0.32	$ 0.34
$ 0.13	$ 0.21	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.32
$ 0.12	$ 0.19	$ 0.20	$ 0.21	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29
$ 0.17	$ 0.27	$ 0.29	$ 0.30	$ 0.32	$ 0.34	$ 0.37	$ 0.39	$ 0.41
$ 0.16	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.39
		Cost increases with step increase						
		Multiply quantity of liquid sludge by escalated mgmt prices						
		2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
	Athol WWTP	$ 134,286	$ 143,325	$ 152,972	$ 163,269	$ 174,259	$ 185,988	$ 198,507
	Ayer WWTP	$ 456,802	$ 487,549	$ 520,366	$ 555,392	$ 592,776	$ 632,675	$ 675,261
	Barnstable WWTP WPCD - DPW	$ 1,467,036	$ 1,565,782	$ 1,671,175	$ 1,783,662	$ 1,903,720	$ 2,031,860	$ 2,168,624
	Charles River PCD	$ 133,604	$ 142,597	$ 152,195	$ 162,440	$ 173,374	$ 185,043	$ 197,499
	Fall River Regional WWF	$ 3,182,442.04	$ 3,396,652.22	$ 3,625,280.88	$ 3,869,298.53	$ 4,129,741.02	$ 4,407,713.89	$ 4,704,397.11
	Hardwick-Wheelwright WPCF	$ 20,492.35	$ 21,871.69	$ 23,343.88	$ 24,915.15	$ 26,592.19	$ 28,382.11	$ 30,292.51
	Hopedale WWTF	$ 187,846.33	$ 200,490.26	$ 213,985.26	$ 228,388.61	$ 243,761.45	$ 260,169.03	$ 277,681.01
	Mansfield WWTP (MFN)	$ 924,471.48	$ 986,697.65	$ 1,053,112.27	$ 1,123,997.26	$ 1,199,653.51	$ 1,280,402.19	$ 1,366,586.06
	Maynard WWTP	$ 60,188.98	$ 64,240.30	$ 68,564.32	$ 73,179.38	$ 78,105.08	$ 83,362.34	$ 88,973.46
	Medfield WWTP	$ 522,898.68	$ 558,094.99	$ 595,660.36	$ 635,754.26	$ 678,546.88	$ 724,219.87	$ 772,967.11
	Milford WWTP	$ 1,305,280.51	$ 1,393,138.94	$ 1,486,911.12	$ 1,586,995.11	$ 1,693,815.75	$ 1,807,826.49	$ 1,929,511.29
	North Attleborough WPCF	$ 695,424.93	$ 742,233.98	$ 792,193.75	$ 845,516.31	$ 902,428.02	$ 963,170.45	$ 1,028,001.45
	Oxford-Rochdale SD WPCP	$ 92,424.34	$ 98,645.42	$ 105,285.25	$ 112,372.00	$ 119,935.76	$ 128,008.63	$ 136,624.89
	Spencer WWTP	$ 274,103.86	$ 292,553.79	$ 312,245.59	$ 333,262.84	$ 355,694.76	$ 379,636.58	$ 405,189.92
	Sturbridge WPCF	$ 412,574.40	$ 440,344.78	$ 469,984.39	$ 501,619.04	$ 535,383.01	$ 571,419.65	$ 609,881.90
	Warren WWTP	$ 64,001.95	$ 68,309.92	$ 72,907.87	$ 77,815.29	$ 83,053.04	$ 88,643.34	$ 94,609.92
	West Stockbridge	$ 29,726.54	$ 31,727.43	$ 33,863.01	$ 36,142.33	$ 38,575.07	$ 41,171.55	$ 43,942.81
	Westborough WWTF	$ 55,975.75	$ 59,743.48	$ 63,764.81	$ 68,056.82	$ 72,637.73	$ 77,526.97	$ 82,745.31
	Sum increased annual costs for all plants that will haul - WITH step increase							
	SUM of hauling sites	$ 10,019,581	$ 10,693,999	$ 11,413,812	$ 12,182,076	$ 13,002,051	$ 13,877,219	$ 14,811,295
	Convert to present worth using 2.2% discount rate							
	Present worth from future cost	**$ 10,019,581**	**$ 10,463,796**	**$ 10,927,704**	**$ 11,412,180**	**$ 11,918,135**	**$ 12,446,521**	**$ 12,998,333**
		Price increases with step increase						
		2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
	Athol WWTP	$ 0.67	$ 0.71	$ 0.76	$ 0.80	$ 0.85	$ 0.91	$ 0.96
	Ayer WWTP	$ 0.35	$ 0.37	$ 0.40	$ 0.42	$ 0.45	$ 0.48	$ 0.51
	Barnstable WWTP WPCD - DPW	$ 0.47	$ 0.50	$ 0.53	$ 0.56	$ 0.60	$ 0.63	$ 0.67
	Charles River PCD	$ 0.38	$ 0.40	$ 0.43	$ 0.46	$ 0.48	$ 0.51	$ 0.55
	Fall River Regional WWF	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20
	Hardwick-Wheelwright WPCF	$ 0.21	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.28	$ 0.30
	Hopedale WWTF	$ 0.23	$ 0.25	$ 0.26	$ 0.28	$ 0.30	$ 0.31	$ 0.33
	Mansfield WWTP (MFN)	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.40	$ 0.42
	Maynard WWTP	$ 2.59	$ 2.75	$ 2.92	$ 3.10	$ 3.29	$ 3.50	$ 3.71
	Medfield WWTP	$ 0.33	$ 0.35	$ 0.37	$ 0.39	$ 0.42	$ 0.44	$ 0.47
	Milford WWTP	$ 0.41	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56	$ 0.59
	North Attleborough WPCF	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.40	$ 0.42

Table H-6B: Hauling Cost Calculations

	Oxford-Rochdale SD WPCP	$ 0.21	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.28	$ 0.30
	Spencer WWTP	$ 0.36	$ 0.38	$ 0.41	$ 0.43	$ 0.46	$ 0.49	$ 0.52
	Sturbridge WPCF	$ 0.34	$ 0.37	$ 0.39	$ 0.41	$ 0.44	$ 0.47	$ 0.49
	Warren WWTP	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.39	$ 0.42	$ 0.44
	West Stockbridge	$ 0.44	$ 0.46	$ 0.49	$ 0.52	$ 0.56	$ 0.59	$ 0.63
	Westborough WWTF	$ 0.41	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56	$ 0.59
		Cost increases with step increase						
		2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
	Athol WWTP	$ 211,868	$ 226,129	$ 241,350	$ 257,595	$ 274,934	$ 293,440	$ 313,191
	Ayer WWTP	$ 720,713	$ 769,224	$ 821,000	$ 876,262	$ 935,243	$ 998,194	$ 1,065,383
	Barnstable WWTP WPCD - DPW	$ 2,314,594	$ 2,470,390	$ 2,636,672	$ 2,814,146	$ 3,003,566	$ 3,205,736	$ 3,421,514
	Charles River PCD	$ 210,792	$ 224,981	$ 240,124	$ 256,287	$ 273,537	$ 291,949	$ 311,600
	Fall River Regional WWF	$ 5,021,050.08	$ 5,359,016.96	$ 5,719,732.39	$ 6,104,727.58	$ 6,515,636.79	$ 6,954,204.30	$ 7,422,291.79
	Hardwick-Wheelwright WPCF	$ 32,331.50	$ 34,507.73	$ 36,830.45	$ 39,309.51	$ 41,955.43	$ 44,779.45	$ 47,793.55
	Hopedale WWTF	$ 296,371.72	$ 316,320.50	$ 337,612.03	$ 360,336.70	$ 384,590.96	$ 410,477.78	$ 438,107.04
	Mansfield WWTP (MFN)	$ 1,458,570.97	$ 1,556,747.38	$ 1,661,532.05	$ 1,773,369.77	$ 1,892,735.29	$ 2,020,135.30	$ 2,156,110.61
	Maynard WWTP	$ 94,962.26	$ 101,354.17	$ 108,176.32	$ 115,457.67	$ 123,229.12	$ 131,523.67	$ 140,376.53
	Medfield WWTP	$ 824,995.53	$ 880,525.98	$ 939,794.18	$ 1,003,051.73	$ 1,070,567.14	$ 1,142,627.02	$ 1,219,537.24
	Milford WWTP	$ 2,059,386.70	$ 2,198,004.01	$ 2,345,951.66	$ 2,503,857.67	$ 2,672,392.33	$ 2,852,271.06	$ 3,044,257.42
	North Attleborough WPCF	$ 1,097,196.23	$ 1,171,048.50	$ 1,249,871.78	$ 1,334,000.65	$ 1,423,792.23	$ 1,519,627.69	$ 1,621,913.83
	Oxford-Rochdale SD WPCP	$ 145,821.12	$ 155,636.33	$ 166,112.22	$ 177,293.23	$ 189,226.84	$ 201,963.70	$ 215,557.87
	Spencer WWTP	$ 432,463.25	$ 461,572.35	$ 492,640.78	$ 525,800.44	$ 561,192.06	$ 598,965.90	$ 639,282.30
	Sturbridge WPCF	$ 650,933.05	$ 694,747.36	$ 741,510.80	$ 791,421.89	$ 844,692.50	$ 901,548.75	$ 962,232.00
	Warren WWTP	$ 100,978.12	$ 107,774.96	$ 115,029.29	$ 122,771.91	$ 131,035.69	$ 139,855.70	$ 149,269.39
	West Stockbridge	$ 46,900.60	$ 50,057.48	$ 53,426.85	$ 57,023.01	$ 60,861.23	$ 64,957.80	$ 69,330.11
	Westborough WWTF	$ 88,314.90	$ 94,259.38	$ 100,603.98	$ 107,375.63	$ 114,603.08	$ 122,317.02	$ 130,550.18
	Sum increased annual costs for all plants that will haul - WITH step increase							
	SUM of hauling sites	$ 15,808,243	$ 16,872,296	$ 18,007,970	$ 19,220,087	$ 20,513,791	$ 21,894,574	$ 23,368,298
	Convert to present worth using 2.2% discount rate							
	Present worth from future cost	**$ 13,574,609**	**$ 14,176,435**	**$ 14,804,942**	**$ 15,461,314**	**$ 16,146,785**	**$ 16,862,647**	**$ 17,610,247**
		Price increases with step increase						
		2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
	Athol WWTP	$ 1.02	$ 1.09	$ 1.15	$ 1.23	$ 1.30	$ 1.38	$ 1.47
	Ayer WWTP	$ 0.54	$ 0.57	$ 0.61	$ 0.64	$ 0.68	$ 0.73	$ 0.77
	Barnstable WWTP WPCD - DPW	$ 0.72	$ 0.76	$ 0.81	$ 0.86	$ 0.91	$ 0.97	$ 1.03
	Charles River PCD	$ 0.58	$ 0.62	$ 0.65	$ 0.69	$ 0.74	$ 0.78	$ 0.83
	Fall River Regional WWF	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.28	$ 0.29	$ 0.31
	Hardwick-Wheelwright WPCF	$ 0.32	$ 0.34	$ 0.36	$ 0.38	$ 0.40	$ 0.43	$ 0.46
	Hopedale WWTF	$ 0.35	$ 0.38	$ 0.40	$ 0.42	$ 0.45	$ 0.48	$ 0.51
	Mansfield WWTP (MFN)	$ 0.45	$ 0.48	$ 0.51	$ 0.54	$ 0.57	$ 0.61	$ 0.64
	Maynard WWTP	$ 3.94	$ 4.19	$ 4.45	$ 4.72	$ 5.02	$ 5.33	$ 5.66
	Medfield WWTP	$ 0.50	$ 0.53	$ 0.56	$ 0.60	$ 0.64	$ 0.68	$ 0.72
	Milford WWTP	$ 0.63	$ 0.67	$ 0.71	$ 0.76	$ 0.80	$ 0.85	$ 0.91
	North Attleborough WPCF	$ 0.45	$ 0.47	$ 0.50	$ 0.53	$ 0.57	$ 0.60	$ 0.64

Table H-6B: Hauling Cost Calculations

	Oxford-Rochdale SD WPCP	$ 0.32	$ 0.34	$ 0.36	$ 0.38	$ 0.40	$ 0.43	$ 0.46
	Spencer WWTP	$ 0.55	$ 0.59	$ 0.62	$ 0.66	$ 0.70	$ 0.75	$ 0.79
	Sturbridge WPCF	$ 0.53	$ 0.56	$ 0.59	$ 0.63	$ 0.67	$ 0.71	$ 0.75
	Warren WWTP	$ 0.47	$ 0.50	$ 0.53	$ 0.56	$ 0.60	$ 0.63	$ 0.67
	West Stockbridge	$ 0.67	$ 0.71	$ 0.75	$ 0.80	$ 0.85	$ 0.90	$ 0.96
	Westborough WWTF	$ 0.63	$ 0.67	$ 0.71	$ 0.76	$ 0.80	$ 0.85	$ 0.91
		Cost increases with step increase						
		2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
	Athol WWTP	$ 334,272	$ 356,772	$ 380,786	$ 406,417	$ 433,773	$ 462,970	$ 494,133
	Ayer WWTP	$ 1,137,093	$ 1,213,631	$ 1,295,321	$ 1,382,509	$ 1,475,565	$ 1,574,886	$ 1,680,891
	Barnstable WWTP WPCD - DPW	$ 3,651,816	$ 3,897,620	$ 4,159,969	$ 4,439,976	$ 4,738,831	$ 5,057,802	$ 5,398,243
	Charles River PCD	$ 332,574	$ 354,960	$ 378,852	$ 404,353	$ 431,570	$ 460,619	$ 491,623
	Fall River Regional WWF	$ 7,921,886.25	$ 8,455,108.42	$ 9,024,221.76	$ 9,631,642.13	$ 10,279,947.96	$ 10,971,891.26	$ 11,710,409.26
	Hardwick-Wheelwright WPCF	$ 51,010.54	$ 54,444.06	$ 58,108.69	$ 62,019.98	$ 66,194.55	$ 70,650.10	$ 75,405.56
	Hopedale WWTF	$ 467,596.02	$ 499,069.91	$ 532,662.31	$ 568,515.81	$ 606,782.61	$ 647,625.14	$ 691,216.79
	Mansfield WWTP (MFN)	$ 2,301,238.41	$ 2,456,134.77	$ 2,621,457.20	$ 2,797,907.49	$ 2,986,234.64	$ 3,187,238.09	$ 3,401,771.09
	Maynard WWTP	$ 149,825.28	$ 159,910.02	$ 170,673.56	$ 182,161.60	$ 194,422.89	$ 207,509.50	$ 221,476.96
	Medfield WWTP	$ 1,301,624.29	$ 1,389,236.62	$ 1,482,746.14	$ 1,582,549.78	$ 1,689,071.21	$ 1,802,762.59	$ 1,924,106.54
	Milford WWTP	$ 3,249,166.39	$ 3,467,867.78	$ 3,701,289.96	$ 3,950,423.79	$ 4,216,326.81	$ 4,500,127.77	$ 4,803,031.37
	North Attleborough WPCF	$ 1,731,084.85	$ 1,847,604.17	$ 1,971,966.40	$ 2,104,699.46	$ 2,246,366.78	$ 2,397,569.73	$ 2,558,950.15
	Oxford-Rochdale SD WPCP	$ 230,067.07	$ 245,552.89	$ 262,081.05	$ 279,721.73	$ 298,549.80	$ 318,645.18	$ 340,093.19
	Spencer WWTP	$ 682,312.39	$ 728,238.83	$ 777,256.59	$ 829,573.73	$ 885,412.34	$ 945,009.44	$ 1,008,618.03
	Sturbridge WPCF	$ 1,026,999.83	$ 1,096,127.19	$ 1,169,907.51	$ 1,248,653.99	$ 1,332,700.89	$ 1,422,404.99	$ 1,518,147.07
	Warren WWTP	$ 159,316.71	$ 170,040.32	$ 181,485.73	$ 193,701.53	$ 206,739.58	$ 220,655.23	$ 235,507.53
	West Stockbridge	$ 73,996.72	$ 78,977.44	$ 84,293.41	$ 89,967.20	$ 96,022.89	$ 102,486.19	$ 109,384.54
	Westborough WWTF	$ 139,337.51	$ 148,716.32	$ 158,726.41	$ 169,410.29	$ 180,813.29	$ 192,983.83	$ 205,973.58
	Sum increased annual costs for all plants that will haul - WITH step increase							
	SUM of hauling sites	$ 24,941,218	$ 26,620,012	$ 28,411,805	$ 30,324,203	$ 32,365,325	$ 34,543,835	$ 36,868,981
	Convert to present worth using 2.2% discount rate							
	Present worth from future cost	**$ 18,390,991**	**$ 19,206,348**	**$ 20,057,855**	**$ 20,947,113**	**$ 21,875,795**	**$ 22,845,651**	**$ 23,858,505**
	Sum the total present worth							
	Sum of cost increases WITH step increase	**$ 336,005,486**						
	INCREASE due to step increase	**$ 126,002,057**						
	How much MORE haulers need to pay from 2024-2044:	**$ 126,002,057**						
	Equivalent annual cost	**$ 9,855,000**						

To determine cost increases for plants that would install dewatering in Scenario 6, a similar approach as for Scenario 5 was taken. Sludge quantity increases, at 0.5% per year to follow population growth, and price increases, including a 60% step increase and increasing at 6.2% per year to match the average rate determined in Part 1, were calculated. The resulting costs were determined by multiplying quantity by price. This provided the cost of hauling liquid sludge that these plants would avoid by installing dewatering. Next, an equivalent amount of wet tons produced per year was calculated, assuming 3.7% solids content in the liquid sludge and 22.8% in the cake (these are average values of the plants studied). Then the costs the plants would have to bear to haul the cake produced at their dewatering facilities, starting with the average cost of $156/wt and including the 60% increase in prices (as well as escalation and population growth), was determined.
Estimated solids growth in dry tons per year was calculated through 2044. This allowed calculation of capital cost in 2044 for screw presses and centrifuges, using cost curves developed in Part 2. O&M costs were also calculated per plant based on the solids produced in a given year. Annual O&M costs and capital costs were incorporated to calculate the net present cost and equivalent annual rate. Finally, the resulting annual cost to these facilities was determined by considering the cost savings by not hauling liquid, the additional cost to haul cake, and the cost of capital cost and O&M for the facilities.
For clarity of calculations, results for individual calculations were not rounded. Only the final result was rounded.

Table H-6C: Dewatering Cost Calculations

POTW name	Liquid - unit cost ($/gal)	Destination Facility	Destination Facility State	Destination Facility Type	volume, for liquid (gal/yr)	Quantity (wet US tons/year)			
Belchertown WWTP	$ 0.17	Cranston WPCF Incinerator	RI	Incinerator	570,594	2,379			
Cohasset WWTF	$ 0.16	Cranston WPCF Incinerator	RI	Incinerator	524,258	2,186			
Fairhaven WPCF	$ 0.09	Synagro in Woonsocket, RI incinerator	RI	Incinerator	4,650,730	19,394			
Hardwick-Gilbertville WPCF	$ 0.11	Cranston WPCF Incinerator	RI	Incinerator	238,609	995			
Hull WWTF	$ 0.16	Cranston WPCF Incinerator	RI	Incinerator	1,211,484	5,052			
Kingston Sewer Commission	$ 0.16	Cranston WPCF Incinerator	RI	Incinerator	937,999	3,911			
Lee WWTP	$ 0.19	Cranston WPCF Incinerator	RI	Incinerator	1,153,383	4,810			
Manchester By the Sea WWTP	$ 0.16	Cranston WPCF Incinerator	RI	Incinerator	111,964	467			
Marshfield WWTF	$ 0.17	Cranston WPCF Incinerator	RI	Incinerator	536,735	2,238			
New Bedford WWTP	$ 0.19	Synagro in Woonsocket, RI incinerator	RI	Incinerator	26,053,293	108,642			
Northbridge WWTF	$ 0.06	Cranston WPCF Incinerator	RI	Incinerator	2,759,820	11,508			
Plymouth WWTF	$ 0.16	Cranston WPCF Incinerator	RI	Incinerator	6,344,891	26,458			
Somerset WWTF	$ 0.14	Synagro in Woonsocket, RI incinerator	RI	Incinerator	2,050,609	8,551			
Stockbridge WWTP	$ 0.09	Cranston WPCF Incinerator	RI	Incinerator	282,280	1,177			
Upton WWTP	$ 0.08	Cranston WPCF Incinerator	RI	Incinerator	324,000	1,351			
Uxbridge WWTF	$ 0.16	Cranston WPCF Incinerator	RI	Incinerator	2,997,369	12,499			
Ware WWTP	$ 0.08	Cranston WPCF Incinerator	RI	Incinerator	2,713,568	11,316			
Webster WWTF	$ 0.11	Synagro in Woonsocket, RI incinerator	RI	Incinerator	3,185,671	13,284			
Winchendon WPCF	$ 0.07	Cranston WPCF Incinerator	RI	Incinerator	1,282,214	5,347			

Sludge Quantity Increases

Increase quantities of liquid sludge by 0.5% per year to match population growth

Scenario 6 Group		Present Quantity of Liquid Sludge, gal/yr (assume 3.7%	2024	2025	2026	2027	2028	2029	2030
Installs Dewatering	Belchertown WWTP	570,594	573,447	576,314	579,196	582,092	585,002	587,927	590,867
	Cohasset WWTF	524,258	526,879	529,514	532,161	534,822	537,496	540,184	542,885
	Fairhaven WPCF	4,650,730	4,673,984	4,697,354	4,720,840	4,744,445	4,768,167	4,792,008	4,815,968
	Hardwick-Gilbertville WPCF	238,609	239,802	241,001	242,206	243,417	244,634	245,857	247,087
	Hull WWTF	1,211,484	1,217,541	1,223,629	1,229,747	1,235,896	1,242,075	1,248,285	1,254,527
	Kingston Sewer Commission	937,999	942,689	947,402	952,139	956,900	961,684	966,493	971,325
	Lee WWTP	1,153,383	1,159,150	1,164,946	1,170,770	1,176,624	1,182,507	1,188,420	1,194,362
	Manchester By the Sea WWTF	111,964	112,524	113,086	113,652	114,220	114,791	115,365	115,942
	Marshfield WWTF	536,735	539,418	542,116	544,826	547,550	550,288	553,039	555,805
	New Bedford WWTP	26,053,293	26,183,560	26,314,477	26,446,050	26,578,280	26,711,171	26,844,727	26,978,951
	Northbridge WWTF	2,759,820	2,773,619	2,787,487	2,801,425	2,815,432	2,829,509	2,843,657	2,857,875
	Plymouth WWTF	6,344,891	6,376,616	6,408,499	6,440,541	6,472,744	6,505,108	6,537,633	6,570,321
	Somerset WWTF	2,050,609	2,060,862	2,071,166	2,081,522	2,091,930	2,102,389	2,112,901	2,123,466
	Stockbridge WWTP	282,280	283,692	285,110	286,536	287,968	289,408	290,855	292,309
	Upton WWTP	324,000	325,620	327,248	328,884	330,528	332,181	333,842	335,511
	Uxbridge WWTF	2,997,369	3,012,356	3,027,417	3,042,554	3,057,767	3,073,056	3,088,421	3,103,863
	Ware WWTP	2,713,568	2,727,136	2,740,772	2,754,476	2,768,248	2,782,089	2,796,000	2,809,980
	Webster WWTF	3,185,671	3,201,600	3,217,608	3,233,696	3,249,864	3,266,113	3,282,444	3,298,856
	Winchendon WPCF	1,282,214	1,288,625	1,295,068	1,301,544	1,308,052	1,314,592	1,321,165	1,327,771

Price increases WITH step increase

Increased cost of hauling by 60% due to direct impacts

Escalate unit cost by 6.2% per year (following sludge mgmt price increase trends)

	Present Price of Hauling per gallon	Step Increase	2024	2025	2026	2027	2028	2029	2030
Belchertown WWTP	$ 0.17	$ 0.26	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.38	$ 0.40
Cohasset WWTF	$ 0.16	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.39

Table H-6C: Dewatering Cost Calculations

Fairhaven WPCF	$ 0.09	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22
Hardwick-Gilbertville WPCF	$ 0.11	$ 0.17	$ 0.18	$ 0.20	$ 0.21	$ 0.22	$ 0.23	$ 0.25	$ 0.26
Hull WWTF	$ 0.16	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.39
Kingston Sewer Commission	$ 0.16	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.39
Lee WWTP	$ 0.19	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.40	$ 0.42	$ 0.45	$ 0.47
Manchester By the Sea WWTP	$ 0.16	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.39
Marshfield WWTF	$ 0.17	$ 0.26	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.38	$ 0.40
New Bedford WWTP	$ 0.19	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.39	$ 0.41	$ 0.44	$ 0.46
Northbridge WWTF	$ 0.06	$ 0.10	$ 0.10	$ 0.11	$ 0.12	$ 0.12	$ 0.13	$ 0.14	$ 0.15
Plymouth WWTF	$ 0.16	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.39
Somerset WWTF	$ 0.14	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.29	$ 0.30	$ 0.32	$ 0.34
Stockbridge WWTP	$ 0.09	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.21	$ 0.22
Upton WWTP	$ 0.08	$ 0.12	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19
Uxbridge WWTF	$ 0.16	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.39
Ware WWTP	$ 0.08	$ 0.14	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.20	$ 0.21
Webster WWTF	$ 0.11	$ 0.17	$ 0.18	$ 0.19	$ 0.21	$ 0.22	$ 0.23	$ 0.25	$ 0.26
Winchendon WPCF	$ 0.07	$ 0.11	$ 0.12	$ 0.12	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.17

Cost increases WITH step increase

Multiply quantity of liquid sludge by escalated mgmt prices

	2024	2025	2026	2027	2028	2029	2030
Belchertown WWTP	$ 160,955	$ 171,788	$ 183,352	$ 195,693	$ 208,865	$ 222,924	$ 237,929
Cohasset WWTF	$ 143,244	$ 152,885	$ 163,176	$ 174,160	$ 185,882	$ 198,394	$ 211,748
Fairhaven WPCF	$ 700,459	$ 747,606	$ 797,928	$ 851,636	$ 908,960	$ 970,142	$ 1,035,442
Hardwick-Gilbertville WPCF	$ 44,059	$ 47,024	$ 50,189	$ 53,568	$ 57,173	$ 61,022	$ 65,129
Hull WWTF	$ 331,015	$ 353,296	$ 377,076	$ 402,457	$ 429,547	$ 458,460	$ 489,318
Kingston Sewer Commission	$ 256,171	$ 273,414	$ 291,818	$ 311,460	$ 332,424	$ 354,800	$ 378,681
Lee WWTP	$ 382,524	$ 408,272	$ 435,752	$ 465,083	$ 496,388	$ 529,799	$ 565,460
Manchester By the Sea WWTP	$ 30,592	$ 32,651	$ 34,849	$ 37,195	$ 39,698	$ 42,370	$ 45,222
Marshfield WWTF	$ 151,403	$ 161,594	$ 172,471	$ 184,080	$ 196,470	$ 209,694	$ 223,809
New Bedford WWTP	$ 8,440,555	$ 9,008,689	$ 9,615,064	$ 10,262,253	$ 10,953,006	$ 11,690,253	$ 12,477,123
Northbridge WWTF	$ 285,411	$ 304,622	$ 325,126	$ 347,010	$ 370,367	$ 395,297	$ 421,904
Plymouth WWTF	$ 1,733,623	$ 1,850,313	$ 1,974,858	$ 2,107,786	$ 2,249,661	$ 2,401,085	$ 2,562,702
Somerset WWTF	$ 492,234	$ 525,366	$ 560,729	$ 598,472	$ 638,755	$ 681,749	$ 727,638
Stockbridge WWTP	$ 43,384	$ 46,305	$ 49,421	$ 52,748	$ 56,298	$ 60,088	$ 64,132
Upton WWTP	$ 42,568	$ 45,434	$ 48,492	$ 51,756	$ 55,240	$ 58,958	$ 62,926
Uxbridge WWTF	$ 818,975	$ 874,100	$ 932,936	$ 995,732	$ 1,062,755	$ 1,134,289	$ 1,210,638
Ware WWTP	$ 393,788	$ 420,294	$ 448,584	$ 478,779	$ 511,005	$ 545,401	$ 582,112
Webster WWTF	$ 584,817	$ 624,181	$ 666,195	$ 711,036	$ 758,896	$ 809,977	$ 864,497
Winchendon WPCF	$ 149,562	$ 159,629	$ 170,374	$ 181,841	$ 194,081	$ 207,145	$ 221,088
Sum increased annual costs for all plants that will haul - WITH step increase							
Sum	$ 15,185,339	$ 16,207,464	$ 17,298,389	$ 18,462,743	$ 19,705,471	$ 21,031,846	$ 22,447,499
Convert to present worth using 2.2% discount rate							
Present worth from future cost	**$ 15,185,339**	**$ 15,858,576**	**$ 16,561,660**	**$ 17,295,915**	**$ 18,062,723**	**$ 18,863,528**	**$ 19,699,835**

Sludge Quantity Increases

	2031	2032	2033	2034	2035	2036	2037
Belchertown WWTP	593,821	596,790	599,774	602,773	605,787	608,816	611,860
Cohasset WWTF	545,599	548,327	551,069	553,824	556,593	559,376	562,173
Fairhaven WPCF	4,840,048	4,864,248	4,888,569	4,913,012	4,937,577	4,962,265	4,987,076
Hardwick-Gilbertville WPCF	248,322	249,564	250,812	252,066	253,326	254,593	255,866
Hull WWTF	1,260,800	1,267,104	1,273,439	1,279,806	1,286,205	1,292,636	1,299,099
Kingston Sewer Commission	976,182	981,063	985,968	990,898	995,853	1,000,832	1,005,836
Lee WWTP	1,200,334	1,206,336	1,212,367	1,218,429	1,224,521	1,230,644	1,236,797
Manchester By the Sea WWTP	116,522	117,104	117,690	118,278	118,870	119,464	120,061
Marshfield WWTF	558,584	561,377	564,183	567,004	569,839	572,689	575,552

Table H-6C: Dewatering Cost Calculations

		New Bedford WWTP	27,113,846	27,249,415	27,385,662	27,522,590	27,660,203	27,798,504	27,937,497
		Northbridge WWTF	2,872,164	2,886,525	2,900,958	2,915,462	2,930,040	2,944,690	2,959,413
		Plymouth WWTF	6,603,173	6,636,189	6,669,370	6,702,716	6,736,230	6,769,911	6,803,761
		Somerset WWTF	2,134,083	2,144,753	2,155,477	2,166,255	2,177,086	2,187,971	2,198,911
		Stockbridge WWTP	293,771	295,240	296,716	298,200	299,691	301,189	302,695
		Upton WWTP	337,189	338,875	340,569	342,272	343,983	345,703	347,432
		Uxbridge WWTF	3,119,383	3,134,980	3,150,655	3,166,408	3,182,240	3,198,151	3,214,142
		Ware WWTP	2,824,030	2,838,150	2,852,340	2,866,602	2,880,935	2,895,340	2,909,817
		Webster WWTF	3,315,350	3,331,927	3,348,587	3,365,330	3,382,156	3,399,067	3,416,062
		Winchendon WPCF	1,334,409	1,341,081	1,347,787	1,354,526	1,361,298	1,368,105	1,374,945
			Price increases WITH step increase						
			2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
		Belchertown WWTP	$ 0.43	$ 0.45	$ 0.48	$ 0.51	$ 0.54	$ 0.58	$ 0.61
		Cohasset WWTF	$ 0.41	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56	$ 0.59
		Fairhaven WPCF	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33
		Hardwick-Gilbertville WPCF	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.38	$ 0.40
		Hull WWTF	$ 0.41	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56	$ 0.59
		Kingston Sewer Commission	$ 0.41	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56	$ 0.59
		Lee WWTP	$ 0.50	$ 0.53	$ 0.57	$ 0.60	$ 0.64	$ 0.68	$ 0.72
		Manchester By the Sea WWTP	$ 0.41	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56	$ 0.59
		Marshfield WWTF	$ 0.43	$ 0.45	$ 0.48	$ 0.51	$ 0.54	$ 0.58	$ 0.61
		New Bedford WWTP	$ 0.49	$ 0.52	$ 0.55	$ 0.59	$ 0.62	$ 0.66	$ 0.70
		Northbridge WWTF	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.22
		Plymouth WWTF	$ 0.41	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56	$ 0.59
		Somerset WWTF	$ 0.36	$ 0.39	$ 0.41	$ 0.44	$ 0.46	$ 0.49	$ 0.52
		Stockbridge WWTP	$ 0.23	$ 0.25	$ 0.26	$ 0.28	$ 0.30	$ 0.31	$ 0.33
		Upton WWTP	$ 0.20	$ 0.21	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.29
		Uxbridge WWTF	$ 0.41	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56	$ 0.59
		Ware WWTP	$ 0.22	$ 0.23	$ 0.25	$ 0.26	$ 0.28	$ 0.30	$ 0.32
		Webster WWTF	$ 0.28	$ 0.30	$ 0.31	$ 0.33	$ 0.35	$ 0.38	$ 0.40
		Winchendon WPCF	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.22	$ 0.24	$ 0.25
			Cost increases WITH step increase						
			2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
		Belchertown WWTP	$ 253,944	$ 271,037	$ 289,280	$ 308,752	$ 329,534	$ 351,715	$ 375,388
		Cohasset WWTF	$ 226,001	$ 241,213	$ 257,449	$ 274,778	$ 293,273	$ 313,013	$ 334,082
		Fairhaven WPCF	$ 1,105,138	$ 1,179,525	$ 1,258,919	$ 1,343,657	$ 1,434,098	$ 1,530,627	$ 1,633,654
		Hardwick-Gilbertville WPCF	$ 69,513	$ 74,192	$ 79,185	$ 84,515	$ 90,204	$ 96,276	$ 102,756
		Hull WWTF	$ 522,254	$ 557,407	$ 594,926	$ 634,971	$ 677,711	$ 723,328	$ 772,015
		Kingston Sewer Commission	$ 404,170	$ 431,375	$ 460,411	$ 491,401	$ 524,477	$ 559,780	$ 597,459
		Lee WWTP	$ 603,521	$ 644,144	$ 687,502	$ 733,777	$ 783,168	$ 835,883	$ 892,146
		Manchester By the Sea WWTP	$ 48,266	$ 51,515	$ 54,982	$ 58,683	$ 62,633	$ 66,849	$ 71,349
		Marshfield WWTF	$ 238,873	$ 254,952	$ 272,113	$ 290,429	$ 309,977	$ 330,842	$ 353,111
		New Bedford WWTP	$ 13,316,959	$ 14,213,323	$ 15,170,022	$ 16,191,116	$ 17,280,940	$ 18,444,120	$ 19,685,594
		Northbridge WWTF	$ 450,303	$ 480,612	$ 512,963	$ 547,490	$ 584,342	$ 623,674	$ 665,653
		Plymouth WWTF	$ 2,735,198	$ 2,919,304	$ 3,115,802	$ 3,325,527	$ 3,549,368	$ 3,788,276	$ 4,043,265
		Somerset WWTF	$ 776,615	$ 828,889	$ 884,682	$ 944,230	$ 1,007,786	$ 1,075,620	$ 1,148,020
		Stockbridge WWTP	$ 68,449	$ 73,056	$ 77,974	$ 83,222	$ 88,824	$ 94,803	$ 101,184
		Upton WWTP	$ 67,162	$ 71,682	$ 76,507	$ 81,657	$ 87,153	$ 93,020	$ 99,281
		Uxbridge WWTF	$ 1,292,126	$ 1,379,099	$ 1,471,926	$ 1,571,001	$ 1,676,745	$ 1,789,607	$ 1,910,065
		Ware WWTP	$ 621,294	$ 663,113	$ 707,747	$ 755,386	$ 806,231	$ 860,498	$ 918,418
		Webster WWTF	$ 922,686	$ 984,792	$ 1,051,079	$ 1,121,827	$ 1,197,337	$ 1,277,930	$ 1,363,947
		Winchendon WPCF	$ 235,969	$ 251,852	$ 268,804	$ 286,898	$ 306,209	$ 326,820	$ 348,818
		Sum increased annual costs for all plants that will haul - WITH step increase							
		Sum	$ 23,958,441	$ 25,571,083	$ 27,292,273	$ 29,129,316	$ 31,090,010	$ 33,182,679	$ 35,416,205
		Convert to present worth using 2.2% discount rate							

Table H-6C: Dewatering Cost Calculations

		Present worth from future cost	**$ 20,573,220**	**$ 21,485,327**	**$ 22,437,871**	**$ 23,432,646**	**$ 24,471,524**	**$ 25,556,460**	**$ 26,689,496**
			Sludge Quantity Increases						
			2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
		Belchertown WWTP	614,919	617,994	621,084	624,189	627,310	630,447	633,599
		Cohasset WWTF	564,984	567,809	570,648	573,501	576,369	579,250	582,147
		Fairhaven WPCF	5,012,011	5,037,072	5,062,257	5,087,568	5,113,006	5,138,571	5,164,264
		Hardwick-Gilbertville WPCF	257,145	258,431	259,723	261,021	262,327	263,638	264,956
		Hull WWTF	1,305,595	1,312,123	1,318,684	1,325,277	1,331,903	1,338,563	1,345,256
		Kingston Sewer Commission	1,010,865	1,015,919	1,020,999	1,026,104	1,031,235	1,036,391	1,041,573
		Lee WWTP	1,242,981	1,249,196	1,255,442	1,261,719	1,268,028	1,274,368	1,280,740
		Manchester By the Sea WWTP	120,662	121,265	121,871	122,481	123,093	123,708	124,327
		Marshfield WWTF	578,430	581,322	584,229	587,150	590,085	593,036	596,001
		New Bedford WWTP	28,077,184	28,217,570	28,358,658	28,500,451	28,642,954	28,786,168	28,930,099
		Northbridge WWTF	2,974,210	2,989,081	3,004,027	3,019,047	3,034,142	3,049,313	3,064,560
		Plymouth WWTF	6,837,780	6,871,968	6,906,328	6,940,860	6,975,564	7,010,442	7,045,494
		Somerset WWTF	2,209,906	2,220,955	2,232,060	2,243,220	2,254,436	2,265,709	2,277,037
		Stockbridge WWTP	304,208	305,729	307,258	308,794	310,338	311,890	313,450
		Upton WWTP	349,169	350,915	352,669	354,433	356,205	357,986	359,776
		Uxbridge WWTF	3,230,213	3,246,364	3,262,595	3,278,908	3,295,303	3,311,780	3,328,338
		Ware WWTP	2,924,366	2,938,987	2,953,682	2,968,451	2,983,293	2,998,210	3,013,201
		Webster WWTF	3,433,143	3,450,309	3,467,560	3,484,898	3,502,322	3,519,834	3,537,433
		Winchendon WPCF	1,381,820	1,388,729	1,395,673	1,402,651	1,409,665	1,416,713	1,423,796
			Price increases WITH step increase						
			2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
		Belchertown WWTP	$ 0.65	$ 0.69	$ 0.73	$ 0.78	$ 0.83	$ 0.88	$ 0.93
		Cohasset WWTF	$ 0.63	$ 0.67	$ 0.71	$ 0.76	$ 0.80	$ 0.85	$ 0.91
		Fairhaven WPCF	$ 0.35	$ 0.37	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50
		Hardwick-Gilbertville WPCF	$ 0.43	$ 0.45	$ 0.48	$ 0.51	$ 0.54	$ 0.58	$ 0.61
		Hull WWTF	$ 0.63	$ 0.67	$ 0.71	$ 0.76	$ 0.80	$ 0.85	$ 0.91
		Kingston Sewer Commission	$ 0.63	$ 0.67	$ 0.71	$ 0.76	$ 0.80	$ 0.85	$ 0.91
		Lee WWTP	$ 0.77	$ 0.81	$ 0.86	$ 0.92	$ 0.97	$ 1.03	$ 1.10
		Manchester By the Sea WWTP	$ 0.63	$ 0.67	$ 0.71	$ 0.76	$ 0.80	$ 0.85	$ 0.91
		Marshfield WWTF	$ 0.65	$ 0.69	$ 0.73	$ 0.78	$ 0.83	$ 0.88	$ 0.93
		New Bedford WWTP	$ 0.75	$ 0.79	$ 0.84	$ 0.90	$ 0.95	$ 1.01	$ 1.07
		Northbridge WWTF	$ 0.24	$ 0.25	$ 0.27	$ 0.29	$ 0.30	$ 0.32	$ 0.34
		Plymouth WWTF	$ 0.63	$ 0.67	$ 0.71	$ 0.76	$ 0.80	$ 0.85	$ 0.91
		Somerset WWTF	$ 0.55	$ 0.59	$ 0.63	$ 0.66	$ 0.71	$ 0.75	$ 0.80
		Stockbridge WWTP	$ 0.36	$ 0.38	$ 0.40	$ 0.43	$ 0.45	$ 0.48	$ 0.51
		Upton WWTP	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.39	$ 0.41	$ 0.44
		Uxbridge WWTF	$ 0.63	$ 0.67	$ 0.71	$ 0.76	$ 0.80	$ 0.85	$ 0.91
		Ware WWTP	$ 0.34	$ 0.36	$ 0.38	$ 0.40	$ 0.43	$ 0.45	$ 0.48
		Webster WWTF	$ 0.42	$ 0.45	$ 0.48	$ 0.51	$ 0.54	$ 0.57	$ 0.61
		Winchendon WPCF	$ 0.27	$ 0.29	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.39
			Cost increases WITH step increase						
			2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
		Belchertown WWTP	$ 400,656	$ 427,624	$ 456,407	$ 487,128	$ 519,917	$ 554,912	$ 592,264
		Cohasset WWTF	$ 356,569	$ 380,570	$ 406,186	$ 433,526	$ 462,707	$ 493,852	$ 527,093
		Fairhaven WPCF	$ 1,743,615	$ 1,860,978	$ 1,986,240	$ 2,119,934	$ 2,262,627	$ 2,414,924	$ 2,577,473
		Hardwick-Gilbertville WPCF	$ 109,673	$ 117,055	$ 124,934	$ 133,343	$ 142,318	$ 151,898	$ 162,122
		Hull WWTF	$ 823,979	$ 879,441	$ 938,636	$ 1,001,816	$ 1,069,248	$ 1,141,219	$ 1,218,035
		Kingston Sewer Commission	$ 637,673	$ 680,595	$ 726,406	$ 775,301	$ 827,486	$ 883,184	$ 942,631
		Lee WWTP	$ 952,197	$ 1,016,289	$ 1,084,695	$ 1,157,706	$ 1,235,632	$ 1,318,802	$ 1,407,570
		Manchester By the Sea WWTP	$ 76,151	$ 81,277	$ 86,748	$ 92,587	$ 98,819	$ 105,470	$ 112,569
		Marshfield WWTF	$ 376,879	$ 402,247	$ 429,322	$ 458,220	$ 489,062	$ 521,981	$ 557,116
		New Bedford WWTP	$ 21,010,631	$ 22,424,857	$ 23,934,274	$ 25,545,290	$ 27,264,743	$ 29,099,933	$ 31,058,650
		Northbridge WWTF	$ 710,458	$ 758,279	$ 809,319	$ 863,794	$ 921,936	$ 983,992	$ 1,050,224

Table H-6C: Dewatering Cost Calculations

		Plymouth WWTF	$ 4,315,417	$ 4,605,888	$ 4,915,911	$ 5,246,800	$ 5,599,963	$ 5,976,896	$ 6,379,201
		Somerset WWTF	$ 1,225,293	$ 1,307,767	$ 1,395,793	$ 1,489,744	$ 1,590,019	$ 1,697,043	$ 1,811,271
		Stockbridge WWTP	$ 107,994	$ 115,264	$ 123,022	$ 131,303	$ 140,141	$ 149,573	$ 159,641
		Upton WWTP	$ 105,963	$ 113,096	$ 120,708	$ 128,833	$ 137,505	$ 146,760	$ 156,639
		Uxbridge WWTF	$ 2,038,632	$ 2,175,852	$ 2,322,309	$ 2,478,623	$ 2,645,460	$ 2,823,526	$ 3,013,577
		Ware WWTP	$ 980,237	$ 1,046,217	$ 1,116,638	$ 1,191,798	$ 1,272,018	$ 1,357,638	$ 1,449,021
		Webster WWTF	$ 1,455,754	$ 1,553,741	$ 1,658,323	$ 1,769,945	$ 1,889,080	$ 2,016,234	$ 2,151,947
		Winchendon WPCF	$ 372,297	$ 397,356	$ 424,102	$ 452,648	$ 483,116	$ 515,635	$ 550,342
		Sum increased annual costs for all plants that will haul - WITH step increase							
		Sum	$ 37,800,069	$ 40,344,392	$ 43,059,973	$ 45,958,340	$ 49,051,796	$ 52,353,472	$ 55,877,384
		Convert to present worth using 2.2% discount rate							
		Present worth from future cost	**$ 27,872,765**	**$ 29,108,494**	**$ 30,399,009**	**$ 31,746,738**	**$ 33,154,218**	**$ 34,624,098**	**$ 36,159,145**
		How much dewaterers are saving by not hauling liquid, 2024-	**$ 509,238,586**						
		Equivalent Annual Cost	**$ 39,829,674**						
		Calculate cost to haul wet cake after dewatering	**Sludge Quantity Increases**						
		Convert liquid sludge (avg 3.7% solids) to cake (avg 22.8% solids)							
		Present Quantity of Dewatered Cake, WTPY (assume 22.8% solids)	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
	Belchertown WWTP	387	389	391	393	395	397	399	401
	Cohasset WWTF	356	358	359	361	363	365	367	368
	Fairhaven WPCF	3,156	3,171	3,187	3,203	3,219	3,235	3,252	3,268
	Hardwick-Gilbertville WPCF	162	163	164	164	165	166	167	168
	Hull WWTF	822	826	830	834	839	843	847	851
	Kingston Sewer Commission	636	640	643	646	649	653	656	659
	Lee WWTP	783	787	790	794	798	802	806	810
	Manchester By the Sea WWTF	76	76	77	77	78	78	78	79
	Marshfield WWTF	364	366	368	370	372	373	375	377
	New Bedford WWTP	17,678	17,767	17,855	17,945	18,034	18,125	18,215	18,306
	Northbridge WWTF	1,873	1,882	1,891	1,901	1,910	1,920	1,930	1,939
	Plymouth WWTF	4,305	4,327	4,348	4,370	4,392	4,414	4,436	4,458
	Somerset WWTF	1,391	1,398	1,405	1,412	1,419	1,427	1,434	1,441
	Stockbridge WWTP	192	192	193	194	195	196	197	198
	Upton WWTP	220	221	222	223	224	225	227	228
	Uxbridge WWTF	2,034	2,044	2,054	2,064	2,075	2,085	2,096	2,106
	Ware WWTP	1,841	1,850	1,860	1,869	1,878	1,888	1,897	1,907
	Webster WWTF	2,162	2,172	2,183	2,194	2,205	2,216	2,227	2,238
	Winchendon WPCF	870	874	879	883	888	892	896	901
			Price Increases						
	Average cost to haul cake	Step Increase	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
	$ 156.00	$ 249.60	$ 265.08	$ 281.51	$ 298.96	$ 317.50	$ 337.18	$ 358.09	$ 380.29
			Cost Increases						
			2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
		Belchertown WWTP	$ 103,142	$ 110,085	$ 117,495	$ 125,403	$ 133,844	$ 142,853	$ 152,469
		Cohasset WWTF	$ 94,767	$ 101,145	$ 107,953	$ 115,220	$ 122,975	$ 131,253	$ 140,087
		Fairhaven WPCF	$ 840,681	$ 897,268	$ 957,663	$ 1,022,123	$ 1,090,922	$ 1,164,352	$ 1,242,725
		Hardwick-Gilbertville WPCF	$ 43,132	$ 46,035	$ 49,134	$ 52,441	$ 55,971	$ 59,738	$ 63,759
		Hull WWTF	$ 218,992	$ 233,732	$ 249,465	$ 266,256	$ 284,178	$ 303,306	$ 323,721

Table H-6C: Dewatering Cost Calculations

		Kingston Sewer Commission	$ 169,556	$ 180,969	$ 193,150	$ 206,150	$ 220,026	$ 234,836	$ 250,643
		Lee WWTP	$ 208,489	$ 222,523	$ 237,501	$ 253,487	$ 270,549	$ 288,760	$ 308,196
		Manchester By the Sea WWTP	$ 20,239	$ 21,601	$ 23,055	$ 24,607	$ 26,263	$ 28,031	$ 29,918
		Marshfield WWTF	$ 97,022	$ 103,552	$ 110,523	$ 117,962	$ 125,902	$ 134,376	$ 143,421
		New Bedford WWTP	$ 4,709,479	$ 5,026,474	$ 5,364,806	$ 5,725,912	$ 6,111,323	$ 6,522,676	$ 6,961,717
		Northbridge WWTF	$ 498,874	$ 532,453	$ 568,293	$ 606,545	$ 647,371	$ 690,946	$ 737,453
		Plymouth WWTF	$ 1,146,923	$ 1,224,123	$ 1,306,519	$ 1,394,460	$ 1,488,322	$ 1,588,500	$ 1,695,422
		Somerset WWTF	$ 370,675	$ 395,625	$ 422,254	$ 450,676	$ 481,011	$ 513,388	$ 547,944
		Stockbridge WWTP	$ 51,026	$ 54,460	$ 58,126	$ 62,039	$ 66,214	$ 70,671	$ 75,428
		Upton WWTP	$ 58,567	$ 62,509	$ 66,717	$ 71,208	$ 76,001	$ 81,116	$ 86,576
		Uxbridge WWTF	$ 541,814	$ 578,284	$ 617,208	$ 658,752	$ 703,093	$ 750,418	$ 800,929
		Ware WWTP	$ 490,514	$ 523,530	$ 558,769	$ 596,380	$ 636,522	$ 679,366	$ 725,094
		Webster WWTF	$ 575,852	$ 614,613	$ 655,983	$ 700,137	$ 747,263	$ 797,561	$ 851,245
		Winchendon WPCF	$ 231,777	$ 247,378	$ 264,029	$ 281,801	$ 300,769	$ 321,014	$ 342,621
		Sum increased annual costs for all plants that will haul - WITH step increase							
		Sum	$ 10,471,523	$ 11,176,361	$ 11,928,642	$ 12,731,559	$ 13,588,520	$ 14,503,163	$ 15,479,371
		Convert to present worth using 2.2% discount rate							
		Present worth from future cost	**$ 10,471,523**	**$ 10,935,774**	**$ 11,420,607**	**$ 11,926,936**	**$ 12,455,712**	**$ 13,007,932**	**$ 13,584,634**
			Sludge Quantity Increases						
			2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
		Belchertown WWTP	403	405	407	409	411	413	415
		Cohasset WWTF	370	372	374	376	378	380	381
		Fairhaven WPCF	3,284	3,301	3,317	3,334	3,350	3,367	3,384
		Hardwick-Gilbertville WPCF	168	169	170	171	172	173	174
		Hull WWTF	856	860	864	868	873	877	881
		Kingston Sewer Commission	662	666	669	672	676	679	682
		Lee WWTP	814	819	823	827	831	835	839
		Manchester By the Sea WWTP	79	79	80	80	81	81	81
		Marshfield WWTF	379	381	383	385	387	389	391
		New Bedford WWTP	18,398	18,490	18,582	18,675	18,769	18,862	18,957
		Northbridge WWTF	1,949	1,959	1,968	1,978	1,988	1,998	2,008
		Plymouth WWTF	4,481	4,503	4,525	4,548	4,571	4,594	4,617
		Somerset WWTF	1,448	1,455	1,463	1,470	1,477	1,485	1,492
		Stockbridge WWTP	199	200	201	202	203	204	205
		Upton WWTP	229	230	231	232	233	235	236
		Uxbridge WWTF	2,117	2,127	2,138	2,149	2,159	2,170	2,181
		Ware WWTP	1,916	1,926	1,935	1,945	1,955	1,965	1,974
		Webster WWTF	2,250	2,261	2,272	2,284	2,295	2,306	2,318
		Winchendon WPCF	905	910	915	919	924	928	933
			Price Increases						
			2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
			$ 403.87	$ 428.91	$ 455.50	$ 483.74	$ 513.73	$ 545.59	$ 579.41
			Cost Increases						
			2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
		Belchertown WWTP	$ 162,731	$ 173,685	$ 185,376	$ 197,853	$ 211,171	$ 225,385	$ 240,555
		Cohasset WWTF	$ 149,517	$ 159,581	$ 170,322	$ 181,786	$ 194,022	$ 207,082	$ 221,021
		Fairhaven WPCF	$ 1,326,372	$ 1,415,650	$ 1,510,938	$ 1,612,639	$ 1,721,186	$ 1,837,039	$ 1,960,690
		Hardwick-Gilbertville WPCF	$ 68,051	$ 72,631	$ 77,520	$ 82,738	$ 88,307	$ 94,251	$ 100,595
		Hull WWTF	$ 345,511	$ 368,767	$ 393,589	$ 420,082	$ 448,357	$ 478,536	$ 510,746
		Kingston Sewer Commission	$ 267,514	$ 285,520	$ 304,739	$ 325,251	$ 347,143	$ 370,510	$ 395,449
		Lee WWTP	$ 328,941	$ 351,082	$ 374,713	$ 399,935	$ 426,855	$ 455,586	$ 486,252
		Manchester By the Sea WWTP	$ 31,932	$ 34,081	$ 36,375	$ 38,823	$ 41,437	$ 44,226	$ 47,203
		Marshfield WWTF	$ 153,075	$ 163,378	$ 174,375	$ 186,113	$ 198,640	$ 212,010	$ 226,281

Table H-6C: Dewatering Cost Calculations

		New Bedford WWTP	$ 7,430,310	$ 7,930,445	$ 8,464,243	$ 9,033,971	$ 9,642,047	$ 10,291,054	$ 10,983,745
		Northbridge WWTF	$ 787,091	$ 840,070	$ 896,616	$ 956,967	$ 1,021,380	$ 1,090,129	$ 1,163,506
		Plymouth WWTF	$ 1,809,541	$ 1,931,342	$ 2,061,340	$ 2,200,089	$ 2,348,177	$ 2,506,233	$ 2,674,927
		Somerset WWTF	$ 584,827	$ 624,191	$ 666,206	$ 711,048	$ 758,909	$ 809,991	$ 864,511
		Stockbridge WWTP	$ 80,505	$ 85,924	$ 91,708	$ 97,881	$ 104,469	$ 111,501	$ 119,006
		Upton WWTP	$ 92,404	$ 98,623	$ 105,262	$ 112,347	$ 119,909	$ 127,980	$ 136,594
		Uxbridge WWTF	$ 854,839	$ 912,379	$ 973,791	$ 1,039,337	$ 1,109,294	$ 1,183,961	$ 1,263,653
		Ware WWTP	$ 773,900	$ 825,992	$ 881,589	$ 940,929	$ 1,004,263	$ 1,071,860	$ 1,144,007
		Webster WWTF	$ 908,543	$ 969,697	$ 1,034,967	$ 1,104,630	$ 1,178,983	$ 1,258,340	$ 1,343,039
		Winchendon WPCF	$ 365,683	$ 390,297	$ 416,568	$ 444,607	$ 474,534	$ 506,475	$ 540,566
		Sum increased annual costs for all plants that will haul - WITH step increase							
		Sum	$ 16,521,287	$ 17,633,335	$ 18,820,235	$ 20,087,025	$ 21,439,083	$ 22,882,147	$ 24,422,345
		Convert to present worth using 2.2% discount rate							
		Present worth from future cost	**$ 14,186,904**	**$ 14,815,875**	**$ 15,472,731**	**$ 16,158,709**	**$ 16,875,100**	**$ 17,623,251**	**$ 18,404,572**
			Sludge Quantity Increases						
			2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
		Belchertown WWTP	417	419	421	424	426	428	430
		Cohasset WWTF	383	385	387	389	391	393	395
		Fairhaven WPCF	3,401	3,418	3,435	3,452	3,469	3,487	3,504
		Hardwick-Gilbertville WPCF	174	175	176	177	178	179	180
		Hull WWTF	886	890	895	899	904	908	913
		Kingston Sewer Commission	686	689	693	696	700	703	707
		Lee WWTP	843	848	852	856	860	865	869
		Manchester By the Sea WWTP	82	82	83	83	84	84	84
		Marshfield WWTF	392	394	396	398	400	402	404
		New Bedford WWTP	19,051	19,147	19,242	19,339	19,435	19,533	19,630
		Northbridge WWTF	2,018	2,028	2,038	2,049	2,059	2,069	2,079
		Plymouth WWTF	4,640	4,663	4,686	4,710	4,733	4,757	4,781
		Somerset WWTF	1,500	1,507	1,515	1,522	1,530	1,537	1,545
		Stockbridge WWTP	206	207	208	210	211	212	213
		Upton WWTP	237	238	239	240	242	243	244
		Uxbridge WWTF	2,192	2,203	2,214	2,225	2,236	2,247	2,258
		Ware WWTP	1,984	1,994	2,004	2,014	2,024	2,034	2,045
		Webster WWTF	2,330	2,341	2,353	2,365	2,376	2,388	2,400
		Winchendon WPCF	938	942	947	952	957	961	966
			Price Increases						
			2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
			$ 615.34	$ 653.49	$ 694.00	$ 737.03	$ 782.73	$ 831.26	$ 882.79
			Cost Increases						
			2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
		Belchertown WWTP	$ 256,747	$ 274,029	$ 292,474	$ 312,160	$ 333,171	$ 355,597	$ 379,532
		Cohasset WWTF	$ 235,898	$ 251,776	$ 268,723	$ 286,811	$ 306,116	$ 326,721	$ 348,712
		Fairhaven WPCF	$ 2,092,664	$ 2,233,521	$ 2,383,860	$ 2,544,317	$ 2,715,575	$ 2,898,360	$ 3,093,449
		Hardwick-Gilbertville WPCF	$ 107,366	$ 114,592	$ 122,306	$ 130,538	$ 139,325	$ 148,703	$ 158,712
		Hull WWTF	$ 545,125	$ 581,817	$ 620,979	$ 662,777	$ 707,389	$ 755,003	$ 805,823
		Kingston Sewer Commission	$ 422,066	$ 450,476	$ 480,797	$ 513,160	$ 547,700	$ 584,566	$ 623,913
		Lee WWTP	$ 518,982	$ 553,914	$ 591,198	$ 630,992	$ 673,464	$ 718,795	$ 767,177
		Manchester By the Sea WWTP	$ 50,380	$ 53,771	$ 57,390	$ 61,253	$ 65,376	$ 69,777	$ 74,473
		Marshfield WWTF	$ 241,512	$ 257,768	$ 275,118	$ 293,636	$ 313,401	$ 334,496	$ 357,011
		New Bedford WWTP	$ 11,723,060	$ 12,512,140	$ 13,354,332	$ 14,253,212	$ 15,212,595	$ 16,236,555	$ 17,329,438
		Northbridge WWTF	$ 1,241,821	$ 1,325,408	$ 1,414,622	$ 1,509,840	$ 1,611,467	$ 1,719,935	$ 1,835,704
		Plymouth WWTF	$ 2,854,977	$ 3,047,145	$ 3,252,248	$ 3,471,157	$ 3,704,801	$ 3,954,171	$ 4,220,326
		Somerset WWTF	$ 922,701	$ 984,808	$ 1,051,096	$ 1,121,845	$ 1,197,357	$ 1,277,951	$ 1,363,969
		Stockbridge WWTP	$ 127,016	$ 135,566	$ 144,690	$ 154,430	$ 164,824	$ 175,919	$ 187,760

Table H-6C: Dewatering Cost Calculations

		Upton WWTP	$ 145,788	$ 155,601	$ 166,075	$ 177,253	$ 189,184	$ 201,918	$ 215,509
		Uxbridge WWTF	$ 1,348,710	$ 1,439,492	$ 1,536,384	$ 1,639,798	$ 1,750,173	$ 1,867,977	$ 1,993,710
		Ware WWTP	$ 1,221,010	$ 1,303,196	$ 1,390,914	$ 1,484,536	$ 1,584,461	$ 1,691,111	$ 1,804,939
		Webster WWTF	$ 1,433,439	$ 1,529,924	$ 1,632,903	$ 1,742,814	$ 1,860,123	$ 1,985,328	$ 2,118,960
		Winchendon WPCF	$ 576,951	$ 615,786	$ 657,234	$ 701,473	$ 748,689	$ 799,083	$ 852,869
		Sum increased annual costs for all plants that will haul - WITH step increase							
		Sum	$ 26,066,213	$ 27,820,729	$ 29,693,343	$ 31,692,002	$ 33,825,190	$ 36,101,964	$ 38,531,987
		Convert to present worth using 2.2% discount rate							
		Present worth from future cost	**$ 19,220,532**	**$ 20,072,667**	**$ 20,962,581**	**$ 21,891,950**	**$ 22,862,521**	**$ 23,876,123**	**$ 24,934,662**
		How much dewaterers still have to pay to haul cake, 2024-20	**$ 351,161,294**						
		Equivalent Annual Cost	**$ 27,465,790**						
			% population growth rate	0.50%					
			Starting Year	2023					
			Increase in sludge due to population growth						
			Increase quantities of sludge by 0.5% per year to match population growth						
		Present Quantity of Sludge, dt/yr	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
	Belchertown WWTP	98	98	99	99	100	100	101	101
	Cohasset WWTF	87	88	88	89	89	90	90	91
	Fairhaven WPCF	601	604	607	610	613	616	619	623
	Hardwick-Gilbertville WPCF	20	20	20	20	20	20	21	21
	Hull WWTF	202	203	204	205	206	207	208	209
	Kingston Sewer Commission	215	216	217	218	219	221	222	223
	Lee WWTP	204	205	206	207	208	209	210	211
	Manchester By the Sea WWTF	21	21	21	21	21	22	22	22
	Marshfield WWTF	140	140	141	142	142	143	144	145
	New Bedford WWTP	7,312	7,348	7,385	7,422	7,459	7,496	7,534	7,571
	Northbridge WWTF	457	459	461	464	466	468	471	473
	Plymouth WWTF	1,058	1,064	1,069	1,074	1,080	1,085	1,090	1,096
	Somerset WWTF	359	361	363	365	366	368	370	372
	Stockbridge WWTP	33	33	33	33	34	34	34	34
	Upton WWTP	61	61	61	62	62	62	63	63
	Uxbridge WWTF	401	403	405	407	409	411	413	415
	Ware WWTP	170	171	171	172	173	174	175	176
	Webster WWTF	518	521	523	526	529	531	534	536
	Winchendon WPCF	187	188	189	190	191	192	193	194
			2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
		Belchertown WWTP	102	102	103	103	104	104	105
		Cohasset WWTF	91	91	92	92	93	93	94
		Fairhaven WPCF	626	629	632	635	638	641	645
		Hardwick-Gilbertville WPCF	21	21	21	21	21	21	21
		Hull WWTF	210	211	212	213	215	216	217
		Kingston Sewer Commission	224	225	226	227	228	230	231
		Lee WWTP	212	213	214	215	217	218	219
		Manchester By the Sea WWTP	22	22	22	22	22	22	23
		Marshfield WWTF	145	146	147	148	148	149	150
		New Bedford WWTP	7,609	7,647	7,686	7,724	7,763	7,801	7,840
		Northbridge WWTF	475	478	480	483	485	487	490
		Plymouth WWTF	1,101	1,107	1,112	1,118	1,124	1,129	1,135
		Somerset WWTF	374	376	378	379	381	383	385
		Stockbridge WWTP	34	34	35	35	35	35	35
		Upton WWTP	63	64	64	64	65	65	65
		Uxbridge WWTF	418	420	422	424	426	428	430
		Ware WWTP	177	178	178	179	180	181	182

Table H-6C: Dewatering Cost Calculations

		Webster WWTF	539	542	545	547	550	553	556
		Winchendon WPCF	195	196	197	198	199	200	201
			2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
		Belchertown WWTP	105	106	106	107	107	108	108
		Cohasset WWTF	94	95	95	96	96	97	97
		Fairhaven WPCF	648	651	654	658	661	664	668
		Hardwick-Gilbertville WPCF	21	22	22	22	22	22	22
		Hull WWTF	218	219	220	221	222	223	224
		Kingston Sewer Commission	232	233	234	235	237	238	239
		Lee WWTP	220	221	222	223	224	225	226
		Manchester By the Sea WWTP	23	23	23	23	23	23	23
		Marshfield WWTF	151	151	152	153	154	154	155
		New Bedford WWTP	7,880	7,919	7,959	7,998	8,038	8,079	8,119
		Northbridge WWTF	492	495	497	500	502	505	507
		Plymouth WWTF	1,141	1,146	1,152	1,158	1,164	1,169	1,175
		Somerset WWTF	387	389	391	393	395	397	399
		Stockbridge WWTP	36	36	36	36	36	36	37
		Upton WWTP	66	66	66	67	67	67	68
		Uxbridge WWTF	432	435	437	439	441	443	446
		Ware WWTP	183	184	185	186	187	188	188
		Webster WWTF	558	561	564	567	570	572	575
		Winchendon WPCF	202	203	204	205	206	207	208
		Use cost curves to calculate Capital and O&M costs	**Capital Cost of buildout facility, Screw Press**		**Capital Cost of buildout facility, Centrifuge**				
		Belchertown WWTP	$ 9,755,476		$ 9,339,330				
		Cohasset WWTF	$ 9,635,263		$ 9,279,167				
		Fairhaven WPCF	$ 15,745,129		$ 12,336,952				
		Hardwick-Gilbertville WPCF	$ 8,831,963		$ 8,877,142				
		Hull WWTF	$ 10,998,502		$ 9,961,423				
		Kingston Sewer Commission	$ 11,153,755		$ 10,039,122				
		Lee WWTP	$ 11,020,526		$ 9,972,445				
		Manchester By the Sea WWTP	$ 8,845,164		$ 8,883,749				
		Marshfield WWTF	$ 10,256,252		$ 9,589,952				
		New Bedford WWTP	$ 95,549,490		$ 52,276,390				
		Northbridge WWTF	$ 14,028,855		$ 11,478,014				
		Plymouth WWTF	$ 21,181,568		$ 15,057,710				
		Somerset WWTF	$ 12,866,451		$ 10,896,269				
		Stockbridge WWTP	$ 8,987,269		$ 8,954,867				
		Upton WWTP	$ 9,318,352		$ 9,120,564				
		Uxbridge WWTF	$ 13,366,834		$ 11,146,695				
		Ware WWTP	$ 10,613,875		$ 9,768,930				
		Webster WWTF	$ 14,756,685		$ 11,842,269				
		Winchendon WPCF	$ 10,820,871		$ 9,872,525				
		Cost for all 19 plants to install given dewatering facilities	**$ 307,732,281**		**$ 238,693,514**				
		Average cost of facilities		**$ 273,212,898**					
			Screw Press Cost of O&M per year, 2023 dollars						
		Calculate Annual O&M cost, by year, per plant, for screw presses	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
		Belchertown WWTP	$ 222,938	$ 223,379	$ 223,823	$ 224,268	$ 224,716	$ 225,166	$ 225,618
		Cohasset WWTF	$ 213,795	$ 214,191	$ 214,588	$ 214,988	$ 215,389	$ 215,792	$ 216,198
		Fairhaven WPCF	$ 678,485	$ 681,204	$ 683,937	$ 686,683	$ 689,443	$ 692,217	$ 695,004
		Hardwick-Gilbertville WPCF	$ 152,700	$ 152,790	$ 152,880	$ 152,971	$ 153,062	$ 153,154	$ 153,246
		Hull WWTF	$ 317,477	$ 318,391	$ 319,310	$ 320,233	$ 321,160	$ 322,093	$ 323,030
		Kingston Sewer Commission	$ 329,285	$ 330,258	$ 331,236	$ 332,219	$ 333,206	$ 334,199	$ 335,196

Table H-6C: Dewatering Cost Calculations

		Lee WWTP	$ 319,152	$ 320,075	$ 321,001	$ 321,933	$ 322,869	$ 323,810	$ 324,755
		Manchester By the Sea WWTP	$ 153,704	$ 153,799	$ 153,894	$ 153,990	$ 154,087	$ 154,183	$ 154,281
		Marshfield WWTF	$ 261,025	$ 261,657	$ 262,291	$ 262,929	$ 263,570	$ 264,215	$ 264,862
		New Bedford WWTP	$ 6,748,062	$ 6,781,129	$ 6,814,361	$ 6,847,760	$ 6,881,325	$ 6,915,058	$ 6,948,960
		Northbridge WWTF	$ 547,953	$ 550,019	$ 552,096	$ 554,183	$ 556,280	$ 558,388	$ 560,506
		Plymouth WWTF	$ 1,091,958	$ 1,096,744	$ 1,101,554	$ 1,106,388	$ 1,111,247	$ 1,116,129	$ 1,121,037
		Somerset WWTF	$ 459,545	$ 461,170	$ 462,802	$ 464,442	$ 466,091	$ 467,748	$ 469,413
		Stockbridge WWTP	$ 164,511	$ 164,660	$ 164,810	$ 164,961	$ 165,112	$ 165,264	$ 165,417
		Upton WWTP	$ 189,692	$ 189,967	$ 190,244	$ 190,521	$ 190,800	$ 191,081	$ 191,363
		Uxbridge WWTF	$ 497,602	$ 499,417	$ 501,240	$ 503,073	$ 504,915	$ 506,766	$ 508,626
		Ware WWTP	$ 288,224	$ 288,992	$ 289,763	$ 290,539	$ 291,318	$ 292,101	$ 292,888
		Webster WWTF	$ 603,309	$ 605,652	$ 608,006	$ 610,373	$ 612,751	$ 615,141	$ 617,544
		Winchendon WPCF	$ 303,967	$ 304,814	$ 305,664	$ 306,519	$ 307,378	$ 308,242	$ 309,109
		Capital cost of screw press	**$ 307,732,281**						
		Capital and O&M cost, per year	$ 321,275,666	$ 13,598,306	$ 13,653,501	$ 13,708,972	$ 13,764,720	$ 13,820,747	$ 13,877,054
		Escalated at 4.7% per year	$ 321,275,666	$ 14,237,426	$ 14,967,090	$ 15,734,209	$ 16,540,709	$ 17,388,613	$ 18,280,050
		Discounted at 2.2% per year	$ 321,275,666	$ 13,930,945	$ 14,329,650	$ 14,739,822	$ 15,161,792	$ 15,595,900	$ 16,042,499
			2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
		Belchertown WWTP	$ 226,073	$ 226,530	$ 226,989	$ 227,450	$ 227,914	$ 228,380	$ 228,849
		Cohasset WWTF	$ 216,605	$ 217,015	$ 217,426	$ 217,840	$ 218,256	$ 218,674	$ 219,093
		Fairhaven WPCF	$ 697,806	$ 700,621	$ 703,451	$ 706,295	$ 709,153	$ 712,025	$ 714,911
		Hardwick-Gilbertville WPCF	$ 153,339	$ 153,432	$ 153,526	$ 153,620	$ 153,715	$ 153,810	$ 153,905
		Hull WWTF	$ 323,971	$ 324,918	$ 325,869	$ 326,825	$ 327,785	$ 328,751	$ 329,721
		Kingston Sewer Commission	$ 336,199	$ 337,206	$ 338,219	$ 339,236	$ 340,259	$ 341,287	$ 342,320
		Lee WWTP	$ 325,706	$ 326,661	$ 327,621	$ 328,585	$ 329,555	$ 330,529	$ 331,508
		Manchester By the Sea WWTP	$ 154,379	$ 154,477	$ 154,576	$ 154,675	$ 154,775	$ 154,876	$ 154,977
		Marshfield WWTF	$ 265,513	$ 266,167	$ 266,825	$ 267,485	$ 268,149	$ 268,816	$ 269,487
		New Bedford WWTP	$ 6,983,031	$ 7,017,273	$ 7,051,686	$ 7,086,271	$ 7,121,028	$ 7,155,960	$ 7,191,066
		Northbridge WWTF	$ 562,636	$ 564,775	$ 566,926	$ 569,087	$ 571,259	$ 573,441	$ 575,635
		Plymouth WWTF	$ 1,125,968	$ 1,130,925	$ 1,135,906	$ 1,140,912	$ 1,145,943	$ 1,150,999	$ 1,156,081
		Somerset WWTF	$ 471,087	$ 472,769	$ 474,459	$ 476,158	$ 477,865	$ 479,581	$ 481,306
		Stockbridge WWTP	$ 165,571	$ 165,725	$ 165,880	$ 166,036	$ 166,193	$ 166,350	$ 166,508
		Upton WWTP	$ 191,646	$ 191,931	$ 192,217	$ 192,505	$ 192,794	$ 193,084	$ 193,376
		Uxbridge WWTF	$ 510,496	$ 512,375	$ 514,263	$ 516,161	$ 518,069	$ 519,985	$ 521,912
		Ware WWTP	$ 293,679	$ 294,474	$ 295,273	$ 296,075	$ 296,882	$ 297,693	$ 298,508
		Webster WWTF	$ 619,958	$ 622,384	$ 624,823	$ 627,273	$ 629,736	$ 632,211	$ 634,699
		Winchendon WPCF	$ 309,981	$ 310,858	$ 311,739	$ 312,624	$ 313,513	$ 314,407	$ 315,306
		Capital and O&M cost, per year	$ 13,933,643	$ 13,990,515	$ 14,047,671	$ 14,105,113	$ 14,162,842	$ 14,220,860	$ 14,279,167
		Escalated at 4.7% per year	$ 19,217,260	$ 20,202,595	$ 21,238,530	$ 22,327,669	$ 23,472,746	$ 24,676,640	$ 25,942,376
		Discounted at 2.2% per year	$ 16,501,947	$ 16,974,617	$ 17,460,891	$ 17,961,162	$ 18,475,834	$ 19,005,324	$ 19,550,060
			2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
		Belchertown WWTP	$ 229,319	$ 229,793	$ 230,268	$ 230,746	$ 231,226	$ 231,709	$ 232,194
		Cohasset WWTF	$ 219,515	$ 219,939	$ 220,366	$ 220,794	$ 221,224	$ 221,657	$ 222,092
		Fairhaven WPCF	$ 717,812	$ 720,728	$ 723,658	$ 726,603	$ 729,562	$ 732,537	$ 735,526
		Hardwick-Gilbertville WPCF	$ 154,001	$ 154,098	$ 154,195	$ 154,292	$ 154,390	$ 154,489	$ 154,588
		Hull WWTF	$ 330,696	$ 331,676	$ 332,661	$ 333,651	$ 334,645	$ 335,645	$ 336,650
		Kingston Sewer Commission	$ 343,358	$ 344,401	$ 345,450	$ 346,503	$ 347,562	$ 348,627	$ 349,696
		Lee WWTP	$ 332,492	$ 333,481	$ 334,475	$ 335,474	$ 336,478	$ 337,487	$ 338,501
		Manchester By the Sea WWTP	$ 155,078	$ 155,180	$ 155,282	$ 155,385	$ 155,489	$ 155,592	$ 155,697
		Marshfield WWTF	$ 270,161	$ 270,838	$ 271,519	$ 272,203	$ 272,890	$ 273,581	$ 274,276
		New Bedford WWTP	$ 7,226,348	$ 7,261,806	$ 7,297,442	$ 7,333,256	$ 7,369,248	$ 7,405,421	$ 7,441,775
		Northbridge WWTF	$ 577,840	$ 580,056	$ 582,282	$ 584,520	$ 586,769	$ 589,030	$ 591,301
		Plymouth WWTF	$ 1,161,187	$ 1,166,320	$ 1,171,478	$ 1,176,662	$ 1,181,872	$ 1,187,108	$ 1,192,370
		Somerset WWTF	$ 483,039	$ 484,780	$ 486,531	$ 488,290	$ 490,058	$ 491,835	$ 493,620

Table H-6C: Dewatering Cost Calculations

		Stockbridge WWTP	$	166,667	$	166,827	$	166,988	$	167,149	$	167,312	$	167,475	$	167,639
		Upton WWTP	$	193,669	$	193,964	$	194,261	$	194,558	$	194,858	$	195,158	$	195,461
		Uxbridge WWTF	$	523,848	$	525,794	$	527,749	$	529,714	$	531,689	$	533,674	$	535,669
		Ware WWTP	$	299,327	$	300,150	$	300,978	$	301,809	$	302,644	$	303,484	$	304,328
		Webster WWTF	$	637,199	$	639,711	$	642,236	$	644,774	$	647,324	$	649,888	$	652,463
		Winchendon WPCF	$	316,209	$	317,117	$	318,029	$	318,945	$	319,866	$	320,792	$	321,723
		Capital and O&M cost, per year	$	14,337,767	$	14,396,659	$	14,455,846	$	14,515,329	$	14,575,109	$	14,635,188	$	14,695,567
		Escalated at 4.7% per year	$	27,273,135	$	28,672,261	$	30,143,274	$	31,689,870	$	33,315,940	$	35,025,573	$	36,823,070
		Discounted at 2.2% per year	$	20,110,484	$	20,687,047	$	21,280,219	$	21,890,477	$	22,518,318	$	23,164,249	$	23,828,795
		NPC, Screw Press	**$**	**690,485,700**												
		O&M only	$	382,753,419												
			Centrifuge Cost of O&M per year, 2023 dollars													
		Calculate Annual O&M cost, by year, per plant, for centrifuges		**2024**		**2025**		**2026**		**2027**		**2028**		**2029**		**2030**
		Belchertown WWTP	$	156,355	$	156,992	$	157,633	$	158,276	$	158,923	$	159,573	$	160,227
		Cohasset WWTF	$	143,149	$	143,720	$	144,294	$	144,871	$	145,451	$	146,033	$	146,619
		Fairhaven WPCF	$	814,368	$	818,295	$	822,242	$	826,209	$	830,195	$	834,202	$	838,228
		Hardwick-Gilbertville WPCF	$	54,899	$	55,029	$	55,160	$	55,291	$	55,423	$	55,556	$	55,689
		Hull WWTF	$	292,912	$	294,232	$	295,558	$	296,892	$	298,232	$	299,578	$	300,932
		Kingston Sewer Commission	$	309,967	$	311,373	$	312,785	$	314,205	$	315,631	$	317,065	$	318,506
		Lee WWTP	$	295,331	$	296,663	$	298,002	$	299,348	$	300,700	$	302,059	$	303,425
		Manchester By the Sea WWTP	$	56,350	$	56,487	$	56,625	$	56,763	$	56,903	$	57,043	$	57,183
		Marshfield WWTF	$	211,369	$	212,282	$	213,199	$	214,120	$	215,046	$	215,977	$	216,912
		New Bedford WWTP	$	9,581,534	$	9,629,298	$	9,677,300	$	9,725,542	$	9,774,025	$	9,822,750	$	9,871,720
		Northbridge WWTF	$	625,821	$	628,805	$	631,805	$	634,819	$	637,849	$	640,894	$	643,954
		Plymouth WWTF	$	1,411,605	$	1,418,519	$	1,425,467	$	1,432,450	$	1,439,468	$	1,446,520	$	1,453,608
		Somerset WWTF	$	498,121	$	500,467	$	502,825	$	505,195	$	507,576	$	509,970	$	512,375
		Stockbridge WWTP	$	71,961	$	72,176	$	72,393	$	72,610	$	72,829	$	73,048	$	73,269
		Upton WWTP	$	108,333	$	108,730	$	109,130	$	109,531	$	109,934	$	110,339	$	110,746
		Uxbridge WWTF	$	553,092	$	555,713	$	558,347	$	560,995	$	563,655	$	566,329	$	569,016
		Ware WWTP	$	250,657	$	251,766	$	252,880	$	254,000	$	255,126	$	256,257	$	257,393
		Webster WWTF	$	705,779	$	709,163	$	712,565	$	715,983	$	719,418	$	722,871	$	726,341
		Winchendon WPCF	$	273,397	$	274,620	$	275,848	$	277,083	$	278,324	$	279,571	$	280,825
		Capital cost of centrifuge	**$**	**238,693,514**												
		Capital and O&M cost, per year	$	255,108,515	$	16,494,331	$	16,574,057	$	16,654,181	$	16,734,707	$	16,815,635	$	16,896,968
		Escalated at 4.7% per year	$	255,108,515	$	17,269,564	$	18,168,630	$	19,114,517	$	20,109,665	$	21,156,639	$	22,258,140
		Discounted at 2.2% per year	$	255,108,515	$	16,897,812	$	17,394,838	$	17,906,498	$	18,433,222	$	18,975,455	$	19,533,654
				2031		**2032**		**2033**		**2034**		**2035**		**2036**		**2037**
		Belchertown WWTP	$	160,883	$	161,543	$	162,206	$	162,873	$	163,543	$	164,216	$	164,893
		Cohasset WWTF	$	147,208	$	147,799	$	148,394	$	148,991	$	149,592	$	150,195	$	150,802
		Fairhaven WPCF	$	842,275	$	846,342	$	850,429	$	854,537	$	858,665	$	862,814	$	866,983
		Hardwick-Gilbertville WPCF	$	55,823	$	55,958	$	56,093	$	56,229	$	56,366	$	56,503	$	56,641
		Hull WWTF	$	302,292	$	303,659	$	305,033	$	306,413	$	307,801	$	309,195	$	310,597
		Kingston Sewer Commission	$	319,954	$	321,409	$	322,871	$	324,341	$	325,818	$	327,303	$	328,795
		Lee WWTP	$	304,797	$	306,177	$	307,563	$	308,956	$	310,357	$	311,764	$	313,178
		Manchester By the Sea WWTP	$	57,325	$	57,467	$	57,610	$	57,753	$	57,898	$	58,043	$	58,188
		Marshfield WWTF	$	217,852	$	218,797	$	219,747	$	220,701	$	221,660	$	222,624	$	223,592
		New Bedford WWTP	$	9,920,934	$	9,970,394	$	10,020,101	$	10,070,057	$	10,120,263	$	10,170,720	$	10,221,429
		Northbridge WWTF	$	647,029	$	650,120	$	653,226	$	656,347	$	659,485	$	662,638	$	665,806
		Plymouth WWTF	$	1,460,732	$	1,467,891	$	1,475,086	$	1,482,317	$	1,489,584	$	1,496,888	$	1,504,227
		Somerset WWTF	$	514,792	$	517,222	$	519,663	$	522,117	$	524,583	$	527,062	$	529,552
		Stockbridge WWTP	$	73,491	$	73,714	$	73,938	$	74,163	$	74,389	$	74,617	$	74,845
		Upton WWTP	$	111,155	$	111,567	$	111,980	$	112,396	$	112,813	$	113,233	$	113,654
		Uxbridge WWTF	$	571,717	$	574,431	$	577,158	$	579,900	$	582,655	$	585,423	$	588,206

Table H-6C: Dewatering Cost Calculations

		Ware WWTP	$ 258,536	$ 259,684	$ 260,838	$ 261,998	$ 263,163	$ 264,335	$ 265,512
		Webster WWTF	$ 729,828	$ 733,333	$ 736,855	$ 740,395	$ 743,952	$ 747,527	$ 751,121
		Winchendon WPCF	$ 282,084	$ 283,350	$ 284,622	$ 285,901	$ 287,186	$ 288,477	$ 289,775
		Capital and O&M cost, per year	$ 16,978,707	$ 17,060,855	$ 17,143,414	$ 17,226,385	$ 17,309,772	$ 17,393,575	$ 17,477,797
		Escalated at 4.7% per year	$ 23,417,007	$ 24,636,230	$ 25,918,952	$ 27,268,483	$ 28,688,302	$ 30,182,071	$ 31,753,643
		Discounted at 2.2% per year	$ 20,108,289	$ 20,699,844	$ 21,308,819	$ 21,935,726	$ 22,581,094	$ 23,245,468	$ 23,929,406
			2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
		Belchertown WWTP	$ 165,573	$ 166,256	$ 166,943	$ 167,633	$ 168,327	$ 169,024	$ 169,724
		Cohasset WWTF	$ 151,411	$ 152,024	$ 152,639	$ 153,258	$ 153,880	$ 154,505	$ 155,133
		Fairhaven WPCF	$ 871,174	$ 875,385	$ 879,617	$ 883,871	$ 888,146	$ 892,442	$ 896,760
		Hardwick-Gilbertville WPCF	$ 56,780	$ 56,919	$ 57,059	$ 57,200	$ 57,341	$ 57,484	$ 57,627
		Hull WWTF	$ 312,005	$ 313,421	$ 314,843	$ 316,273	$ 317,710	$ 319,154	$ 320,605
		Kingston Sewer Commission	$ 330,295	$ 331,801	$ 333,316	$ 334,838	$ 336,368	$ 337,905	$ 339,450
		Lee WWTP	$ 314,600	$ 316,028	$ 317,464	$ 318,907	$ 320,357	$ 321,814	$ 323,279
		Manchester By the Sea WWTP	$ 58,335	$ 58,482	$ 58,630	$ 58,779	$ 58,928	$ 59,078	$ 59,229
		Marshfield WWTF	$ 224,566	$ 225,544	$ 226,527	$ 227,515	$ 228,508	$ 229,506	$ 230,510
		New Bedford WWTP	$ 10,272,392	$ 10,323,609	$ 10,375,083	$ 10,426,814	$ 10,478,803	$ 10,531,053	$ 10,583,564
		Northbridge WWTF	$ 668,991	$ 672,191	$ 675,408	$ 678,640	$ 681,889	$ 685,154	$ 688,435
		Plymouth WWTF	$ 1,511,604	$ 1,519,018	$ 1,526,468	$ 1,533,956	$ 1,541,481	$ 1,549,044	$ 1,556,645
		Somerset WWTF	$ 532,056	$ 534,572	$ 537,100	$ 539,641	$ 542,195	$ 544,761	$ 547,340
		Stockbridge WWTP	$ 75,075	$ 75,306	$ 75,538	$ 75,771	$ 76,006	$ 76,241	$ 76,478
		Upton WWTP	$ 114,078	$ 114,504	$ 114,932	$ 115,362	$ 115,794	$ 116,229	$ 116,665
		Uxbridge WWTF	$ 591,003	$ 593,813	$ 596,638	$ 599,476	$ 602,329	$ 605,196	$ 608,078
		Ware WWTP	$ 266,695	$ 267,884	$ 269,079	$ 270,280	$ 271,486	$ 272,699	$ 273,918
		Webster WWTF	$ 754,732	$ 758,361	$ 762,008	$ 765,674	$ 769,357	$ 773,060	$ 776,781
		Winchendon WPCF	$ 291,080	$ 292,391	$ 293,708	$ 295,032	$ 296,363	$ 297,700	$ 299,044
		Capital and O&M cost, per year	$ 17,562,441	$ 17,647,508	$ 17,733,000	$ 17,818,919	$ 17,905,268	$ 17,992,049	$ 18,079,264
		Escalated at 4.7% per year	$ 33,407,073	$ 35,146,623	$ 36,976,782	$ 38,902,270	$ 40,928,055	$ 43,059,361	$ 45,301,687
		Discounted at 2.2% per year	$ 24,633,486	$ 25,358,302	$ 26,104,464	$ 26,872,602	$ 27,663,363	$ 28,477,415	$ 29,315,443
		NPC, Centrifuge	**$ 706,483,715**						
		O&M only	$ 467,790,201						
		Average O&M for Screw Press and Centrifuge	$ 425,271,810						
		Average NPC of centrifuges and screw presses	**$ 698,484,708**						
		Savings from not hauling liquid	**$ 509,238,586**						
		Costs from hauling cake	**$ 351,161,294**						
		Total Cost (NPC of dewatering - liquid sludge hauling savings + cake hauling costs)	**$ 540,407,416**						
		Equivalent Annual Cost	**$ 42,268,000**						

To determine cost increases for plants that would need to find new outlets for their cake in Scenario 6, the following approach was taken (similar to that taken in Scenario 5). Sludge quantity increases, at 0.5% per year to follow population growth, and price increases, increasing at 6.2% per year to match the average rate determined in Part 1, were calculated. The resulting costs were determined by multiplying quantity by price. This provided the cost of hauling the plants would see before a 60% increase (owing to the difficulty of finding outlets for sludge). Next, these calculations were repeated, but including the 60% increase in prices (as well as escalation and population growth). The difference between the two was found, which provided the overall increase in solids hauling costs that would have to be paid over 20 years, and converted to an annual cost.
For clarity of calculations, results for individual calculations were not rounded. Only the final result was rounded.

Table H-6D: Redirected Cake Hauling Cost Calculations

POTW name	Cake - unit cost ($/wt)	Destination Facility	Destination Facility State	Destination Facility Type	Quantity (wet US tons/year)			
Chicopee WWTP	$ 140.17	Cranston WPCF Incinerator	RI	Incinerator	366			
Holyoke WWTP	$ 140.00	Cranston WPCF Incinerator	RI	Incinerator	312			
Lowell Regional WW Utility	$ 190.37	Synagro in Woonsocket, RI incinerator	RI	Incinerator	64			
Montague WPCF	$ 178.65	Synagro in Woonsocket, RI incinerator	RI	Incinerator	124			
Rockland WWTP	$ 190.00	Synagro in Woonsocket, RI incinerator	RI	Incinerator	1,315			
South Essex Sewerage District	$ 135.08	Synagro in Woonsocket, RI incinerator	RI	Incinerator	5,680			
Springfield WWTP - Bondi's Island	$ 142.57	Synagro in Woonsocket, RI incinerator	RI	Incinerator	2,545			

Sludge Quantity Increases

Increase quantities of liquid sludge by 0.5% per year to match population growth

	Present Quantity of Cake, wt/yr	2024	2025	2026	2027	2028	2029	2030
Chicopee WWTP	366	368	370	372	374	376	378	379
Holyoke WWTP	312	314	315	317	318	320	321	323
Lowell Regional WW Utility	64	64	65	65	65	66	66	66
Montague WPCF	124	125	125	126	127	127	128	129
Rockland WWTP	1,315	1,322	1,328	1,335	1,342	1,348	1,355	1,362
South Essex Sewerage District	5,680	5,709	5,737	5,766	5,795	5,824	5,853	5,882
Springfield WWTP - Bondi's Island	2,545	2,557	2,570	2,583	2,596	2,609	2,622	2,635

Price increases without 60% step increase

Escalate unit cost by 6.2% per year (following sludge mgmt price increase trends)

	Present Price of Hauling per wet ton	2024	2025	2026	2027	2028	2029	2030
Chicopee WWTP	$ 140.17	$ 148.86	$ 158.09	$ 167.89	$ 178.30	$ 189.36	$ 201.10	$ 213.56
Holyoke WWTP	$ 140.00	$ 148.68	$ 157.90	$ 167.69	$ 178.08	$ 189.13	$ 200.85	$ 213.30
Lowell Regional WW Utility	$ 190.37	$ 202.17	$ 214.71	$ 228.02	$ 242.16	$ 257.17	$ 273.12	$ 290.05
Montague WPCF	$ 178.65	$ 189.72	$ 201.49	$ 213.98	$ 227.25	$ 241.34	$ 256.30	$ 272.19
Rockland WWTP	$ 190.00	$ 201.78	$ 214.29	$ 227.58	$ 241.69	$ 256.67	$ 272.58	$ 289.48
South Essex Sewerage District	$ 135.08	$ 143.46	$ 152.35	$ 161.80	$ 171.83	$ 182.48	$ 193.79	$ 205.81
Springfield WWTP - Bondi's Island	$ 142.57	$ 151.41	$ 160.80	$ 170.77	$ 181.35	$ 192.60	$ 204.54	$ 217.22

Cost increases without 60% step increase

		2024	2025	2026	2027	2028	2029	2030
	Chicopee WWTP	$ 54,821	$ 58,511	$ 62,449	$ 66,652	$ 71,139	$ 75,927	$ 81,038
	Holyoke WWTP	$ 46,620	$ 49,758	$ 53,107	$ 56,682	$ 60,497	$ 64,569	$ 68,915
	Lowell Regional WW Utility	$ 12,984	$ 13,858	$ 14,791	$ 15,786	$ 16,849	$ 17,983	$ 19,193
	Montague WPCF	$ 23,669	$ 25,262	$ 26,962	$ 28,777	$ 30,714	$ 32,781	$ 34,988
	Rockland WWTP	$ 266,696	$ 284,648	$ 303,807	$ 324,257	$ 346,082	$ 369,377	$ 394,240
	South Essex Sewerage District	$ 818,967	$ 874,092	$ 932,927	$ 995,722	$ 1,062,745	$ 1,134,278	$ 1,210,626
	Springfield WWTP - Bondi's Island	$ 387,224	$ 413,288	$ 441,106	$ 470,797	$ 502,486	$ 536,309	$ 572,407
	Sum increased annual costs for all plants that will find a new outlet for their cake - WITHOUT step increase							
	Sum	$ 1,610,981	$ 1,719,416	$ 1,835,150	$ 1,958,674	$ 2,090,512	$ 2,231,224	$ 2,381,408
	Convert to present worth using 2.2% discount rate							
	Present worth from future cost	**$ 1,610,981**	**$ 1,682,403**	**$ 1,756,992**	**$ 1,834,887**	**$ 1,916,236**	**$ 2,001,192**	**$ 2,089,914**

Sludge Quantity Increases

	2031	2032	2033	2034	2035	2036	2037
Chicopee WWTP	381	383	385	387	389	391	393
Holyoke WWTP	325	326	328	330	331	333	335
Lowell Regional WW Utility	67	67	67	68	68	68	69

Table H-6D: Redirected Cake Hauling Cost Calculations

	Montague WPCF	129	130	130	131	132	132	133
	Rockland WWTP	1,369	1,376	1,382	1,389	1,396	1,403	1,410
	South Essex Sewerage District	5,912	5,941	5,971	6,001	6,031	6,061	6,091
	Springfield WWTP - Bondi's Island	2,648	2,662	2,675	2,688	2,702	2,715	2,729
		Price increases without 60% step increase						
		2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
	Chicopee WWTP	$ 226.80	$ 240.87	$ 255.80	$ 271.66	$ 288.50	$ 306.39	$ 325.39
	Holyoke WWTP	$ 226.53	$ 240.57	$ 255.49	$ 271.33	$ 288.15	$ 306.02	$ 324.99
	Lowell Regional WW Utility	$ 308.03	$ 327.13	$ 347.41	$ 368.95	$ 391.83	$ 416.12	$ 441.92
	Montague WPCF	$ 289.06	$ 306.99	$ 326.02	$ 346.23	$ 367.70	$ 390.50	$ 414.71
	Rockland WWTP	$ 307.43	$ 326.49	$ 346.74	$ 368.23	$ 391.06	$ 415.31	$ 441.06
	South Essex Sewerage District	$ 218.57	$ 232.12	$ 246.51	$ 261.80	$ 278.03	$ 295.26	$ 313.57
	Springfield WWTP - Bondi's Island	$ 230.69	$ 244.99	$ 260.18	$ 276.31	$ 293.44	$ 311.64	$ 330.96
		Cost increases without 60% step increase						
		2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
	Chicopee WWTP	$ 86,493	$ 92,314	$ 98,528	$ 105,160	$ 112,238	$ 119,793	$ 127,856
	Holyoke WWTP	$ 73,554	$ 78,505	$ 83,789	$ 89,429	$ 95,449	$ 101,873	$ 108,730
	Lowell Regional WW Utility	$ 20,485	$ 21,864	$ 23,336	$ 24,906	$ 26,583	$ 28,372	$ 30,282
	Montague WPCF	$ 37,343	$ 39,856	$ 42,539	$ 45,403	$ 48,459	$ 51,720	$ 55,202
	Rockland WWTP	$ 420,776	$ 449,099	$ 479,328	$ 511,591	$ 546,026	$ 582,779	$ 622,006
	South Essex Sewerage District	$ 1,292,113	$ 1,379,086	$ 1,471,912	$ 1,570,986	$ 1,676,729	$ 1,789,590	$ 1,910,047
	Springfield WWTP - Bondi's Island	$ 610,936	$ 652,058	$ 695,948	$ 742,793	$ 792,790	$ 846,153	$ 903,107
	Sum increased annual costs for all plants that will find a new outlet for their cake - WITHOUT step increase							
	Sum	$ 2,541,701	$ 2,712,782	$ 2,895,380	$ 3,090,268	$ 3,298,274	$ 3,520,281	$ 3,757,231
	Convert to present worth using 2.2% discount rate							
	Present worth from future cost	**$ 2,182,570**	**$ 2,279,333**	**$ 2,380,386**	**$ 2,485,920**	**$ 2,596,132**	**$ 2,711,231**	**$ 2,831,432**
		Sludge Quantity Increases						
		2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
	Chicopee WWTP	395	397	399	401	403	405	407
	Holyoke WWTP	336	338	340	341	343	345	346
	Lowell Regional WW Utility	69	69	70	70	70	71	71
	Montague WPCF	134	134	135	136	136	137	138
	Rockland WWTP	1,417	1,424	1,432	1,439	1,446	1,453	1,460
	South Essex Sewerage District	6,122	6,152	6,183	6,214	6,245	6,276	6,308
	Springfield WWTP - Bondi's Island	2,742	2,756	2,770	2,784	2,798	2,812	2,826
		Price increases without 60% step increase						
		2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
	Chicopee WWTP	$ 346	$ 367	$ 390	$ 414	$ 440	$ 467	$ 496
	Holyoke WWTP	$ 345	$ 367	$ 389	$ 413	$ 439	$ 466	$ 495
	Lowell Regional WW Utility	$ 469	$ 498	$ 529	$ 562	$ 597	$ 634	$ 673
	Montague WPCF	$ 440	$ 468	$ 497	$ 528	$ 560	$ 595	$ 632
	Rockland WWTP	$ 468	$ 497	$ 528	$ 561	$ 596	$ 633	$ 672
	South Essex Sewerage District	$ 333	$ 354	$ 376	$ 399	$ 424	$ 450	$ 478
	Springfield WWTP - Bondi's Island	$ 351	$ 373	$ 396	$ 421	$ 447	$ 475	$ 504
		Cost increases without 60% step increase						
		2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
	Chicopee WWTP	$ 136,462	$ 145,648	$ 155,451	$ 165,915	$ 177,082	$ 189,002	$ 201,723
	Holyoke WWTP	$ 116,049	$ 123,860	$ 132,197	$ 141,095	$ 150,593	$ 160,729	$ 171,548
	Lowell Regional WW Utility	$ 32,320	$ 34,495	$ 36,817	$ 39,296	$ 41,941	$ 44,764	$ 47,777
	Montague WPCF	$ 58,917	$ 62,883	$ 67,116	$ 71,633	$ 76,455	$ 81,601	$ 87,094
	Rockland WWTP	$ 663,873	$ 708,559	$ 756,252	$ 807,155	$ 861,485	$ 919,471	$ 981,361
	South Essex Sewerage District	$ 2,038,612	$ 2,175,831	$ 2,322,287	$ 2,478,600	$ 2,645,434	$ 2,823,499	$ 3,013,548

Table H-6D: Redirected Cake Hauling Cost Calculations

	Springfield WWTP - Bondi's Island	$ 963,895	$ 1,028,775	$ 1,098,022	$ 1,171,930	$ 1,250,812	$ 1,335,005	$ 1,424,864
	Sum increased annual costs for all plants that will find a new outlet for their cake - WITHOUT step increase							
	Sum	$ 4,010,130	$ 4,280,052	$ 4,568,142	$ 4,875,624	$ 5,203,802	$ 5,554,070	$ 5,927,914
	Convert to present worth using 2.2% discount rate							
	Present worth from future cost	**$ 2,956,963**	**$ 3,088,059**	**$ 3,224,967**	**$ 3,367,945**	**$ 3,517,261**	**$ 3,673,198**	**$ 3,836,048**
	Sum the total present worth							
	Sum of cost increases WITHOUT step increase	**$ 54,024,050**						
		Price increases with step increase						
	Increased cost of hauling by 60% due to direct impacts	Escalate unit cost by 6.2% per year (following sludge mgmt price increase trends)						
Present Price of Hauling per wet ton	Step Increase	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
$ 140.17	$ 224.27	$ 238.18	$ 252.94	$ 268.63	$ 285.28	$ 302.97	$ 321.75	$ 341.70
$ 140.00	$ 224.00	$ 237.89	$ 252.64	$ 268.30	$ 284.94	$ 302.60	$ 321.36	$ 341.29
$ 190.37	$ 304.59	$ 323.48	$ 343.53	$ 364.83	$ 387.45	$ 411.47	$ 436.98	$ 464.08
$ 178.65	$ 285.84	$ 303.56	$ 322.38	$ 342.37	$ 363.59	$ 386.14	$ 410.08	$ 435.50
$ 190.00	$ 304.00	$ 322.85	$ 342.86	$ 364.12	$ 386.70	$ 410.67	$ 436.13	$ 463.18
$ 135.08	$ 216.13	$ 229.53	$ 243.76	$ 258.87	$ 274.92	$ 291.97	$ 310.07	$ 329.29
$ 142.57	$ 228.11	$ 242.25	$ 257.27	$ 273.23	$ 290.17	$ 308.16	$ 327.26	$ 347.55
		Cost increases with step increase						
		Multiply quantity of liquid sludge by escalated mgmt prices						
		2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
	Chicopee WWTP	$ 87,713	$ 93,617	$ 99,918	$ 106,644	$ 113,822	$ 121,484	$ 129,661
	Holyoke WWTP	$ 74,592	$ 79,613	$ 84,972	$ 90,691	$ 96,796	$ 103,311	$ 110,265
	Lowell Regional WW Utility	$ 20,774	$ 22,172	$ 23,665	$ 25,258	$ 26,958	$ 28,772	$ 30,709
	Montague WPCF	$ 37,870	$ 40,419	$ 43,140	$ 46,043	$ 49,142	$ 52,450	$ 55,981
	Rockland WWTP	$ 426,714.25	$ 455,436.39	$ 486,091.81	$ 518,810.65	$ 553,731.79	$ 591,003.48	$ 630,783.92
	South Essex Sewerage District	$ 1,310,347.74	$ 1,398,547.24	$ 1,492,683.46	$ 1,593,155.98	$ 1,700,391.31	$ 1,814,844.65	$ 1,937,001.84
	Springfield WWTP - Bondi's Island	$ 619,557.73	$ 661,260.16	$ 705,769.58	$ 753,274.93	$ 803,977.87	$ 858,093.62	$ 915,851.90
	Sum increased annual costs for all plants that will find other outlets - WITH step increase							
	SUM of hauling sites	$ 2,577,569	$ 2,751,065	$ 2,936,239	$ 3,133,878	$ 3,344,819	$ 3,569,959	$ 3,810,253
	Convert to present worth using 2.2% discount rate							
	Present worth from future cost	**$ 2,577,569**	**$ 2,691,845**	**$ 2,811,187**	**$ 2,935,820**	**$ 3,065,978**	**$ 3,201,907**	**$ 3,343,862**
		Price increases with step increase						
		2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
	Chicopee WWTP	$ 362.89	$ 385.39	$ 409.28	$ 434.66	$ 461.60	$ 490.22	$ 520.62
	Holyoke WWTP	$ 362.45	$ 384.92	$ 408.78	$ 434.13	$ 461.04	$ 489.63	$ 519.99
	Lowell Regional WW Utility	$ 492.85	$ 523.41	$ 555.86	$ 590.32	$ 626.92	$ 665.79	$ 707.07
	Montague WPCF	$ 462.50	$ 491.18	$ 521.63	$ 553.97	$ 588.32	$ 624.79	$ 663.53
	Rockland WWTP	$ 491.89	$ 522.39	$ 554.78	$ 589.17	$ 625.70	$ 664.50	$ 705.69
	South Essex Sewerage District	$ 349.71	$ 371.39	$ 394.42	$ 418.87	$ 444.84	$ 472.42	$ 501.71
	Springfield WWTP - Bondi's Island	$ 369.10	$ 391.98	$ 416.29	$ 442.10	$ 469.51	$ 498.62	$ 529.53
		Cost increases with step increase						
		2031	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**
	Chicopee WWTP	$ 138,388	$ 147,703	$ 157,645	$ 168,256	$ 179,581	$ 191,669	$ 204,570
	Holyoke WWTP	$ 117,687	$ 125,608	$ 134,063	$ 143,087	$ 152,718	$ 162,997	$ 173,969

Table H-6D: Redirected Cake Hauling Cost Calculations

	Lowell Regional WW Utility	$ 32,776	$ 34,982	$ 37,337	$ 39,850	$ 42,532	$ 45,395	$ 48,451
	Montague WPCF	$ 59,749	$ 63,770	$ 68,063	$ 72,644	$ 77,534	$ 82,753	$ 88,323
	Rockland WWTP	$ 673,241.99	$ 718,557.91	$ 766,924.04	$ 818,545.70	$ 873,642.01	$ 932,446.85	$ 995,209.85
	South Essex Sewerage District	$ 2,067,381.44	$ 2,206,536.88	$ 2,355,058.88	$ 2,513,577.89	$ 2,682,766.82	$ 2,863,343.85	$ 3,056,075.53
	Springfield WWTP - Bondi's Island	$ 977,497.89	$ 1,043,293.27	$ 1,113,517.34	$ 1,188,468.19	$ 1,268,463.99	$ 1,353,844.30	$ 1,444,971.56
	Sum increased annual costs for all plants that will find other outlets - WITH step increase							
	SUM of hauling sites	$ 4,066,721	$ 4,340,452	$ 4,632,608	$ 4,944,428	$ 5,277,238	$ 5,632,449	$ 6,011,569
	Convert to present worth using 2.2% discount rate							
	Present worth from future cost	**$ 3,492,111**	**$ 3,646,933**	**$ 3,808,618**	**$ 3,977,472**	**$ 4,153,812**	**$ 4,337,970**	**$ 4,530,292**
		Price increases with step increase						
		2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
	Chicopee WWTP	$ 552.90	$ 587.17	$ 623.58	$ 662.24	$ 703.30	$ 746.91	$ 793.21
	Holyoke WWTP	$ 552.22	$ 586.46	$ 622.82	$ 661.44	$ 702.45	$ 746.00	$ 792.25
	Lowell Regional WW Utility	$ 750.91	$ 797.46	$ 846.91	$ 899.41	$ 955.18	$ 1,014.40	$ 1,077.29
	Montague WPCF	$ 704.67	$ 748.36	$ 794.76	$ 844.03	$ 896.36	$ 951.94	$ 1,010.96
	Rockland WWTP	$ 749.45	$ 795.91	$ 845.26	$ 897.67	$ 953.32	$ 1,012.43	$ 1,075.20
	South Essex Sewerage District	$ 532.82	$ 565.85	$ 600.94	$ 638.20	$ 677.76	$ 719.79	$ 764.41
	Springfield WWTP - Bondi's Island	$ 562.36	$ 597.23	$ 634.26	$ 673.58	$ 715.34	$ 759.69	$ 806.79
		Cost increases with step increase						
		2038	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
	Chicopee WWTP	$ 218,340	$ 233,036	$ 248,722	$ 265,463	$ 283,332	$ 302,403	$ 322,757
	Holyoke WWTP	$ 185,678	$ 198,176	$ 211,516	$ 225,753	$ 240,948	$ 257,166	$ 274,476
	Lowell Regional WW Utility	$ 51,712	$ 55,193	$ 58,908	$ 62,873	$ 67,105	$ 71,622	$ 76,443
	Montague WPCF	$ 94,268	$ 100,613	$ 107,385	$ 114,613	$ 122,328	$ 130,562	$ 139,350
	Rockland WWTP	$ 1,062,197.43	$ 1,133,693.94	$ 1,210,002.87	$ 1,291,448.17	$ 1,378,375.54	$ 1,471,154.00	$ 1,570,177.38
	South Essex Sewerage District	$ 3,261,779.97	$ 3,481,330.38	$ 3,715,658.73	$ 3,965,759.72	$ 4,232,695.01	$ 4,517,597.71	$ 4,821,677.21
	Springfield WWTP - Bondi's Island	$ 1,542,232.59	$ 1,646,040.27	$ 1,756,835.24	$ 1,875,087.82	$ 2,001,299.98	$ 2,136,007.48	$ 2,279,782.15
	Sum increased annual costs for all plants that will find other outlets - WITH step increase							
	SUM of hauling sites	$ 6,416,208	$ 6,848,083	$ 7,309,027	$ 7,800,998	$ 8,326,083	$ 8,886,511	$ 9,484,663
	Convert to present worth using 2.2% discount rate							
	Present worth from future cost	**$ 4,731,141**	**$ 4,940,894**	**$ 5,159,947**	**$ 5,388,711**	**$ 5,627,618**	**$ 5,877,116**	**$ 6,137,676**
	Sum the total present worth							
	Sum of cost increases WITH step increase	**$ 86,438,480**						
	INCREASE due to step increase	**$ 32,414,430**						
	How much MORE haulers need to pay from 2024-2044:	**$ 32,414,430**						
	Equivalent annual cost	**$ 2,535,000**						

Calculation approach
Total Annual Solids Handling Costs were estimated
For facilities hauling liquid, Column A was multipled by Column C to get Column E (eg, for Acton, 236,631 gal/yr * $0.11/gal = $25,031/yr). Numbers will not be exact due to rounding errors.
For facilities hauling cake, Column B was multipled by Column D to get Column E (eg, for Adams, 983 wt/yr * $170/wt = $167,193/yr)
This provided the total annual solids handling costs for each facility BEFORE price increases
The entirety of these annual costs would be subjected to indirect price increase, therefore Column F is identical to Column E
Next, to determine the INCREASE in annual sludge handling costs, the annual solids handling costs that would be indirectly impacted are multiplied by the percent increase associated with indirect impacts for this Scenario.
According to Table 5-1, since Scenario 6 affects over 20,000 dt/yr, the INDIRECT price increase percentage is 30%.
Multiply Column F by 30% to get the indirect price increase, shown in Column G (eg, for Acton, $25,031 * 22.5% = $7,509)
Note: data on annual solids handling costs were not available for all plants; these were deemed negligible and not considered.
For clarity of calculations, results for individual plants or sludge loads are not rounded. When values are totaled for Column G (total indirect impacts), this total is rounded.

Table H-6E: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (30%)**
Acton Wastewater Collection	Greater Lawrence Sanitary District	236,361	986	$ 0.11	liquid	$ 25,031	$ 25,031	$ 7,509
Adams WWTP	Synagro Waterbury CT incinerator	not liquid	983	not liquid	$ 170.00	$ 167,193	$ 167,193	$ 50,158
Amesbury WWTP	Agresource/Ipswich Compost Facility	not liquid	2,120	not liquid	$ 156.00	$ 330,739	$ 330,739	$ 99,222
Amherst WWTP	MDC Hartford Connecticut Incinerator	3,448,975	14,382	$ 0.19	liquid	$ 661,600	$ 661,600	$ 198,480
Ashfield	Lowell Regional WW Utility	20,869	87	$ 0.24	liquid	$ 5,044	$ 5,044	$ 1,513
Athol WWTP	Upper Blackstone Clean Water	1,804,657	7,525	$ 0.26	liquid	$ 468,308	$ 468,308	$ 140,493
Attleboro WWTP	Attleboro Monofill	not liquid	9,521	not liquid	$ 156.00	$ 1,485,246	$ 1,485,246	$ 445,574
Barnstable WWTP WPCD - DPW	Upper Blackstone Clean Water	248,482	1,036	$ 0.18	liquid	$ 45,113	$ 45,113	$ 13,534
Barre WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Billerica WWTP	Hawk Ridge Compost Facility	not liquid	7,003	not liquid	$ 146.70	$ 1,027,369	$ 1,027,369	$ 308,211
Brockton WWTP	Veolia Naugatuck, CT	not liquid	17,335	not liquid	$ 148.52	$ 2,574,569	$ 2,574,569	$ 772,371
Charlemont Sewer District		-	-	$ 0.16	liquid	$ -	$ -	$ -
Charles River PCD	Upper Blackstone Clean Water	6,247,045	26,050	$ 0.15	liquid	$ 917,709	$ 917,709	$ 275,313
Charlton WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Chatham WPCF	Hawk Ridge Compost Facility	not liquid	271	not liquid	$ 156.00	$ 42,336	$ 42,336	$ 12,701
Chicopee WWTP	Synagro Waterbury CT incinerator	not liquid	412	not liquid	$ 140.17	$ 57,796	$ 57,796	$ 17,339
Chicopee WWTP	Casella composting Grasslands NY	not liquid	3,443	not liquid	$ 140.17	$ 482,629	$ 482,629	$ 144,789
Concord WWTF	New England Waste Services of VT Landfill (Waste USA Landfill)	31,175	130	$ 0.06	liquid	$ 1,882	$ 1,882	$ 565
Concord WWTF	Greater Lawrence Sanitary District	978,417	4,080	$ 0.06	liquid	$ 59,058	$ 59,058	$ 17,717
Devens WWTP	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	3,844	not liquid	$ 170.00	$ 653,421	$ 653,421	$ 196,026
Douglas WWTP	Upper Blackstone Clean Water	1,236,248	5,155	$ 0.10	liquid	$ 125,000	$ 125,000	$ 37,500
Easthampton WWTP	Synagro Waterbury CT incinerator	not liquid	2,539	not liquid	$ 118.17	$ 300,000	$ 300,000	$ 90,000
Edgartown WWTP	Synagro in Woonsocket, RI incinerator	not liquid	1,011	not liquid	$ 119.00	$ 120,271	$ 120,271	$ 36,081
Erving POTW #1	Lowell Regional WW Utility	192,970	805	$ 0.20	liquid	$ 38,451	$ 38,451	$ 11,535
Erving POTW #3	Erving POTW #1	4,958	21	$ 0.16	liquid	$ 793	$ 793	$ 238
Falmouth WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Fitchburg East WWTP	Resource Control, Inc. – RCI Fitchburg Landfill	not liquid	8,748	not liquid	$ 37.59	$ 328,849	$ 328,849	$ 98,655
Gardner WPCF	City of Gardner West St. Sludge Landfill	not liquid	3,276	not liquid	$ 2.72	$ 8,925	$ 8,925	$ 2,678
Gloucester WPCF	Hawk Ridge Compost Facility	not liquid	2,604	not liquid	$ 156.00	$ 406,256	$ 406,256	$ 121,877
Grafton WWTP	Upper Blackstone Clean Water	2,769,789	11,550	$ 0.11	liquid	$ 301,245	$ 301,245	$ 90,373
Great Barrington WWTP	Synagro Waterbury CT incinerator	not liquid	937	not liquid	$ 151.00	$ 141,446	$ 141,446	$ 42,434
Greenfield WPCF	Lowell Regional WW Utility	3,138,258	13,087	$ 0.23	liquid	$ 730,183	$ 730,183	$ 219,055
Hadley WWTP	Lowell Regional WW Utility	1,039,319	4,334	$ 0.23	liquid	$ 243,928	$ 243,928	$ 73,178

Table H-6E: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (30%)**
Hatfield WWTP	Lowell Regional WW Utility	328,759	1,371	$ 0.24	liquid	$ 78,398	$ 78,398	$ 23,519
Haverhill WWTP	Crossroads Landfill in Maine	not liquid	14,583	not liquid	$ 175.00	$ 2,552,052	$ 2,552,052	$ 765,616
Holyoke WWTP	Veolia Naugatuck, CT	not liquid	428	not liquid	$ 140.00	$ 59,920	$ 59,920	$ 17,976
Holyoke WWTP	Ontario County MSW LF NY	not liquid	3,639	not liquid	$ 140.00	$ 509,390	$ 509,390	$ 152,817
Holyoke WWTP	Casella composting Grasslands NY	not liquid	5,229	not liquid	$ 140.00	$ 732,060	$ 732,060	$ 219,618
Hudson WWTF	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	2,133	not liquid	$ 156.00	$ 332,773	$ 332,773	$ 99,832
Huntington WWTP	Westfield WPCP	72,000	300	$ 0.34	liquid	$ 24,480	$ 24,480	$ 7,344
Ipswich WWTP	Agresource/Ipswich Compost Facility	not liquid	2,364	not liquid	$ 156.00	$ 368,759	$ 368,759	$ 110,628
Leicester WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Lenox Center WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Leominster WPCF	Upper Blackstone Clean Water	6,370,102	26,563	$ 0.06	liquid	$ 379,114	$ 379,114	$ 113,734
Lowell Regional WW Utility	Bethleham MSW Landfill NH	not liquid	7,648	not liquid	$ 190.37	$ 1,456,002	$ 1,456,002	$ 436,801
Lowell Regional WW Utility	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	2,448	not liquid	$ 190.37	$ 466,073	$ 466,073	$ 139,822
Lowell Regional WW Utility	Hawk Ridge Compost Facility	not liquid	11,211	not liquid	$ 190.37	$ 2,134,202	$ 2,134,202	$ 640,261
Lowell Regional WW Utility	Envirem Organics (NB)	not liquid	5,751	not liquid	$ 190.37	$ 1,094,853	$ 1,094,853	$ 328,456
Lynn Regional WF	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	3,306	not liquid	$ 225.00	$ 743,959	$ 743,959	$ 223,188
Lynn Regional WF	Lynn WWTF	not liquid	1,415	not liquid	$ 225.00	$ 318,271	Exception - not directly or indirectly impacted in this scenario	
Manchester By the Sea WWTP	Upper Blackstone Clean Water	129,822	541	$ 0.16	liquid	$ 20,771	$ 20,771	$ 6,231
Mansfield WWTP (MFN)	Lowell Regional WW Utility	85,106	355	$ 0.11	liquid	$ 9,680	$ 9,680	$ 2,904
Marlborough East WWTP	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	5,598	not liquid	$ 163.75	$ 916,704	$ 916,704	$ 275,011
Marlborough West WWTP	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	3,345	not liquid	$ 156.00	$ 521,814	$ 521,814	$ 156,544
Marshfield WWTF	Upper Blackstone Clean Water	656,197	2,736	$ 0.17	liquid	$ 108,392	$ 108,392	$ 32,518
Maynard WWTP	Greater Lawrence Sanitary District	2,798,422	11,669	$ 1.00	liquid	$ 2,798,422	$ 2,798,422	$ 839,527
MCI Bridgewater	New Bedford WWTP	379,521	1,583	$ 0.19	liquid	$ 70,591	$ 70,591	$ 21,177
MCI Concord		1,216,199	5,072	$ 0.05	liquid	$ 58,515	$ 58,515	$ 17,554
MCI Norfolk	New Bedford WWTP	366,013	1,526	$ 0.13	liquid	$ 48,497	$ 48,497	$ 14,549
Merrimac WWTP	Agresource/Ipswich Compost Facility	678,068	2,828	$ 0.16	liquid	$ 108,491	$ 108,491	$ 32,547
Middleborough WWTP	Middleborough MSW Landfill	not liquid	2,195	not liquid	$ 156.00	$ 342,407	$ 342,407	$ 102,722
Monroe WWTP	Hoosac WQD	488,109	2,035	$ 0.16	liquid	$ 78,098	$ 78,098	$ 23,429
Montague WPCF	Veolia Naugatuck, CT	not liquid	972	not liquid	$ 178.65	$ 173,623	$ 173,623	$ 52,087
Montague WPCF	Synagro Waterbury CT incinerator	not liquid	24	not liquid	$ 178.65	$ 4,245	$ 4,245	$ 1,273
MWRA Clinton WWTP	Town of Clinton Recycling Center	not liquid	1,464	not liquid	$ 156.00	$ 228,350	$ 228,350	$ 68,505
Nantucket Sewer Dept. - Siasconset		-	-	$ 0.16	liquid	$ -	$ -	$ -
Nantucket Sewer Dept. - Surfside		not liquid	-	not liquid	$ 156.00	$ -	$ -	$ -
Newburyport WWTP	Agresource/Ipswich Compost Facility	not liquid	2,729	not liquid	$ 156.00	$ 425,666	$ 425,666	$ 127,700
North Attleborough WPCF	Lowell Regional WW Utility	585,784	2,443	$ 0.11	liquid	$ 66,194	$ 66,194	$ 19,858
North Brookfield WWTP	Synagro Waterbury CT incinerator	not liquid	985	not liquid	$ 203.01	$ 199,951	$ 199,951	$ 59,985
Northampton WWTF	Synagro Waterbury CT incinerator	not liquid	4,506	not liquid	$ 157.00	$ 707,394	$ 707,394	$ 212,218
Northfield WPCF	Lowell Regional WW Utility	145,531	607	$ 0.25	liquid	$ 36,048	$ 36,048	$ 10,814
Oak Bluffs WWTP		400,000	1,668	$ 0.30	liquid	$ 119,000	$ 119,000	$ 35,700
Old Deerfield - Historic WWTP	Lowell Regional WW Utility	202,009	842	$ 0.25	liquid	$ 51,452	$ 51,452	$ 15,435
Orange WWTP	Lowell Regional WW Utility	313,571	1,308	$ 0.22	liquid	$ 67,582	$ 67,582	$ 20,275
Orange WWTP	Montague WPCF	107,211	447	$ 0.22	liquid	$ 23,106	$ 23,106	$ 6,932

Table H-6E: Indirect Costs for Remaining Facilities

		A	B	C	D	E	F	G
POTW name	**Destination Facility**	**Volume, for liquid (gal/yr)**	**Quantity (wet US tons/year)**	**Liquid Unit Costs**	**Solid Unit Costs**	**Total Annual Solids Handling Cost**	**Indirect Impacts - Base Cost**	**Indirect Impacts - Increased Cost (30%)**
Otis DPW		-	-	$ 0.16	liquid	$ -	$ -	$ -
Palmer WWTF	MDC Hartford Connecticut Incinerator	not liquid	2,921	not liquid	$ 160.07	$ 467,584	$ 467,584	$ 140,275
Pepperell WWTF		not liquid	1,047	not liquid	$ 156.00	$ 163,332	$ 163,332	$ 49,000
Pittsfield WWTP	Casella composting Grasslands NY	not liquid	6,022	not liquid	$ 161.00	$ 969,536	$ 969,536	$ 290,861
Provincetown Public Works	Cranston WPCF Incinerator	888,700	3,706	$ 0.17	liquid	$ 147,042	$ 147,042	$ 44,113
Rockport WWTP	Agresource/Ipswich Compost Facility	not liquid	473	not liquid	$ 156.00	$ 73,840	$ 73,840	$ 22,152
Royalston WWTF		-	-	$ 0.16	liquid	$ -	$ -	$ -
Russell Village WWTF	Westfield WPCP	70,519	294	$ 0.21	liquid	$ 15,000	$ 15,000	$ 4,500
Salisbury WWTF		-	-	$ 0.16	liquid	$ -	$ -	$ -
Scituate WWTF	Middleborough MSW Landfill	not liquid	1,895	not liquid	$ 172.00	$ 325,917	$ 325,917	$ 97,775
South Deerfield	Lowell Regional WW Utility	1,303,836	5,437	$ 0.18	liquid	$ 238,870	$ 238,870	$ 71,661
South Essex Sewerage District	Hawk Ridge Compost Facility	not liquid	19,646	not liquid	$ 135.08	$ 2,653,817	$ 2,653,817	$ 796,145
South Essex Sewerage District	Bethleham MSW Landfill NH	not liquid	1,389	not liquid	$ 135.08	$ 187,687	$ 187,687	$ 56,306
South Essex Sewerage District	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	5,020	not liquid	$ 135.08	$ 678,091	$ 678,091	$ 203,427
South Essex Sewerage District	Synagro Waterbury CT incinerator	not liquid	2,538	not liquid	$ 135.08	$ 342,788	$ 342,788	$ 102,836
South Hadley WWTP	Synagro Waterbury CT incinerator	not liquid	4,217	not liquid	$ 143.00	$ 603,037	$ 603,037	$ 180,911
Springfield WWTP - Bondi's Island	New England Waste Services of VT Landfill (Waste USA Landfill)	not liquid	4,344	not liquid	$ 142.57	$ 619,278	$ 619,278	$ 185,783
Springfield WWTP - Bondi's Island	Bethleham MSW Landfill NH	not liquid	1,479	not liquid	$ 142.57	$ 210,905	$ 210,905	$ 63,271
Springfield WWTP - Bondi's Island	Ontario County MSW LF NY	not liquid	3,598	not liquid	$ 142.57	$ 512,949	$ 512,949	$ 153,885
Springfield WWTP - Bondi's Island	Casella composting Grasslands NY	not liquid	17,547	not liquid	$ 142.57	$ 2,501,648	$ 2,501,648	$ 750,495
Springfield WWTP - Bondi's Island	Synagro Waterbury CT incinerator	not liquid	1,627	not liquid	$ 142.57	$ 231,937	$ 231,937	$ 69,581
Springfield WWTP - Bondi's Island	Chemung MSW Landfill NY	not liquid	6,397	not liquid	$ 142.57	$ 911,974	$ 911,974	$ 273,592
Sunderland WWTP	Lowell Regional WW Utility	56,463	235	$ 0.24	liquid	$ 13,345	$ 13,345	$ 4,003
Sunderland WWTP	Montague WPCF	282,739	1,179	$ 0.24	liquid	$ 66,825	$ 66,825	$ 20,048
Taunton WWTP	Veolia Naugatuck, CT	not liquid	7,430	not liquid	$ 133.25	$ 990,051	$ 990,051	$ 297,015
Tisbury Public Works		-	-	$ 0.16	liquid	$ -	$ -	$ -
Wareham WPCF		-	-	$ 0.16	liquid	$ -	$ -	$ -
Wayland WWTP		-	-	$ 0.16	liquid	$ -	$ -	$ -
Westborough WWTF	Upper Blackstone Clean Water	12,026,379	50,150	$ 0.16	liquid	$ 1,924,221	$ 1,924,221	$ 577,266
Westfield WPCP	Veolia Naugatuck, CT	not liquid	5,151	not liquid	$ 135.00	$ 695,421	$ 695,421	$ 208,626
							Total	**$ 13,624,000**

Table H-6F: Summary of Scenario 6 calculations		
Assumptions		
Population increases 0.5% per year		
Sludge mgmt prices increase 6.2% per year		
Directly impacted plants see increase of 60% to sludge mgmt costs in the first year		
Escalation (apart from sludge mgmt) is 4.7% per year		
Discount rate is 2.2% per year		
Half of the plants which currently haul liquid have to haul further		
Half of the plants which currently haul liquid install dewatering		
The plants which had been hauling cake haul further		
Dewatering facilities are sized for the need in 2044		
Plants that continue to haul	Amount paid due to escalation and population growth ONLY, NPV	$ 210,003,000
	Amount paid due to escalation, population growth AND step increase, NPV	$ 336,005,000
	Net Increase in hauling costs	$ 126,002,000
	Present worth of hauling, converted to annual costs	$ 9,855,000
Plants that install dewatering	Amount that would be paid for liquid hauling if dewatering were not installed	$ 509,239,000
	Amount that still has to be paid to haul cake	$ 351,161,000
	Capital cost of dewatering, average	$ 273,213,000
	Average NPV of O&M costs	$ 425,272,000
	Total NPV of dewatering	$ 698,485,000
	Dewatering costs, minus liquid hauling savings, plus cake hauling costs	$ 540,407,000
	Present worth of dewatering, converted to annual costs	$ 42,268,000
Plants that currently haul cake	Present worth of additional hauling charges	$ 32,414,000
	Present worth of increased hauling, converted to annual costs	$ 2,535,000

Total annual increase, direct costs to plants (including amortized capital costs)		**$ 54,658,000**
Total annual increase, indirect costs to plants		**$ 13,624,000**

Table H-7A: Plants Directly Impacted in Scenarios 7-10 (all plants)

POTW name	DEP "region"	Permitted or design flow (MGD)
Acton Wastewater Collection	Central	0.30
Adams WWTP	West	4.60
Amesbury WWTP	Northeast	2.40
Amherst WWTP	West	7.10
Ashfield	West	0.03
Athol WWTP	West	1.75
Attleboro WWTP	Southeast	8.60
Ayer WWTP	Central	1.79
Barnstable WWTP WPCD - DPW	Southeast	4.20
Barre WWTP	Central	0.30
Belchertown WWTP	West	1.00
Billerica WWTP	Northeast	5.55
Bridgewater WWTP	Southeast	1.44
Brockton WWTP	Southeast	18.00
Charlemont Sewer District	West	0.05
Charles River PCD	Central	5.70
Charlton WWTP	Central	0.45
Chatham WPCF	Southeast	1.50
Chicopee WWTP	West	15.50
Cohasset WWTF	Southeast	0.05
Concord WWTF	Northeast	1.20
Dartmouth WPCF	Southeast	4.20
Devens WWTP	Central	4.65
Douglas WWTP	Central	0.60
Easthampton WWTP	West	3.80
Edgartown WWTP	Southeast	0.75
Erving Center WWTP (#2)	West	2.70
Erving POTW #1	West	1.10
Erving POTW #3	West	0.01
Fairhaven WPCF	Southeast	5.00
Fall River Regional WWF	Southeast	30.90
Falmouth WWTP	Southeast	1.20
Fitchburg East WWTP	Central	12.40
Gardner WPCF	Central	5.00
Gloucester WPCF	Northeast	5.15
Grafton WWTP	Central	2.40
Great Barrington WWTP	West	3.20
Greater Lawrence Sanitary District	Northeast	52.00
Greenfield WPCF	West	3.45

Table H-7A: Plants Directly Impacted in Scenarios 7-10 (all plants)

POTW name	DEP "region"	Permitted or design flow (MGD)
Hadley WWTP	West	0.54
Hardwick-Gilbertville WPCF	West	0.23
Hardwick-Wheelwright WPCF	West	0.04
Hatfield WWTP	West	0.50
Haverhill WWTP	Northeast	18.10
Holyoke WWTP	West	17.50
Hoosac WQD	West	6.50
Hopedale WWTF	Central	0.59
Hudson WWTF	Central	3.05
Hull WWTF	Southeast	3.07
Huntington WWTP	West	0.20
Ipswich WWTP	Northeast	1.80
Kingston Sewer Commission	Southeast	0.50
Lee WWTP	West	1.25
Leicester WWTP	Central	0.37
Lenox Center WWTP	West	1.80
Leominster WPCF	Central	9.30
Lowell Regional WW Utility	Northeast	32.00
Lynn Regional WF	Northeast	25.80
Manchester By the Sea WWTP	Northeast	0.67
Mansfield WWTP (MFN)	Southeast	3.14
Marion WWTP - Marion DPW	Southeast	0.59
Marlborough East WWTP	Central	5.50
Marlborough West WWTP	Central	2.89
Marshfield WWTF	Southeast	2.10
Maynard WWTP	Central	1.45
MCI Bridgewater	Southeast	0.55
MCI Concord	Northeast	0.35
MCI Norfolk	Central	0.48
Medfield WWTP	Central	1.52
Merrimac WWTP	Northeast	0.45
Middleborough WWTP	Southeast	2.16
Milford WWTP	Central	4.20
Monroe WWTP	West	0.02
Montague WPCF	West	1.83
MWRA Clinton WWTP	Central	3.01
MWRA Deer Island WWTP	Northeast	361.00
Nantucket Sewer Dept. - Siasconset	Southeast	0.06
Nantucket Sewer Dept. - Surfside	Southeast	4.00

Table H-7A: Plants Directly Impacted in Scenarios 7-10 (all plants)

POTW name	DEP "region"	Permitted or design flow (MGD)
New Bedford WWTP	Southeast	30.00
Newburyport WWTP	Northeast	3.40
North Attleborough WPCF	Southeast	4.61
North Brookfield WWTP	Central	0.76
Northampton WWTF	West	8.60
Northbridge WWTF	Central	2.00
Northfield WPCF	West	0.28
Oak Bluffs WWTP	Southeast	0.34
Old Deerfield - Historic WWTP	West	0.25
Orange WWTP	West	1.10
Otis DPW	West	0.03
Oxford-Rochdale SD WPCP	Central	0.50
Palmer WWTF	West	5.60
Pepperell WWTF	Central	1.10
Pittsfield WWTP	West	17.00
Plymouth WWTF	Southeast	3.00
Provincetown Public Works	Southeast	0.75
Rockland WWTP	Southeast	2.50
Rockport WWTP	Northeast	0.80
Royalston WWTF	West	0.04
Russell Village WWTF	West	0.24
Salisbury WWTF	Northeast	1.30
Scituate WWTF	Southeast	1.60
Shelburne Falls WWTP	West	0.25
Somerset WWTF	Southeast	4.20
South Deerfield	West	0.85
South Essex Sewerage District	Northeast	29.70
South Hadley WWTP	West	4.20
Southbridge WWTP	Central	3.77
Spencer WWTP	Central	1.08
Springfield WWTP - Bondi's Island	West	67.00
Stockbridge WWTP	West	0.46
Sturbridge WPCF	Central	1.30
Sunderland WWTP	West	0.50
Taunton WWTP	Southeast	8.40
Templeton WWTP	Central	0.60
Tisbury Public Works	Southeast	0.14
Upper Blackstone WPAD (Worcester area)	Central	56.00
Upton WWTP	Central	0.40

Table H-7A: Plants Directly Impacted in Scenarios 7-10 (all plants)

POTW name	DEP "region"	Permitted or design flow (MGD)
Uxbridge WWTF	Central	1.50
Ware WWTP	West	1.00
Wareham WPCF	Southeast	1.60
Warren WWTP	West	1.50
Wayland WWTP	Northeast	0.09
Webster WWTF	Central	6.00
West Stockbridge	West	0.08
Westborough WWTF	Central	7.68
Westfield WPCP	West	6.10
Winchendon WPCF	Central	1.10
	Total # of Plants	127

Calculation Approach

Material quantities were calculated for each plant and each load, for each year from 2024 to 2044.

2023 was used as the baseline. Quantities were increased by 0.5% (ie, multiplied by 100.5%) each year to reflect population growth.

For example, Acton produced 236,361 gallons per year in 2023. In 2024, this grows to 236,631 * 1.005 = 237,543 gal/yr. Subsequent years are calculated according to the same logic.

Table H-7B: Annual Projected Material Quantities by Plant and Sludge Load

POTW name	Material Type	Units	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Acton Wastewater Collection	Liquid	gal	236,361	237,543	238,730	239,924	241,124	242,329	243,541	244,759	245,982	247,212	248,448	249,691	250,939
Adams WWTP	Cake	wet tons	983	988	993	998	1,003	1,008	1,013	1,018	1,024	1,029	1,034	1,039	1,044
Amesbury WWTP	Cake	wet tons	2,120	2,131	2,141	2,152	2,163	2,174	2,185	2,195	2,206	2,217	2,229	2,240	2,251
Amherst WWTP	Liquid	gal	3,448,975	3,466,220	3,483,551	3,500,969	3,518,474	3,536,066	3,553,746	3,571,515	3,589,373	3,607,320	3,625,356	3,643,483	3,661,700
Ashfield	Liquid	gal	20,869	20,974	21,078	21,184	21,290	21,396	21,503	21,611	21,719	21,827	21,936	22,046	22,156
Athol WWTP	Liquid	gal	303,029	304,544	306,067	307,597	309,135	310,681	312,234	313,795	315,364	316,941	318,526	320,118	321,719
Athol WWTP	Liquid	gal	1,804,657	1,813,680	1,822,748	1,831,862	1,841,021	1,850,226	1,859,477	1,868,775	1,878,119	1,887,509	1,896,947	1,906,432	1,915,964
Attleboro WWTP	Cake	wet tons	9,521	9,568	9,616	9,664	9,713	9,761	9,810	9,859	9,908	9,958	10,008	10,058	10,108
Ayer WWTP	Liquid	gal	1,964,446	1,974,268	1,984,139	1,994,060	2,004,030	2,014,050	2,024,121	2,034,241	2,044,412	2,054,634	2,064,908	2,075,232	2,085,608
Barnstable WWTP WPCD - DPW	Liquid	gal	4,731,738	4,755,397	4,779,174	4,803,070	4,827,085	4,851,221	4,875,477	4,899,854	4,924,353	4,948,975	4,973,720	4,998,589	5,023,582
Barnstable WWTP WPCD - DPW	Liquid	gal	248,482	249,725	250,973	252,228	253,489	254,757	256,031	257,311	258,597	259,890	261,190	262,496	263,808
Barre WWTP	Liquid	gal	3,488	3,505	3,523	3,541	3,558	3,576	3,594	3,612	3,630	3,648	3,666	3,685	3,703
Belchertown WWTP	Liquid	gal	570,594	573,447	576,314	579,196	582,092	585,002	587,927	590,867	593,821	596,790	599,774	602,773	605,787
Billerica WWTP	Cake	wet tons	7,003	7,038	7,073	7,109	7,144	7,180	7,216	7,252	7,288	7,325	7,361	7,398	7,435
Bridgewater WWTP	Cake	wet tons	573	576	579	582	585	588	591	594	597	600	603	606	609
Brockton WWTP	Cake	wet tons	17,335	17,422	17,509	17,596	17,684	17,773	17,861	17,951	18,040	18,131	18,221	18,312	18,404
Charlemont Sewer District	Liquid	gal	581	584	587	590	593	596	599	602	605	608	611	614	617
Charles River PCD	Liquid	gal	532,573	535,236	537,912	540,602	543,305	546,021	548,751	551,495	554,253	557,024	559,809	562,608	565,421
Charles River PCD	Liquid	gal	6,247,045	6,278,281	6,309,672	6,341,220	6,372,926	6,404,791	6,436,815	6,468,999	6,501,344	6,533,851	6,566,520	6,599,353	6,632,349
Charlton WWTP	Liquid	gal	5,232	5,258	5,284	5,311	5,337	5,364	5,391	5,418	5,445	5,472	5,500	5,527	5,555
Chatham WPCF	Cake	wet tons	271	273	274	275	277	278	280	281	282	284	285	287	288
Chicopee WWTP	Cake	wet tons	412	414	416	419	421	423	425	427	429	431	433	436	438
Chicopee WWTP	Cake	wet tons	366	368	370	372	374	376	378	379	381	383	385	387	389
Chicopee WWTP	Cake	wet tons	3,443	3,460	3,478	3,495	3,513	3,530	3,548	3,565	3,583	3,601	3,619	3,637	3,656
Cohasset WWTF	Liquid	gal	524,258	526,879	529,514	532,161	534,822	537,496	540,184	542,885	545,599	548,327	551,069	553,824	556,593
Concord WWTF	Liquid	gal	31,175	31,331	31,488	31,645	31,803	31,962	32,122	32,283	32,444	32,606	32,769	32,933	33,098
Concord WWTF	Liquid	gal	978,417	983,309	988,226	993,167	998,133	1,003,124	1,008,139	1,013,180	1,018,246	1,023,337	1,028,454	1,033,596	1,038,764
Dartmouth WPCF	Cake	wet tons	1,653	1,662	1,670	1,678	1,687	1,695	1,704	1,712	1,721	1,729	1,738	1,747	1,755
Devens WWTP	Cake	wet tons	3,844	3,863	3,882	3,902	3,921	3,941	3,960	3,980	4,000	4,020	4,040	4,060	4,081
Douglas WWTP	Liquid	gal	1,236,248	1,242,429	1,248,642	1,254,885	1,261,159	1,267,465	1,273,802	1,280,171	1,286,572	1,293,005	1,299,470	1,305,967	1,312,497
Easthampton WWTP	Cake	wet tons	2,539	2,551	2,564	2,577	2,590	2,603	2,616	2,629	2,642	2,655	2,669	2,682	2,695
Edgartown WWTP	Cake	wet tons	1,011	1,016	1,021	1,026	1,031	1,036	1,041	1,047	1,052	1,057	1,062	1,068	1,073
Erving Center WWTP (#2)	Cake	wet tons	30,917	30,917	30,917	30,917	30,917	30,917	30,917	30,917	30,917	30,917	30,917	30,917	30,917
Erving Center WWTP (#2)	Cake	wet tons	2,217	2,217	2,217	2,217	2,217	2,217	2,217	2,217	2,217	2,217	2,217	2,217	2,217
Erving POTW #1	Liquid	gal	192,970	193,935	194,905	195,879	196,859	197,843	198,832	199,826	200,826	201,830	202,839	203,853	204,872
Erving POTW #3	Liquid	gal	4,958	4,982	5,007	5,032	5,057	5,083	5,108	5,134	5,159	5,185	5,211	5,237	5,263
Fairhaven WPCF	Liquid	gal	4,650,730	4,673,984	4,697,354	4,720,840	4,744,445	4,768,167	4,792,008	4,815,968	4,840,048	4,864,248	4,888,569	4,913,012	4,937,577

Table H-7B: Annual Projected Material Quantities by Plant and Sludge Load

POTW name	2036	2037	2038	2039	2040	2041	2042	2043	2044
Acton Wastewater Collection	252,194	253,455	254,722	255,996	257,276	258,562	259,855	261,154	262,460
Adams WWTP	1,049	1,055	1,060	1,065	1,071	1,076	1,081	1,087	1,092
Amesbury WWTP	2,262	2,273	2,285	2,296	2,308	2,319	2,331	2,343	2,354
Amherst WWTP	3,680,009	3,698,409	3,716,901	3,735,486	3,754,163	3,772,934	3,791,798	3,810,757	3,829,811
Ashfield	22,267	22,378	22,490	22,603	22,716	22,829	22,944	23,058	23,174
Athol WWTP	323,328	324,944	326,569	328,202	329,843	331,492	333,150	334,815	336,489
Athol WWTP	1,925,544	1,935,171	1,944,847	1,954,571	1,964,344	1,974,166	1,984,037	1,993,957	2,003,927
Attleboro WWTP	10,159	10,209	10,260	10,312	10,363	10,415	10,467	10,519	10,572
Ayer WWTP	2,096,036	2,106,516	2,117,049	2,127,634	2,138,272	2,148,964	2,159,709	2,170,507	2,181,360
Barnstable WWTP WPCD - DPW	5,048,700	5,073,943	5,099,313	5,124,809	5,150,433	5,176,186	5,202,066	5,228,077	5,254,217
Barnstable WWTP WPCD - DPW	265,127	266,453	267,785	269,124	270,470	271,822	273,181	274,547	275,920
Barre WWTP	3,722	3,740	3,759	3,778	3,797	3,816	3,835	3,854	3,873
Belchertown WWTP	608,816	611,860	614,919	617,994	621,084	624,189	627,310	630,447	633,599
Billerica WWTP	7,472	7,510	7,547	7,585	7,623	7,661	7,699	7,738	7,776
Bridgewater WWTP	612	615	618	621	624	627	630	633	636
Brockton WWTP	18,496	18,589	18,681	18,775	18,869	18,963	19,058	19,153	19,249
Charlemont Sewer District	620	623	626	630	633	636	639	642	646
Charles River PCD	568,248	571,090	573,945	576,815	579,699	582,597	585,510	588,438	591,380
Charles River PCD	6,665,511	6,698,839	6,732,333	6,765,995	6,799,825	6,833,824	6,867,993	6,902,333	6,936,844
Charlton WWTP	5,582	5,610	5,638	5,667	5,695	5,723	5,752	5,781	5,810
Chatham WPCF	290	291	292	294	295	297	298	300	301
Chicopee WWTP	440	442	444	447	449	451	453	456	458
Chicopee WWTP	391	393	395	397	399	401	403	405	407
Chicopee WWTP	3,674	3,692	3,711	3,729	3,748	3,767	3,785	3,804	3,823
Cohasset WWTF	559,376	562,173	564,984	567,809	570,648	573,501	576,369	579,250	582,147
Concord WWTF	33,263	33,430	33,597	33,765	33,934	34,103	34,274	34,445	34,617
Concord WWTF	1,043,958	1,049,178	1,054,423	1,059,696	1,064,994	1,070,319	1,075,671	1,081,049	1,086,454
Dartmouth WPCF	1,764	1,773	1,782	1,791	1,800	1,809	1,818	1,827	1,836
Devens WWTP	4,101	4,122	4,142	4,163	4,184	4,205	4,226	4,247	4,268
Douglas WWTP	1,319,060	1,325,655	1,332,283	1,338,945	1,345,639	1,352,368	1,359,130	1,365,925	1,372,755
Easthampton WWTP	2,709	2,722	2,736	2,750	2,763	2,777	2,791	2,805	2,819
Edgartown WWTP	1,078	1,084	1,089	1,095	1,100	1,106	1,111	1,117	1,122
Erving Center WWTP (#2)	30,917	30,917	30,917	30,917	30,917	30,917	30,917	30,917	30,917
Erving Center WWTP (#2)	2,217	2,217	2,217	2,217	2,217	2,217	2,217	2,217	2,217
Erving POTW #1	205,897	206,926	207,961	209,001	210,046	211,096	212,151	213,212	214,278
Erving POTW #3	5,290	5,316	5,343	5,369	5,396	5,423	5,450	5,478	5,505
Fairhaven WPCF	4,962,265	4,987,076	5,012,011	5,037,072	5,062,257	5,087,568	5,113,006	5,138,571	5,164,264

Table H-7B: Annual Projected Material Quantities by Plant and Sludge Load

POTW name	Material Type	Units	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Fall River Regional WWF	Liquid	gal	33,968,066	34,137,906	34,308,596	34,480,139	34,652,539	34,825,802	34,999,931	35,174,931	35,350,805	35,527,560	35,705,197	35,883,723	36,063,142
Falmouth WWTP	Liquid	gal	13,952	14,022	14,092	14,162	14,233	14,304	14,376	14,448	14,520	14,593	14,666	14,739	14,813
Fitchburg East WWTP	Cake	wet tons	8,748	8,792	8,836	8,880	8,925	8,969	9,014	9,059	9,104	9,150	9,196	9,242	9,288
Gardner WPCF	Cake	wet tons	3,276	3,293	3,309	3,326	3,342	3,359	3,376	3,393	3,410	3,427	3,444	3,461	3,478
Gloucester WPCF	Cake	wet tons	2,604	2,617	2,630	2,643	2,657	2,670	2,683	2,697	2,710	2,724	2,737	2,751	2,765
Grafton WWTP	Liquid	gal	2,769,789	2,783,638	2,797,556	2,811,544	2,825,602	2,839,730	2,853,928	2,868,198	2,882,539	2,896,952	2,911,436	2,925,993	2,940,623
Great Barrington WWTP	Cake	wet tons	937	941	946	951	956	960	965	970	975	980	985	990	995
Greater Lawrence Sanitary District	Cake	wet tons	6,480	6,512	6,545	6,577	6,610	6,643	6,677	6,710	6,743	6,777	6,811	6,845	6,879
Greenfield WPCF	Liquid	gal	3,138,258	3,153,950	3,169,719	3,185,568	3,201,496	3,217,503	3,233,591	3,249,759	3,266,008	3,282,338	3,298,749	3,315,243	3,331,819
Hadley WWTP	Liquid	gal	1,039,319	1,044,516	1,049,738	1,054,987	1,060,262	1,065,563	1,070,891	1,076,245	1,081,627	1,087,035	1,092,470	1,097,932	1,103,422
Hardwick-Gilbertville WPCF	Liquid	gal	238,609	239,802	241,001	242,206	243,417	244,634	245,857	247,087	248,322	249,564	250,812	252,066	253,326
Hardwick-Wheelwright WPCF	Liquid	gal	148,681	149,424	150,172	150,922	151,677	152,435	153,198	153,964	154,733	155,507	156,285	157,066	157,851
Hatfield WWTP	Liquid	gal	328,759	330,403	332,055	333,715	335,384	337,061	338,746	340,440	342,142	343,853	345,572	347,300	349,036
Haverhill WWTP	Cake	wet tons	14,583	14,656	14,729	14,803	14,877	14,951	15,026	15,101	15,177	15,253	15,329	15,406	15,483
Holyoke WWTP	Cake	wet tons	428	430	432	434	437	439	441	443	445	448	450	452	454
Holyoke WWTP	Cake	wet tons	312	314	315	317	318	320	321	323	325	326	328	330	331
Holyoke WWTP	Cake	wet tons	3,639	3,657	3,675	3,693	3,712	3,730	3,749	3,768	3,787	3,806	3,825	3,844	3,863
Holyoke WWTP	Cake	wet tons	5,229	5,255	5,281	5,308	5,334	5,361	5,388	5,415	5,442	5,469	5,496	5,524	5,552
Hoosac WQD	Cake	wet tons	465	467	469	472	474	477	479	481	484	486	489	491	493
Hopedale WWTF	Liquid	gal	1,223,998	1,230,118	1,236,269	1,242,450	1,248,663	1,254,906	1,261,181	1,267,486	1,273,824	1,280,193	1,286,594	1,293,027	1,299,492
Hudson WWTF	Cake	wet tons	2,133	2,144	2,155	2,165	2,176	2,187	2,198	2,209	2,220	2,231	2,242	2,253	2,265
Hull WWTF	Liquid	gal	1,211,484	1,217,541	1,223,629	1,229,747	1,235,896	1,242,075	1,248,285	1,254,527	1,260,800	1,267,104	1,273,439	1,279,806	1,286,205
Huntington WWTP	Liquid	gal	72,000	72,360	72,722	73,085	73,451	73,818	74,187	74,558	74,931	75,305	75,682	76,060	76,441
Ipswich WWTP	Cake	wet tons	2,364	2,376	2,388	2,399	2,411	2,424	2,436	2,448	2,460	2,472	2,485	2,497	2,510
Kingston Sewer Commission	Liquid	gal	937,999	942,689	947,402	952,139	956,900	961,684	966,493	971,325	976,182	981,063	985,968	990,898	995,853
Lee WWTP	Liquid	gal	1,153,383	1,159,150	1,164,946	1,170,770	1,176,624	1,182,507	1,188,420	1,194,362	1,200,334	1,206,336	1,212,367	1,218,429	1,224,521
Leicester WWTP	Liquid	gal	4,302	4,323	4,345	4,367	4,389	4,411	4,433	4,455	4,477	4,499	4,522	4,544	4,567
Lenox Center WWTP	Liquid	gal	20,928	21,033	21,138	21,244	21,350	21,457	21,564	21,672	21,780	21,889	21,998	22,108	22,219
Leominster WPCF	Liquid	gal	6,370,102	6,401,953	6,433,962	6,466,132	6,498,463	6,530,955	6,563,610	6,596,428	6,629,410	6,662,557	6,695,870	6,729,349	6,762,996
Lowell Regional WW Utility	Cake	wet tons	7,648	7,687	7,725	7,764	7,802	7,841	7,881	7,920	7,960	7,999	8,039	8,080	8,120
Lowell Regional WW Utility	Cake	wet tons	2,448	2,460	2,473	2,485	2,498	2,510	2,523	2,535	2,548	2,561	2,573	2,586	2,599
Lowell Regional WW Utility	Cake	wet tons	11,211	11,267	11,323	11,380	11,437	11,494	11,551	11,609	11,667	11,726	11,784	11,843	11,902
Lowell Regional WW Utility	Cake	wet tons	64	64	65	65	65	66	66	66	67	67	67	68	68
Lowell Regional WW Utility	Cake	wet tons	5,751	5,780	5,809	5,838	5,867	5,896	5,926	5,956	5,985	6,015	6,045	6,076	6,106
Lynn Regional WF	Cake	wet tons	1,415	1,422	1,429	1,436	1,443	1,450	1,458	1,465	1,472	1,479	1,487	1,494	1,502
Lynn Regional WF	Cake	wet tons	3,306	3,323	3,340	3,356	3,373	3,390	3,407	3,424	3,441	3,458	3,476	3,493	3,510
Manchester By the Sea WWTP	Liquid	gal	111,964	112,524	113,086	113,652	114,220	114,791	115,365	115,942	116,522	117,104	117,690	118,278	118,870
Manchester By the Sea WWTP	Liquid	gal	129,822	130,471	131,123	131,779	132,438	133,100	133,765	134,434	135,106	135,782	136,461	137,143	137,829
Mansfield WWTP (MFN)	Liquid	gal	4,759,417	4,783,214	4,807,130	4,831,166	4,855,322	4,879,598	4,903,996	4,928,516	4,953,159	4,977,925	5,002,814	5,027,828	5,052,967
Mansfield WWTP (MFN)	Liquid	gal	85,106	85,531	85,959	86,389	86,820	87,255	87,691	88,129	88,570	89,013	89,458	89,905	90,355
Marion WWTP - Marion DPW	Cake	wet tons	380	381	383	385	387	389	391	393	395	397	399	401	403

Table H-7B: Annual Projected Material Quantities by Plant and Sludge Load

POTW name	2036	2037	2038	2039	2040	2041	2042	2043	2044
Fall River Regional WWF	36,243,458	36,424,675	36,606,798	36,789,832	36,973,781	37,158,650	37,344,444	37,531,166	37,718,822
Falmouth WWTP	14,887	14,961	15,036	15,111	15,187	15,263	15,339	15,416	15,493
Fitchburg East WWTP	9,334	9,381	9,428	9,475	9,522	9,570	9,618	9,666	9,714
Gardner WPCF	3,496	3,513	3,531	3,548	3,566	3,584	3,602	3,620	3,638
Gloucester WPCF	2,779	2,793	2,807	2,821	2,835	2,849	2,863	2,877	2,892
Grafton WWTP	2,955,327	2,970,103	2,984,954	2,999,878	3,014,878	3,029,952	3,045,102	3,060,328	3,075,629
Great Barrington WWTP	999	1,004	1,009	1,015	1,020	1,025	1,030	1,035	1,040
Greater Lawrence Sanitary District	6,914	6,948	6,983	7,018	7,053	7,088	7,124	7,159	7,195
Greenfield WPCF	3,348,478	3,365,221	3,382,047	3,398,957	3,415,952	3,433,032	3,450,197	3,467,448	3,484,785
Hadley WWTP	1,108,939	1,114,484	1,120,056	1,125,656	1,131,285	1,136,941	1,142,626	1,148,339	1,154,081
Hardwick-Gilbertville WPCF	254,593	255,866	257,145	258,431	259,723	261,021	262,327	263,638	264,956
Hardwick-Wheelwright WPCF	158,641	159,434	160,231	161,032	161,837	162,647	163,460	164,277	165,098
Hatfield WWTP	350,781	352,535	354,298	356,070	357,850	359,639	361,437	363,245	365,061
Haverhill WWTP	15,560	15,638	15,716	15,795	15,874	15,953	16,033	16,113	16,193
Holyoke WWTP	457	459	461	464	466	468	471	473	475
Holyoke WWTP	333	335	336	338	340	341	343	345	346
Holyoke WWTP	3,882	3,902	3,921	3,941	3,960	3,980	4,000	4,020	4,040
Holyoke WWTP	5,579	5,607	5,635	5,663	5,692	5,720	5,749	5,777	5,806
Hoosac WQD	496	498	501	503	506	508	511	514	516
Hopedale WWTF	1,305,989	1,312,519	1,319,082	1,325,677	1,332,306	1,338,967	1,345,662	1,352,391	1,359,152
Hudson WWTF	2,276	2,287	2,299	2,310	2,322	2,334	2,345	2,357	2,369
Hull WWTF	1,292,636	1,299,099	1,305,595	1,312,123	1,318,684	1,325,277	1,331,903	1,338,563	1,345,256
Huntington WWTP	76,823	77,207	77,593	77,981	78,371	78,763	79,157	79,552	79,950
Ipswich WWTP	2,522	2,535	2,547	2,560	2,573	2,586	2,599	2,612	2,625
Kingston Sewer Commission	1,000,832	1,005,836	1,010,865	1,015,919	1,020,999	1,026,104	1,031,235	1,036,391	1,041,573
Lee WWTP	1,230,644	1,236,797	1,242,981	1,249,196	1,255,442	1,261,719	1,268,028	1,274,368	1,280,740
Leicester WWTP	4,590	4,613	4,636	4,659	4,683	4,706	4,729	4,753	4,777
Lenox Center WWTP	22,330	22,442	22,554	22,667	22,780	22,894	23,008	23,123	23,239
Leominster WPCF	6,796,811	6,830,795	6,864,949	6,899,274	6,933,770	6,968,439	7,003,281	7,038,298	7,073,489
Lowell Regional WW Utility	8,161	8,201	8,242	8,284	8,325	8,367	8,409	8,451	8,493
Lowell Regional WW Utility	2,612	2,625	2,638	2,652	2,665	2,678	2,692	2,705	2,719
Lowell Regional WW Utility	11,962	12,022	12,082	12,142	12,203	12,264	12,325	12,387	12,449
Lowell Regional WW Utility	68	69	69	69	70	70	70	71	71
Lowell Regional WW Utility	6,136	6,167	6,198	6,229	6,260	6,291	6,323	6,354	6,386
Lynn Regional WF	1,509	1,517	1,524	1,532	1,540	1,547	1,555	1,563	1,571
Lynn Regional WF	3,528	3,546	3,563	3,581	3,599	3,617	3,635	3,653	3,672
Manchester By the Sea WWTP	119,464	120,061	120,662	121,265	121,871	122,481	123,093	123,708	124,327
Manchester By the Sea WWTP	138,518	139,211	139,907	140,606	141,309	142,016	142,726	143,439	144,157
Mansfield WWTP (MFN)	5,078,232	5,103,623	5,129,142	5,154,787	5,180,561	5,206,464	5,232,496	5,258,659	5,284,952
Mansfield WWTP (MFN)	90,806	91,260	91,717	92,175	92,636	93,099	93,565	94,033	94,503
Marion WWTP - Marion DPW	405	407	409	411	413	415	417	419	422

Table H-7B: Annual Projected Material Quantities by Plant and Sludge Load

POTW name	Material Type	Units	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Marlborough East WWTP	Cake	wet tons	5,598	5,626	5,654	5,683	5,711	5,740	5,768	5,797	5,826	5,855	5,884	5,914	5,943
Marlborough West WWTP	Cake	wet tons	3,345	3,362	3,378	3,395	3,412	3,429	3,447	3,464	3,481	3,499	3,516	3,534	3,551
Marshfield WWTF	Liquid	gal	536,735	539,418	542,116	544,826	547,550	550,288	553,039	555,805	558,584	561,377	564,183	567,004	569,839
Marshfield WWTF	Liquid	gal	656,197	659,478	662,776	666,090	669,420	672,767	676,131	679,512	682,909	686,324	689,755	693,204	696,670
Maynard WWTP	Liquid	gal	35,246	35,422	35,599	35,777	35,956	36,136	36,316	36,498	36,680	36,864	37,048	37,233	37,420
Maynard WWTP	Liquid	gal	2,798,422	2,812,414	2,826,477	2,840,609	2,854,812	2,869,086	2,883,431	2,897,849	2,912,338	2,926,900	2,941,534	2,956,242	2,971,023
MCI Bridgewater	Liquid	gal	379,521	381,419	383,326	385,242	387,168	389,104	391,050	393,005	394,970	396,945	398,930	400,924	402,929
MCI Concord	Liquid	gal	1,216,199	1,222,279	1,228,391	1,234,533	1,240,706	1,246,909	1,253,144	1,259,409	1,265,706	1,272,035	1,278,395	1,284,787	1,291,211
MCI Norfolk	Liquid	gal	366,013	367,843	369,683	371,531	373,389	375,256	377,132	379,018	380,913	382,817	384,731	386,655	388,588
Medfield WWTP	Liquid	gal	2,415,888	2,427,967	2,440,107	2,452,308	2,464,569	2,476,892	2,489,276	2,501,723	2,514,231	2,526,803	2,539,437	2,552,134	2,564,894
Merrimac WWTP	Liquid	gal	678,068	681,458	684,866	688,290	691,731	695,190	698,666	702,159	705,670	709,198	712,744	716,308	719,890
Middleborough WWTP	Cake	wet tons	2,195	2,206	2,217	2,228	2,239	2,250	2,262	2,273	2,284	2,296	2,307	2,319	2,330
Milford WWTP	Liquid	gal	4,777,199	4,801,085	4,825,090	4,849,216	4,873,462	4,897,829	4,922,318	4,946,930	4,971,664	4,996,523	5,021,505	5,046,613	5,071,846
Monroe WWTP	Liquid	gal	488,109	490,550	493,003	495,468	497,945	500,435	502,937	505,452	507,979	510,519	513,071	515,637	518,215
Montague WPCF	Cake	wet tons	972	977	982	987	991	996	1,001	1,006	1,011	1,016	1,022	1,027	1,032
Montague WPCF	Cake	wet tons	24	24	24	24	24	24	24	25	25	25	25	25	25
Montague WPCF	Cake	wet tons	124	125	125	126	127	127	128	129	129	130	130	131	132
MWRA Clinton WWTP	Cake	wet tons	1,464	1,471	1,478	1,486	1,493	1,501	1,508	1,516	1,523	1,531	1,539	1,546	1,554
MWRA Deer Island WWTP	Cake	wet tons	35,373	35,550	35,727	35,906	36,086	36,266	36,447	36,630	36,813	36,997	37,182	37,368	37,555
Nantucket Sewer Dept. - Siasconset	Liquid	gal	639	643	646	649	652	656	659	662	665	669	672	676	679
Nantucket Sewer Dept. - Surfside	Cake	wet tons	32	32	32	32	32	32	33	33	33	33	33	33	34
New Bedford WWTP	Liquid	gal	26,053,293	26,183,560	26,314,477	26,446,050	26,578,280	26,711,171	26,844,727	26,978,951	27,113,846	27,249,415	27,385,662	27,522,590	27,660,203
Newburyport WWTP	Cake	wet tons	2,729	2,742	2,756	2,770	2,784	2,798	2,812	2,826	2,840	2,854	2,868	2,883	2,897
North Attleborough WPCF	Liquid	gal	42,277	42,489	42,701	42,915	43,129	43,345	43,562	43,779	43,998	44,218	44,439	44,662	44,885
North Attleborough WPCF	Liquid	gal	42,277	42,489	42,701	42,915	43,129	43,345	43,562	43,779	43,998	44,218	44,439	44,662	44,885
North Brookfield WWTP	Cake	wet tons	7	7	7	7	7	7	7	7	7	7	7	7	7
Northampton WWTF	Cake	wet tons	28,836	28,981	29,126	29,271	29,417	29,565	29,712	29,861	30,010	30,160	30,311	30,463	30,615
Northbridge WWTF	Liquid	gal	2,921,729	2,936,338	2,951,020	2,965,775	2,980,604	2,995,507	3,010,484	3,025,537	3,040,664	3,055,868	3,071,147	3,086,503	3,101,935
Northfield WPCF	Liquid	gal	16,918	17,003	17,088	17,173	17,259	17,345	17,432	17,519	17,607	17,695	17,783	17,872	17,961
Oak Bluffs WWTP	Liquid	gal	33,333	33,500	33,668	33,836	34,005	34,175	34,346	34,518	34,690	34,864	35,038	35,213	35,389
Old Deerfield - Historic WWTP	Liquid	gal	116,524	117,107	117,692	118,281	118,872	119,466	120,064	120,664	121,267	121,874	122,483	123,095	123,711
Orange WWTP	Liquid	gal	386,064	387,994	389,934	391,884	393,843	395,812	397,791	399,780	401,779	403,788	405,807	407,836	409,875
Orange WWTP	Liquid	gal	122,757	123,370	123,987	124,607	125,230	125,856	126,486	127,118	127,754	128,392	129,034	129,680	130,328
Otis DPW	Liquid	gal	349	351	352	354	356	358	359	361	363	365	367	368	370
Oxford-Rochdale SD WPCP	Liquid	gal	586,310	589,242	592,188	595,149	598,125	601,115	604,121	607,142	610,177	613,228	616,294	619,376	622,473
Palmer WWTF	Cake	wet tons	20,410	20,512	20,614	20,717	20,821	20,925	21,030	21,135	21,240	21,347	21,453	21,561	21,668
Pepperell WWTF	Cake	wet tons	6	6	6	6	6	6	6	6	6	6	6	6	6
Pittsfield WWTP	Cake	wet tons	52,632	52,895	53,160	53,425	53,693	53,961	54,231	54,502	54,774	55,048	55,324	55,600	55,878
Plymouth WWTF	Liquid	gal	1,586,223	1,594,154	1,602,125	1,610,135	1,618,186	1,626,277	1,634,408	1,642,580	1,650,793	1,659,047	1,667,342	1,675,679	1,684,058
Provincetown Public Works	Liquid	gal	232,617	233,780	234,949	236,124	237,305	238,491	239,683	240,882	242,086	243,297	244,513	245,736	246,964
Rockland WWTP	Cake	wet tons	1,598	1,606	1,614	1,622	1,630	1,638	1,647	1,655	1,663	1,671	1,680	1,688	1,697

Table H-7B: Annual Projected Material Quantities by Plant and Sludge Load

POTW name	2036	2037	2038	2039	2040	2041	2042	2043	2044
Marlborough East WWTP	5,973	6,003	6,033	6,063	6,094	6,124	6,155	6,185	6,216
Marlborough West WWTP	3,569	3,587	3,605	3,623	3,641	3,659	3,677	3,696	3,714
Marshfield WWTF	572,689	575,552	578,430	581,322	584,229	587,150	590,085	593,036	596,001
Marshfield WWTF	700,154	703,654	707,173	710,708	714,262	717,833	721,423	725,030	728,655
Maynard WWTP	37,607	37,795	37,984	38,174	38,364	38,556	38,749	38,943	39,138
Maynard WWTP	2,985,878	3,000,807	3,015,811	3,030,890	3,046,045	3,061,275	3,076,582	3,091,964	3,107,424
MCI Bridgewater	404,944	406,968	409,003	411,048	413,103	415,169	417,245	419,331	421,428
MCI Concord	1,297,667	1,304,155	1,310,676	1,317,230	1,323,816	1,330,435	1,337,087	1,343,772	1,350,491
MCI Norfolk	390,531	392,484	394,446	396,418	398,401	400,393	402,394	404,406	406,428
Medfield WWTP	2,577,719	2,590,607	2,603,561	2,616,578	2,629,661	2,642,810	2,656,024	2,669,304	2,682,650
Merrimac WWTP	723,489	727,107	730,742	734,396	738,068	741,758	745,467	749,194	752,940
Middleborough WWTP	2,342	2,354	2,365	2,377	2,389	2,401	2,413	2,425	2,437
Milford WWTP	5,097,205	5,122,691	5,148,305	5,174,046	5,199,916	5,225,916	5,252,046	5,278,306	5,304,697
Monroe WWTP	520,806	523,410	526,027	528,657	531,301	533,957	536,627	539,310	542,007
Montague WPCF	1,037	1,042	1,047	1,053	1,058	1,063	1,068	1,074	1,079
Montague WPCF	25	25	26	26	26	26	26	26	26
Montague WPCF	132	133	134	134	135	136	136	137	138
MWRA Clinton WWTP	1,562	1,570	1,577	1,585	1,593	1,601	1,609	1,617	1,625
MWRA Deer Island WWTP	37,742	37,931	38,121	38,311	38,503	38,695	38,889	39,083	39,279
Nantucket Sewer Dept. - Siasconset	682	686	689	693	696	700	703	707	710
Nantucket Sewer Dept. - Surfside	34	34	34	34	34	35	35	35	35
New Bedford WWTP	27,798,504	27,937,497	28,077,184	28,217,570	28,358,658	28,500,451	28,642,954	28,786,168	28,930,099
Newburyport WWTP	2,911	2,926	2,941	2,955	2,970	2,985	3,000	3,015	3,030
North Attleborough WPCF	45,109	45,335	45,562	45,789	46,018	46,248	46,480	46,712	46,946
North Attleborough WPCF	45,109	45,335	45,562	45,789	46,018	46,248	46,480	46,712	46,946
North Brookfield WWTP	7	7	7	7	8	8	8	8	8
Northampton WWTF	30,768	30,922	31,077	31,232	31,388	31,545	31,703	31,861	32,021
Northbridge WWTF	3,117,445	3,133,032	3,148,697	3,164,441	3,180,263	3,196,164	3,212,145	3,228,206	3,244,347
Northfield WPCF	18,051	18,141	18,232	18,323	18,415	18,507	18,600	18,693	18,786
Oak Bluffs WWTP	35,566	35,744	35,923	36,102	36,283	36,464	36,647	36,830	37,014
Old Deerfield - Historic WWTP	124,329	124,951	125,576	126,204	126,835	127,469	128,106	128,747	129,391
Orange WWTP	411,925	413,984	416,054	418,134	420,225	422,326	424,438	426,560	428,693
Orange WWTP	130,980	131,635	132,293	132,954	133,619	134,287	134,958	135,633	136,311
Otis DPW	372	374	376	378	380	382	383	385	387
Oxford-Rochdale SD WPCP	625,585	628,713	631,856	635,016	638,191	641,382	644,589	647,812	651,051
Palmer WWTF	21,777	21,886	21,995	22,105	22,216	22,327	22,438	22,550	22,663
Pepperell WWTF	6	6	6	6	6	7	7	7	7
Pittsfield WWTP	56,158	56,438	56,721	57,004	57,289	57,576	57,864	58,153	58,444
Plymouth WWTF	1,692,478	1,700,940	1,709,445	1,717,992	1,726,582	1,735,215	1,743,891	1,752,611	1,761,374
Provincetown Public Works	248,199	249,440	250,687	251,941	253,201	254,467	255,739	257,018	258,303
Rockland WWTP	1,705	1,714	1,722	1,731	1,739	1,748	1,757	1,766	1,774

Table H-7B: Annual Projected Material Quantities by Plant and Sludge Load

POTW name	Material Type	Units	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Rockport WWTP	Cake	wet tons	1,775	1,784	1,793	1,802	1,811	1,820	1,829	1,838	1,847	1,856	1,866	1,875	1,884
Royalston WWTF	Liquid	gal	453	456	458	460	463	465	467	470	472	474	477	479	481
Russell Village WWTF	Liquid	gal	9,960	10,010	10,060	10,110	10,161	10,212	10,263	10,314	10,366	10,418	10,470	10,522	10,575
Salisbury WWTF	Liquid	gal	15,115	15,190	15,266	15,343	15,419	15,496	15,574	15,652	15,730	15,809	15,888	15,967	16,047
Scituate WWTF	Cake	wet tons	13	13	13	13	13	13	13	13	13	14	14	14	14
Shelburne Falls WWTP	Cake	wet tons	83	84	84	84	85	85	86	86	87	87	87	88	88
Somerset WWTF	Liquid	gal	23,177	23,293	23,410	23,527	23,645	23,763	23,882	24,001	24,121	24,242	24,363	24,485	24,607
South Deerfield	Liquid	gal	173,009	173,874	174,743	175,617	176,495	177,378	178,265	179,156	180,052	180,952	181,857	182,766	183,680
South Essex Sewerage District	Cake	wet tons	339	341	343	344	346	348	350	351	353	355	357	358	360
South Essex Sewerage District	Cake	wet tons	7,477	7,514	7,552	7,589	7,627	7,665	7,704	7,742	7,781	7,820	7,859	7,898	7,938
South Essex Sewerage District	Cake	wet tons	54,807	55,081	55,356	55,633	55,911	56,191	56,472	56,754	57,038	57,323	57,609	57,898	58,187
South Essex Sewerage District	Cake	wet tons	5,680	5,709	5,737	5,766	5,795	5,824	5,853	5,882	5,912	5,941	5,971	6,001	6,031
South Essex Sewerage District	Cake	wet tons	2,538	2,550	2,563	2,576	2,589	2,602	2,615	2,628	2,641	2,654	2,667	2,681	2,694
South Hadley WWTP	Cake	wet tons	3,639	3,657	3,675	3,693	3,712	3,730	3,749	3,768	3,787	3,806	3,825	3,844	3,863
Southbridge WWTP	Cake	wet tons	947	952	956	961	966	971	976	981	986	990	995	1,000	1,005
Spencer WWTP	Liquid	gal	279,268	280,664	282,067	283,478	284,895	286,320	287,751	289,190	290,636	292,089	293,550	295,017	296,492
Springfield WWTP - Bondi's Island	Cake	wet tons	5,992	6,022	6,052	6,082	6,113	6,143	6,174	6,205	6,236	6,267	6,298	6,330	6,362
Springfield WWTP - Bondi's Island	Cake	wet tons	1,788	1,797	1,806	1,815	1,825	1,834	1,843	1,852	1,861	1,871	1,880	1,889	1,899
Springfield WWTP - Bondi's Island	Cake	wet tons	17,597	17,685	17,773	17,862	17,951	18,041	18,131	18,222	18,313	18,405	18,497	18,589	18,682
Springfield WWTP - Bondi's Island	Cake	wet tons	17,547	17,635	17,723	17,811	17,900	17,990	18,080	18,170	18,261	18,352	18,444	18,536	18,629
Springfield WWTP - Bondi's Island	Cake	wet tons	2,545	2,557	2,570	2,583	2,596	2,609	2,622	2,635	2,648	2,662	2,675	2,688	2,702
Springfield WWTP - Bondi's Island	Cake	wet tons	1,627	1,635	1,643	1,651	1,660	1,668	1,676	1,685	1,693	1,702	1,710	1,719	1,727
Springfield WWTP - Bondi's Island	Cake	wet tons	6,397	6,429	6,461	6,493	6,526	6,558	6,591	6,624	6,657	6,690	6,724	6,757	6,791
Stockbridge WWTP	Liquid	gal	29,382	29,529	29,677	29,825	29,974	30,124	30,275	30,426	30,578	30,731	30,885	31,039	31,195
Sturbridge WPCF	Liquid	gal	283,407	284,824	286,248	287,679	289,118	290,563	292,016	293,476	294,944	296,418	297,901	299,390	300,887
Sunderland WWTP	Liquid	gal	4,786	4,810	4,834	4,858	4,882	4,907	4,931	4,956	4,980	5,005	5,030	5,056	5,081
Sunderland WWTP	Liquid	gal	230,231	231,382	232,539	233,701	234,870	236,044	237,225	238,411	239,603	240,801	242,005	243,215	244,431
Taunton WWTP	Cake	wet tons	43,253	43,469	43,686	43,905	44,124	44,345	44,566	44,789	45,013	45,238	45,464	45,692	45,920
Templeton WWTP	Cake	wet tons	1,200	1,206	1,212	1,219	1,225	1,231	1,237	1,243	1,249	1,256	1,262	1,268	1,274
Tisbury Public Works	Liquid	gal	1,616	1,624	1,632	1,640	1,649	1,657	1,665	1,674	1,682	1,690	1,699	1,707	1,716
Upper Blackstone WPAD (Worcester area)	Cake	wet tons	85,658	86,086	86,516	86,949	87,384	87,821	88,260	88,701	89,145	89,590	90,038	90,488	90,941
Upton WWTP	Liquid	gal	86,272	86,703	87,137	87,573	88,011	88,451	88,893	89,337	89,784	90,233	90,684	91,137	91,593
Uxbridge WWTF	Liquid	gal	25,893	26,022	26,152	26,283	26,415	26,547	26,679	26,813	26,947	27,082	27,217	27,353	27,490
Ware WWTP	Liquid	gal	178,524	179,417	180,314	181,216	182,122	183,032	183,947	184,867	185,791	186,720	187,654	188,592	189,535
Wareham WPCF	Liquid	gal	18,603	18,696	18,789	18,883	18,978	19,072	19,168	19,264	19,360	19,457	19,554	19,652	19,750
Warren WWTP	Liquid	gal	293,989	295,459	296,936	298,421	299,913	301,412	302,920	304,434	305,956	307,486	309,023	310,569	312,121
Wayland WWTP	Liquid	gal	1,046	1,052	1,057	1,062	1,067	1,073	1,078	1,084	1,089	1,094	1,100	1,105	1,111
Webster WWTF	Liquid	gal	33,435	33,602	33,770	33,939	34,109	34,279	34,451	34,623	34,796	34,970	35,145	35,320	35,497
West Stockbridge	Liquid	gal	93,045	93,511	93,978	94,448	94,920	95,395	95,872	96,351	96,833	97,317	97,804	98,293	98,784
Westborough WWTF	Liquid	gal	33,435	33,602	33,770	33,939	34,109	34,279	34,451	34,623	34,796	34,970	35,145	35,320	35,497
Westborough WWTF	Liquid	gal	12,334,748	12,396,421	12,458,403	12,520,695	12,583,299	12,646,215	12,709,446	12,772,994	12,836,859	12,901,043	12,965,548	13,030,376	13,095,528

Table H-7B: Annual Projected Material Quantities by Plant and Sludge Load

POTW name	2036	2037	2038	2039	2040	2041	2042	2043	2044
Rockport WWTP	1,894	1,903	1,913	1,922	1,932	1,942	1,951	1,961	1,971
Royalston WWTF	484	486	489	491	494	496	499	501	504
Russell Village WWTF	10,628	10,681	10,734	10,788	10,842	10,896	10,950	11,005	11,060
Salisbury WWTF	16,127	16,208	16,289	16,370	16,452	16,534	16,617	16,700	16,784
Scituate WWTF	14	14	14	14	14	14	14	14	14
Shelburne Falls WWTP	89	89	90	90	91	91	92	92	92
Somerset WWTF	24,730	24,854	24,978	25,103	25,228	25,355	25,481	25,609	25,737
South Deerfield	184,598	185,521	186,449	187,381	188,318	189,260	190,206	191,157	192,113
South Essex Sewerage District	362	364	366	368	369	371	373	375	377
South Essex Sewerage District	7,977	8,017	8,057	8,098	8,138	8,179	8,220	8,261	8,302
South Essex Sewerage District	58,478	58,770	59,064	59,359	59,656	59,955	60,254	60,556	60,858
South Essex Sewerage District	6,061	6,091	6,122	6,152	6,183	6,214	6,245	6,276	6,308
South Essex Sewerage District	2,708	2,721	2,735	2,748	2,762	2,776	2,790	2,804	2,818
South Hadley WWTP	3,882	3,902	3,921	3,941	3,961	3,980	4,000	4,020	4,040
Southbridge WWTP	1,010	1,015	1,021	1,026	1,031	1,036	1,041	1,046	1,052
Spencer WWTP	297,975	299,465	300,962	302,467	303,979	305,499	307,027	308,562	310,105
Springfield WWTP - Bondi's Island	6,393	6,425	6,458	6,490	6,522	6,555	6,588	6,621	6,654
Springfield WWTP - Bondi's Island	1,908	1,918	1,927	1,937	1,947	1,956	1,966	1,976	1,986
Springfield WWTP - Bondi's Island	18,776	18,870	18,964	19,059	19,154	19,250	19,346	19,443	19,540
Springfield WWTP - Bondi's Island	18,722	18,816	18,910	19,004	19,099	19,195	19,291	19,387	19,484
Springfield WWTP - Bondi's Island	2,715	2,729	2,742	2,756	2,770	2,784	2,798	2,812	2,826
Springfield WWTP - Bondi's Island	1,736	1,744	1,753	1,762	1,771	1,780	1,789	1,797	1,806
Springfield WWTP - Bondi's Island	6,825	6,859	6,894	6,928	6,963	6,998	7,032	7,068	7,103
Stockbridge WWTP	31,351	31,507	31,665	31,823	31,982	32,142	32,303	32,464	32,627
Sturbridge WPCF	302,391	303,903	305,423	306,950	308,485	310,027	311,577	313,135	314,701
Sunderland WWTP	5,106	5,132	5,157	5,183	5,209	5,235	5,261	5,288	5,314
Sunderland WWTP	245,653	246,881	248,116	249,356	250,603	251,856	253,115	254,381	255,653
Taunton WWTP	46,150	46,381	46,613	46,846	47,080	47,315	47,552	47,790	48,028
Templeton WWTP	1,281	1,287	1,294	1,300	1,307	1,313	1,320	1,326	1,333
Tisbury Public Works	1,724	1,733	1,742	1,750	1,759	1,768	1,777	1,786	1,795
Upper Blackstone WPAD (Worcester area)	91,396	91,853	92,312	92,773	93,237	93,703	94,172	94,643	95,116
Upton WWTP	92,051	92,511	92,974	93,439	93,906	94,376	94,847	95,322	95,798
Uxbridge WWTF	27,627	27,765	27,904	28,044	28,184	28,325	28,467	28,609	28,752
Ware WWTP	190,483	191,435	192,392	193,354	194,321	195,293	196,269	197,251	198,237
Wareham WPCF	19,849	19,948	20,048	20,148	20,249	20,350	20,452	20,554	20,657
Warren WWTP	313,682	315,250	316,827	318,411	320,003	321,603	323,211	324,827	326,451
Wayland WWTP	1,116	1,122	1,128	1,133	1,139	1,145	1,150	1,156	1,162
Webster WWTF	35,675	35,853	36,032	36,212	36,393	36,575	36,758	36,942	37,127
West Stockbridge	99,278	99,775	100,273	100,775	101,279	101,785	102,294	102,806	103,320
Westborough WWTF	35,675	35,853	36,032	36,212	36,393	36,575	36,758	36,942	37,127
Westborough WWTF	13,161,005	13,226,810	13,292,945	13,359,409	13,426,206	13,493,337	13,560,804	13,628,608	13,696,751

Table H-7B: Annual Projected Material Quantities by Plant and Sludge Load

POTW name	Material Type	Units	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Westfield WPCP	Cake	wet tons	38,967	39,162	39,358	39,555	39,752	39,951	40,151	40,352	40,553	40,756	40,960	41,165	41,371
Winchendon WPCF	Liquid	gal	1,121,937	1,127,547	1,133,185	1,138,851	1,144,545	1,150,268	1,156,019	1,161,799	1,167,608	1,173,446	1,179,313	1,185,210	1,191,136

Table H-7B: Annual Projected Material Quantities by Plant and Sludge Load

POTW name	2036	2037	2038	2039	2040	2041	2042	2043	2044
Westfield WPCP	41,577	41,785	41,994	42,204	42,415	42,627	42,840	43,055	43,270
Winchendon WPCF	1,197,092	1,203,077	1,209,093	1,215,138	1,221,214	1,227,320	1,233,456	1,239,624	1,245,822

Calculation Approach

Unit prices were calculated for each plant and each load, for each year from 2024 to 2044.

2023 was used as the baseline. Unit prices were increased by 6.2% (ie, multiplied by 106.2%) each year to reflect escalation under current conditions.

For example, Adams paid $170/wt in 2023. In 2024, this increases to 170 * 1.062 = $180.52/wt. Subsequent years are calculated according to the same logic.

Table H-7C: Yearly Unit Prices by Plant and Sludge Load (6.2% escalation)

POTW name	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Acton Wastewater Collection	$ 0.11	$ 0.11	$ 0.12	$ 0.13	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.25
Adams WWTP	$ 170.00	$ 180.52	$ 191.68	$ 203.54	$ 216.13	$ 229.50	$ 243.70	$ 258.78	$ 274.79	$ 291.79	$ 309.84	$ 329.01	$ 349.36	$ 370.97	$ 393.92
Amesbury WWTP	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
Amherst WWTP	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.39	$ 0.42	$ 0.44
Ashfield	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.39	$ 0.41	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Athol WWTP	$ 0.26	$ 0.28	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.40	$ 0.42	$ 0.45	$ 0.47	$ 0.50	$ 0.53	$ 0.57	$ 0.60
Athol WWTP	$ 0.26	$ 0.28	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.40	$ 0.42	$ 0.45	$ 0.47	$ 0.50	$ 0.53	$ 0.57	$ 0.60
Attleboro WWTP	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
Ayer WWTP	$ 0.14	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.20	$ 0.21	$ 0.22	$ 0.23	$ 0.25	$ 0.26	$ 0.28	$ 0.30	$ 0.32
Barnstable WWTP WPCD - DPW	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.25	$ 0.26	$ 0.28	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.40	$ 0.42
Barnstable WWTP WPCD - DPW	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.25	$ 0.26	$ 0.28	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.40	$ 0.42
Barre WWTP	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Belchertown WWTP	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.38
Billerica WWTP	$ 146.70	$ 155.78	$ 165.41	$ 175.65	$ 186.51	$ 198.05	$ 210.30	$ 223.31	$ 237.13	$ 251.80	$ 267.37	$ 283.91	$ 301.48	$ 320.13	$ 339.93
Bridgewater WWTP	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
Brockton WWTP	$ 148.52	$ 157.71	$ 167.46	$ 177.82	$ 188.82	$ 200.51	$ 212.91	$ 226.08	$ 240.07	$ 254.92	$ 270.69	$ 287.43	$ 305.22	$ 324.10	$ 344.15
Charlemont Sewer District	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Charles River PCD	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.28	$ 0.30	$ 0.32	$ 0.34
Charles River PCD	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.28	$ 0.30	$ 0.32	$ 0.34
Charlton WWTP	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Chatham WPCF	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
Chicopee WWTP	$ 140.17	$ 148.84	$ 158.05	$ 167.83	$ 178.21	$ 189.23	$ 200.94	$ 213.37	$ 226.57	$ 240.59	$ 255.47	$ 271.27	$ 288.06	$ 305.88	$ 324.80
Chicopee WWTP	$ 140.17	$ 148.84	$ 158.05	$ 167.83	$ 178.21	$ 189.23	$ 200.94	$ 213.37	$ 226.57	$ 240.59	$ 255.47	$ 271.27	$ 288.06	$ 305.88	$ 324.80
Chicopee WWTP	$ 140.17	$ 148.84	$ 158.05	$ 167.83	$ 178.21	$ 189.23	$ 200.94	$ 213.37	$ 226.57	$ 240.59	$ 255.47	$ 271.27	$ 288.06	$ 305.88	$ 324.80
Cohasset WWTF	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Concord WWTF	$ 0.06	$ 0.06	$ 0.07	$ 0.07	$ 0.08	$ 0.08	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.11	$ 0.12	$ 0.12	$ 0.13	$ 0.14
Concord WWTF	$ 0.06	$ 0.06	$ 0.07	$ 0.07	$ 0.08	$ 0.08	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.11	$ 0.12	$ 0.12	$ 0.13	$ 0.14
Dartmouth WPCF	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
Devens WWTP	$ 170.00	$ 180.52	$ 191.68	$ 203.54	$ 216.13	$ 229.50	$ 243.70	$ 258.78	$ 274.79	$ 291.79	$ 309.84	$ 329.01	$ 349.36	$ 370.97	$ 393.92
Douglas WWTP	$ 0.10	$ 0.11	$ 0.11	$ 0.12	$ 0.13	$ 0.14	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.20	$ 0.21	$ 0.22	$ 0.23
Easthampton WWTP	$ 118.17	$ 125.48	$ 133.24	$ 141.49	$ 150.24	$ 159.53	$ 169.40	$ 179.88	$ 191.01	$ 202.83	$ 215.38	$ 228.70	$ 242.85	$ 257.87	$ 273.82
Edgartown WWTP	$ 119.00	$ 126.36	$ 134.18	$ 142.48	$ 151.29	$ 160.65	$ 170.59	$ 181.15	$ 192.35	$ 204.25	$ 216.89	$ 230.30	$ 244.55	$ 259.68	$ 275.74
Erving Center WWTP (#2)	$ 200.00	$ 212.37	$ 225.51	$ 239.46	$ 254.28	$ 270.01	$ 286.71	$ 304.45	$ 323.28	$ 343.28	$ 364.52	$ 387.07	$ 411.01	$ 436.44	$ 463.44
Erving Center WWTP (#2)	$ 200.00	$ 212.37	$ 225.51	$ 239.46	$ 254.28	$ 270.01	$ 286.71	$ 304.45	$ 323.28	$ 343.28	$ 364.52	$ 387.07	$ 411.01	$ 436.44	$ 463.44
Erving POTW #1	$ 0.20	$ 0.21	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.29	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.39	$ 0.41	$ 0.43	$ 0.46
Erving POTW #3	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Fairhaven WPCF	$ 0.09	$ 0.09	$ 0.10	$ 0.11	$ 0.11	$ 0.12	$ 0.13	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20

Table H-7C: Yearly Unit Prices by Plant and Sludge Load (6.2% escalation)

POTW name	2038	2039	2040	2041	2042	2043	2044
Acton Wastewater Collection	$ 0.26	$ 0.28	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Adams WWTP	$ 418.29	$ 444.17	$ 471.64	$ 500.82	$ 531.80	$ 564.70	$ 599.64
Amesbury WWTP	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
Amherst WWTP	$ 0.47	$ 0.50	$ 0.53	$ 0.57	$ 0.60	$ 0.64	$ 0.68
Ashfield	$ 0.59	$ 0.63	$ 0.67	$ 0.71	$ 0.76	$ 0.80	$ 0.85
Athol WWTP	$ 0.64	$ 0.68	$ 0.72	$ 0.76	$ 0.81	$ 0.86	$ 0.92
Athol WWTP	$ 0.64	$ 0.68	$ 0.72	$ 0.76	$ 0.81	$ 0.86	$ 0.92
Attleboro WWTP	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
Ayer WWTP	$ 0.34	$ 0.36	$ 0.38	$ 0.40	$ 0.43	$ 0.45	$ 0.48
Barnstable WWTP WPCD - DPW	$ 0.45	$ 0.47	$ 0.50	$ 0.53	$ 0.57	$ 0.60	$ 0.64
Barnstable WWTP WPCD - DPW	$ 0.45	$ 0.47	$ 0.50	$ 0.53	$ 0.57	$ 0.60	$ 0.64
Barre WWTP	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Belchertown WWTP	$ 0.41	$ 0.43	$ 0.46	$ 0.49	$ 0.52	$ 0.55	$ 0.58
Billerica WWTP	$ 360.96	$ 383.29	$ 407.00	$ 432.18	$ 458.92	$ 487.31	$ 517.45
Bridgewater WWTP	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
Brockton WWTP	$ 365.44	$ 388.04	$ 412.05	$ 437.54	$ 464.61	$ 493.35	$ 523.87
Charlemont Sewer District	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Charles River PCD	$ 0.36	$ 0.38	$ 0.41	$ 0.43	$ 0.46	$ 0.49	$ 0.52
Charles River PCD	$ 0.36	$ 0.38	$ 0.41	$ 0.43	$ 0.46	$ 0.49	$ 0.52
Charlton WWTP	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Chatham WPCF	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
Chicopee WWTP	$ 344.89	$ 366.23	$ 388.88	$ 412.94	$ 438.49	$ 465.61	$ 494.42
Chicopee WWTP	$ 344.89	$ 366.23	$ 388.88	$ 412.94	$ 438.49	$ 465.61	$ 494.42
Chicopee WWTP	$ 344.89	$ 366.23	$ 388.88	$ 412.94	$ 438.49	$ 465.61	$ 494.42
Cohasset WWTF	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Concord WWTF	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21
Concord WWTF	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21
Dartmouth WPCF	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
Devens WWTP	$ 418.29	$ 444.17	$ 471.64	$ 500.82	$ 531.80	$ 564.70	$ 599.64
Douglas WWTP	$ 0.25	$ 0.26	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36
Easthampton WWTP	$ 290.76	$ 308.75	$ 327.85	$ 348.13	$ 369.67	$ 392.54	$ 416.82
Edgartown WWTP	$ 292.80	$ 310.92	$ 330.15	$ 350.58	$ 372.26	$ 395.29	$ 419.75
Erving Center WWTP (#2)	$ 492.11	$ 522.55	$ 554.88	$ 589.20	$ 625.65	$ 664.36	$ 705.46
Erving Center WWTP (#2)	$ 492.11	$ 522.55	$ 554.88	$ 589.20	$ 625.65	$ 664.36	$ 705.46
Erving POTW #1	$ 0.49	$ 0.52	$ 0.55	$ 0.59	$ 0.62	$ 0.66	$ 0.70
Erving POTW #3	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Fairhaven WPCF	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.28	$ 0.29	$ 0.31

Table H-7C: Yearly Unit Prices by Plant and Sludge Load (6.2% escalation)

POTW name	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Fall River Regional WWF	$ 0.05	$ 0.06	$ 0.06	$ 0.07	$ 0.07	$ 0.07	$ 0.08	$ 0.08	$ 0.09	$ 0.09	$ 0.10	$ 0.11	$ 0.11	$ 0.12	$ 0.13
Falmouth WWTP	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Fitchburg East WWTP	$ 37.59	$ 39.92	$ 42.38	$ 45.01	$ 47.79	$ 50.75	$ 53.89	$ 57.22	$ 60.76	$ 64.52	$ 68.51	$ 72.75	$ 77.25	$ 82.03	$ 87.10
Gardner WPCF	$ 2.72	$ 2.89	$ 3.07	$ 3.26	$ 3.46	$ 3.68	$ 3.91	$ 4.15	$ 4.40	$ 4.68	$ 4.97	$ 5.27	$ 5.60	$ 5.94	$ 6.31
Gloucester WPCF	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
Grafton WWTP	$ 0.11	$ 0.12	$ 0.12	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.22	$ 0.24	$ 0.25
Great Barrington WWTP	$ 151.00	$ 160.34	$ 170.26	$ 180.79	$ 191.98	$ 203.85	$ 216.47	$ 229.86	$ 244.08	$ 259.18	$ 275.21	$ 292.23	$ 310.31	$ 329.51	$ 349.89
Greater Lawrence Sanitary District	$ 366.90	$ 389.60	$ 413.70	$ 439.29	$ 466.47	$ 495.33	$ 525.97	$ 558.51	$ 593.06	$ 629.75	$ 668.70	$ 710.07	$ 754.00	$ 800.64	$ 850.17
Greenfield WPCF	$ 0.23	$ 0.25	$ 0.26	$ 0.28	$ 0.30	$ 0.31	$ 0.33	$ 0.35	$ 0.38	$ 0.40	$ 0.42	$ 0.45	$ 0.48	$ 0.51	$ 0.54
Hadley WWTP	$ 0.23	$ 0.25	$ 0.26	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.38	$ 0.40	$ 0.43	$ 0.45	$ 0.48	$ 0.51	$ 0.54
Hardwick-Gilbertville WPCF	$ 0.11	$ 0.11	$ 0.12	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.16	$ 0.17	$ 0.19	$ 0.20	$ 0.21	$ 0.22	$ 0.24	$ 0.25
Hardwick-Wheelwright WPCF	$ 0.08	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.11	$ 0.12	$ 0.12	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19
Hatfield WWTP	$ 0.24	$ 0.25	$ 0.27	$ 0.29	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.39	$ 0.41	$ 0.43	$ 0.46	$ 0.49	$ 0.52	$ 0.55
Haverhill WWTP	$ 175.00	$ 185.83	$ 197.32	$ 209.53	$ 222.49	$ 236.25	$ 250.87	$ 266.39	$ 282.87	$ 300.37	$ 318.95	$ 338.68	$ 359.63	$ 381.88	$ 405.51
Holyoke WWTP	$ 140.00	$ 148.66	$ 157.86	$ 167.62	$ 177.99	$ 189.00	$ 200.70	$ 213.11	$ 226.30	$ 240.30	$ 255.16	$ 270.95	$ 287.71	$ 305.51	$ 324.41
Holyoke WWTP	$ 140.00	$ 148.66	$ 157.86	$ 167.62	$ 177.99	$ 189.00	$ 200.70	$ 213.11	$ 226.30	$ 240.30	$ 255.16	$ 270.95	$ 287.71	$ 305.51	$ 324.41
Holyoke WWTP	$ 140.00	$ 148.66	$ 157.86	$ 167.62	$ 177.99	$ 189.00	$ 200.70	$ 213.11	$ 226.30	$ 240.30	$ 255.16	$ 270.95	$ 287.71	$ 305.51	$ 324.41
Holyoke WWTP	$ 140.00	$ 148.66	$ 157.86	$ 167.62	$ 177.99	$ 189.00	$ 200.70	$ 213.11	$ 226.30	$ 240.30	$ 255.16	$ 270.95	$ 287.71	$ 305.51	$ 324.41
Hoosac WQD	$ 195.15	$ 207.22	$ 220.04	$ 233.65	$ 248.10	$ 263.45	$ 279.75	$ 297.06	$ 315.43	$ 334.95	$ 355.67	$ 377.67	$ 401.03	$ 425.84	$ 452.19
Hopedale WWTF	$ 0.09	$ 0.10	$ 0.10	$ 0.11	$ 0.11	$ 0.12	$ 0.13	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.20	$ 0.21
Hudson WWTF	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
Hull WWTF	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Huntington WWTP	$ 0.34	$ 0.36	$ 0.38	$ 0.41	$ 0.43	$ 0.46	$ 0.49	$ 0.52	$ 0.55	$ 0.58	$ 0.62	$ 0.66	$ 0.70	$ 0.74	$ 0.79
Ipswich WWTP	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
Kingston Sewer Commission	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Lee WWTP	$ 0.19	$ 0.21	$ 0.22	$ 0.23	$ 0.25	$ 0.26	$ 0.28	$ 0.30	$ 0.31	$ 0.33	$ 0.35	$ 0.38	$ 0.40	$ 0.42	$ 0.45
Leicester WWTP	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Lenox Center WWTP	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Leominster WPCF	$ 0.06	$ 0.06	$ 0.07	$ 0.07	$ 0.08	$ 0.08	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.11	$ 0.12	$ 0.12	$ 0.13	$ 0.14
Lowell Regional WW Utility	$ 190.37	$ 202.15	$ 214.65	$ 227.93	$ 242.03	$ 257.00	$ 272.90	$ 289.79	$ 307.71	$ 326.75	$ 346.96	$ 368.43	$ 391.22	$ 415.42	$ 441.12
Lowell Regional WW Utility	$ 190.37	$ 202.15	$ 214.65	$ 227.93	$ 242.03	$ 257.00	$ 272.90	$ 289.79	$ 307.71	$ 326.75	$ 346.96	$ 368.43	$ 391.22	$ 415.42	$ 441.12
Lowell Regional WW Utility	$ 190.37	$ 202.15	$ 214.65	$ 227.93	$ 242.03	$ 257.00	$ 272.90	$ 289.79	$ 307.71	$ 326.75	$ 346.96	$ 368.43	$ 391.22	$ 415.42	$ 441.12
Lowell Regional WW Utility	$ 190.37	$ 202.15	$ 214.65	$ 227.93	$ 242.03	$ 257.00	$ 272.90	$ 289.79	$ 307.71	$ 326.75	$ 346.96	$ 368.43	$ 391.22	$ 415.42	$ 441.12
Lowell Regional WW Utility	$ 190.37	$ 202.15	$ 214.65	$ 227.93	$ 242.03	$ 257.00	$ 272.90	$ 289.79	$ 307.71	$ 326.75	$ 346.96	$ 368.43	$ 391.22	$ 415.42	$ 441.12
Lynn Regional WF	$ 225.00	$ 238.92	$ 253.70	$ 269.39	$ 286.06	$ 303.76	$ 322.55	$ 342.50	$ 363.69	$ 386.19	$ 410.08	$ 435.45	$ 462.39	$ 490.99	$ 521.37
Lynn Regional WF	$ 225.00	$ 238.92	$ 253.70	$ 269.39	$ 286.06	$ 303.76	$ 322.55	$ 342.50	$ 363.69	$ 386.19	$ 410.08	$ 435.45	$ 462.39	$ 490.99	$ 521.37
Manchester By the Sea WWTP	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Manchester By the Sea WWTP	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Mansfield WWTP (MFN)	$ 0.11	$ 0.12	$ 0.13	$ 0.14	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.20	$ 0.21	$ 0.22	$ 0.23	$ 0.25	$ 0.26
Mansfield WWTP (MFN)	$ 0.11	$ 0.12	$ 0.13	$ 0.14	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.20	$ 0.21	$ 0.22	$ 0.23	$ 0.25	$ 0.26
Marion WWTP - Marion DPW	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48

Table H-7C: Yearly Unit Prices by Plant and Sludge Load (6.2% escalation)

POTW name	2038	2039	2040	2041	2042	2043	2044
Fall River Regional WWF	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19
Falmouth WWTP	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Fitchburg East WWTP	$ 92.49	$ 98.21	$ 104.29	$ 110.74	$ 117.59	$ 124.87	$ 132.59
Gardner WPCF	$ 6.70	$ 7.12	$ 7.56	$ 8.03	$ 8.52	$ 9.05	$ 9.61
Gloucester WPCF	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
Grafton WWTP	$ 0.27	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.38
Great Barrington WWTP	$ 371.54	$ 394.52	$ 418.93	$ 444.85	$ 472.37	$ 501.59	$ 532.62
Greater Lawrence Sanitary District	$ 902.77	$ 958.62	$ 1,017.92	$ 1,080.89	$ 1,147.76	$ 1,218.76	$ 1,294.16
Greenfield WPCF	$ 0.57	$ 0.61	$ 0.65	$ 0.69	$ 0.73	$ 0.77	$ 0.82
Hadley WWTP	$ 0.58	$ 0.61	$ 0.65	$ 0.69	$ 0.73	$ 0.78	$ 0.83
Hardwick-Gilbertville WPCF	$ 0.27	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.38
Hardwick-Wheelwright WPCF	$ 0.20	$ 0.21	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.28
Hatfield WWTP	$ 0.59	$ 0.62	$ 0.66	$ 0.70	$ 0.75	$ 0.79	$ 0.84
Haverhill WWTP	$ 430.59	$ 457.23	$ 485.52	$ 515.55	$ 547.45	$ 581.31	$ 617.27
Holyoke WWTP	$ 344.47	$ 365.78	$ 388.41	$ 412.44	$ 437.96	$ 465.05	$ 493.82
Holyoke WWTP	$ 344.47	$ 365.78	$ 388.41	$ 412.44	$ 437.96	$ 465.05	$ 493.82
Holyoke WWTP	$ 344.47	$ 365.78	$ 388.41	$ 412.44	$ 437.96	$ 465.05	$ 493.82
Holyoke WWTP	$ 344.47	$ 365.78	$ 388.41	$ 412.44	$ 437.96	$ 465.05	$ 493.82
Hoosac WQD	$ 480.16	$ 509.87	$ 541.41	$ 574.90	$ 610.47	$ 648.23	$ 688.33
Hopedale WWTF	$ 0.22	$ 0.23	$ 0.25	$ 0.26	$ 0.28	$ 0.30	$ 0.32
Hudson WWTF	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
Hull WWTF	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Huntington WWTP	$ 0.84	$ 0.89	$ 0.94	$ 1.00	$ 1.06	$ 1.13	$ 1.20
Ipswich WWTP	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
Kingston Sewer Commission	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Lee WWTP	$ 0.48	$ 0.51	$ 0.54	$ 0.57	$ 0.61	$ 0.65	$ 0.69
Leicester WWTP	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Lenox Center WWTP	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Leominster WPCF	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21
Lowell Regional WW Utility	$ 468.41	$ 497.39	$ 528.16	$ 560.83	$ 595.53	$ 632.37	$ 671.49
Lowell Regional WW Utility	$ 468.41	$ 497.39	$ 528.16	$ 560.83	$ 595.53	$ 632.37	$ 671.49
Lowell Regional WW Utility	$ 468.41	$ 497.39	$ 528.16	$ 560.83	$ 595.53	$ 632.37	$ 671.49
Lowell Regional WW Utility	$ 468.41	$ 497.39	$ 528.16	$ 560.83	$ 595.53	$ 632.37	$ 671.49
Lowell Regional WW Utility	$ 468.41	$ 497.39	$ 528.16	$ 560.83	$ 595.53	$ 632.37	$ 671.49
Lynn Regional WF	$ 553.62	$ 587.87	$ 624.23	$ 662.85	$ 703.86	$ 747.40	$ 793.64
Lynn Regional WF	$ 553.62	$ 587.87	$ 624.23	$ 662.85	$ 703.86	$ 747.40	$ 793.64
Manchester By the Sea WWTP	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Manchester By the Sea WWTP	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Mansfield WWTP (MFN)	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.38	$ 0.40
Mansfield WWTP (MFN)	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.38	$ 0.40
Marion WWTP - Marion DPW	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26

Table H-7C: Yearly Unit Prices by Plant and Sludge Load (6.2% escalation)

POTW name	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Marlborough East WWTP	$ 163.75	$ 173.88	$ 184.64	$ 196.06	$ 208.19	$ 221.07	$ 234.74	$ 249.26	$ 264.69	$ 281.06	$ 298.45	$ 316.91	$ 336.51	$ 357.33	$ 379.44
Marlborough West WWTP	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
Marshfield WWTF	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.38
Marshfield WWTF	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.38
Maynard WWTP	$ 1.00	$ 1.06	$ 1.13	$ 1.20	$ 1.27	$ 1.35	$ 1.43	$ 1.52	$ 1.62	$ 1.72	$ 1.82	$ 1.94	$ 2.06	$ 2.18	$ 2.32
Maynard WWTP	$ 1.00	$ 1.06	$ 1.13	$ 1.20	$ 1.27	$ 1.35	$ 1.43	$ 1.52	$ 1.62	$ 1.72	$ 1.82	$ 1.94	$ 2.06	$ 2.18	$ 2.32
MCI Bridgewater	$ 0.19	$ 0.20	$ 0.21	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.38	$ 0.41	$ 0.43
MCI Concord	$ 0.05	$ 0.05	$ 0.05	$ 0.06	$ 0.06	$ 0.06	$ 0.07	$ 0.07	$ 0.08	$ 0.08	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.11
MCI Norfolk	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31
Medfield WWTP	$ 0.13	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.25	$ 0.26	$ 0.28	$ 0.29
Merrimac WWTP	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Middleborough WWTP	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
Milford WWTP	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Monroe WWTP	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Montague WPCF	$ 178.65	$ 189.70	$ 201.44	$ 213.90	$ 227.13	$ 241.18	$ 256.10	$ 271.94	$ 288.77	$ 306.63	$ 325.60	$ 345.74	$ 367.13	$ 389.84	$ 413.96
Montague WPCF	$ 178.65	$ 189.70	$ 201.44	$ 213.90	$ 227.13	$ 241.18	$ 256.10	$ 271.94	$ 288.77	$ 306.63	$ 325.60	$ 345.74	$ 367.13	$ 389.84	$ 413.96
Montague WPCF	$ 178.65	$ 189.70	$ 201.44	$ 213.90	$ 227.13	$ 241.18	$ 256.10	$ 271.94	$ 288.77	$ 306.63	$ 325.60	$ 345.74	$ 367.13	$ 389.84	$ 413.96
MWRA Clinton WWTP	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
MWRA Deer Island WWTP	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
Nantucket Sewer Dept. - Siasconset	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Nantucket Sewer Dept. - Surfside	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
New Bedford WWTP	$ 0.19	$ 0.20	$ 0.21	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.39	$ 0.41	$ 0.44
Newburyport WWTP	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
North Attleborough WPCF	$ 0.11	$ 0.12	$ 0.13	$ 0.14	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.21	$ 0.22	$ 0.23	$ 0.25	$ 0.26
North Attleborough WPCF	$ 0.11	$ 0.12	$ 0.13	$ 0.14	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.21	$ 0.22	$ 0.23	$ 0.25	$ 0.26
North Brookfield WWTP	$ 203.01	$ 215.57	$ 228.90	$ 243.06	$ 258.10	$ 274.06	$ 291.02	$ 309.02	$ 328.14	$ 348.44	$ 369.99	$ 392.88	$ 417.19	$ 443.00	$ 470.40
Northampton WWTF	$ 157.00	$ 166.71	$ 177.03	$ 187.98	$ 199.61	$ 211.95	$ 225.07	$ 238.99	$ 253.77	$ 269.47	$ 286.14	$ 303.85	$ 322.64	$ 342.60	$ 363.80
Northbridge WWTF	$ 0.06	$ 0.06	$ 0.07	$ 0.07	$ 0.08	$ 0.08	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.11	$ 0.12	$ 0.12	$ 0.13	$ 0.14
Northfield WPCF	$ 0.25	$ 0.26	$ 0.28	$ 0.30	$ 0.31	$ 0.33	$ 0.36	$ 0.38	$ 0.40	$ 0.43	$ 0.45	$ 0.48	$ 0.51	$ 0.54	$ 0.57
Oak Bluffs WWTP	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.38	$ 0.40	$ 0.43	$ 0.45	$ 0.48	$ 0.51	$ 0.54	$ 0.58	$ 0.61	$ 0.65	$ 0.69
Old Deerfield - Historic WWTP	$ 0.25	$ 0.27	$ 0.29	$ 0.30	$ 0.32	$ 0.34	$ 0.37	$ 0.39	$ 0.41	$ 0.44	$ 0.46	$ 0.49	$ 0.52	$ 0.56	$ 0.59
Orange WWTP	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50
Orange WWTP	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50
Otis DPW	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Oxford-Rochdale SD WPCP	$ 0.08	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.11	$ 0.12	$ 0.12	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19
Palmer WWTF	$ 160.07	$ 169.97	$ 180.49	$ 191.65	$ 203.51	$ 216.10	$ 229.47	$ 243.66	$ 258.74	$ 274.74	$ 291.74	$ 309.79	$ 328.95	$ 349.30	$ 370.91
Pepperell WWTF	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
Pittsfield WWTP	$ 161.00	$ 170.96	$ 181.54	$ 192.77	$ 204.69	$ 217.35	$ 230.80	$ 245.08	$ 260.24	$ 276.34	$ 293.43	$ 311.59	$ 330.86	$ 351.33	$ 373.07
Plymouth WWTF	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Provincetown Public Works	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.38
Rockland WWTP	$ 190.00	$ 201.75	$ 214.24	$ 227.49	$ 241.56	$ 256.51	$ 272.37	$ 289.22	$ 307.12	$ 326.11	$ 346.29	$ 367.71	$ 390.46	$ 414.61	$ 440.26

Table H-7C: Yearly Unit Prices by Plant and Sludge Load (6.2% escalation)

POTW name	2038	2039	2040	2041	2042	2043	2044
Marlborough East WWTP	$ 402.91	$ 427.84	$ 454.30	$ 482.41	$ 512.25	$ 543.94	$ 577.59
Marlborough West WWTP	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
Marshfield WWTF	$ 0.41	$ 0.43	$ 0.46	$ 0.49	$ 0.52	$ 0.55	$ 0.58
Marshfield WWTF	$ 0.41	$ 0.43	$ 0.46	$ 0.49	$ 0.52	$ 0.55	$ 0.58
Maynard WWTP	$ 2.46	$ 2.61	$ 2.77	$ 2.95	$ 3.13	$ 3.32	$ 3.53
Maynard WWTP	$ 2.46	$ 2.61	$ 2.77	$ 2.95	$ 3.13	$ 3.32	$ 3.53
MCI Bridgewater	$ 0.46	$ 0.49	$ 0.52	$ 0.55	$ 0.58	$ 0.62	$ 0.66
MCI Concord	$ 0.12	$ 0.13	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.17
MCI Norfolk	$ 0.33	$ 0.35	$ 0.37	$ 0.39	$ 0.41	$ 0.44	$ 0.47
Medfield WWTP	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.40	$ 0.42	$ 0.45
Merrimac WWTP	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Middleborough WWTP	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
Milford WWTP	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Monroe WWTP	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Montague WPCF	$ 439.57	$ 466.76	$ 495.64	$ 526.30	$ 558.86	$ 593.43	$ 630.14
Montague WPCF	$ 439.57	$ 466.76	$ 495.64	$ 526.30	$ 558.86	$ 593.43	$ 630.14
Montague WPCF	$ 439.57	$ 466.76	$ 495.64	$ 526.30	$ 558.86	$ 593.43	$ 630.14
MWRA Clinton WWTP	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
MWRA Deer Island WWTP	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
Nantucket Sewer Dept. - Siasconset	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Nantucket Sewer Dept. - Surfside	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
New Bedford WWTP	$ 0.47	$ 0.50	$ 0.53	$ 0.56	$ 0.59	$ 0.63	$ 0.67
Newburyport WWTP	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
North Attleborough WPCF	$ 0.28	$ 0.30	$ 0.31	$ 0.33	$ 0.35	$ 0.38	$ 0.40
North Attleborough WPCF	$ 0.28	$ 0.30	$ 0.31	$ 0.33	$ 0.35	$ 0.38	$ 0.40
North Brookfield WWTP	$ 499.50	$ 530.40	$ 563.22	$ 598.06	$ 635.06	$ 674.34	$ 716.06
Northampton WWTF	$ 386.30	$ 410.20	$ 435.58	$ 462.52	$ 491.14	$ 521.52	$ 553.78
Northbridge WWTF	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21
Northfield WPCF	$ 0.61	$ 0.65	$ 0.69	$ 0.73	$ 0.77	$ 0.82	$ 0.87
Oak Bluffs WWTP	$ 0.73	$ 0.78	$ 0.83	$ 0.88	$ 0.93	$ 0.99	$ 1.05
Old Deerfield - Historic WWTP	$ 0.63	$ 0.67	$ 0.71	$ 0.75	$ 0.80	$ 0.85	$ 0.90
Orange WWTP	$ 0.53	$ 0.56	$ 0.60	$ 0.63	$ 0.67	$ 0.72	$ 0.76
Orange WWTP	$ 0.53	$ 0.56	$ 0.60	$ 0.63	$ 0.67	$ 0.72	$ 0.76
Otis DPW	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Oxford-Rochdale SD WPCP	$ 0.20	$ 0.21	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.28
Palmer WWTF	$ 393.86	$ 418.22	$ 444.09	$ 471.57	$ 500.74	$ 531.72	$ 564.61
Pepperell WWTF	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
Pittsfield WWTP	$ 396.15	$ 420.65	$ 446.67	$ 474.31	$ 503.65	$ 534.81	$ 567.89
Plymouth WWTF	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Provincetown Public Works	$ 0.41	$ 0.43	$ 0.46	$ 0.49	$ 0.52	$ 0.55	$ 0.58
Rockland WWTP	$ 467.50	$ 496.42	$ 527.13	$ 559.74	$ 594.37	$ 631.14	$ 670.18

Table H-7C: Yearly Unit Prices by Plant and Sludge Load (6.2% escalation)

POTW name	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Rockport WWTP	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
Royalston WWTF	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Russell Village WWTF	$ 0.21	$ 0.23	$ 0.24	$ 0.25	$ 0.27	$ 0.29	$ 0.30	$ 0.32	$ 0.34	$ 0.37	$ 0.39	$ 0.41	$ 0.44	$ 0.46	$ 0.49
Salisbury WWTF	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Scituate WWTF	$ 172.00	$ 182.64	$ 193.94	$ 205.94	$ 218.68	$ 232.20	$ 246.57	$ 261.82	$ 278.02	$ 295.22	$ 313.48	$ 332.88	$ 353.47	$ 375.34	$ 398.56
Shelburne Falls WWTP	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
Somerset WWTF	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33
South Deerfield	$ 0.18	$ 0.19	$ 0.21	$ 0.22	$ 0.23	$ 0.25	$ 0.26	$ 0.28	$ 0.30	$ 0.31	$ 0.33	$ 0.35	$ 0.38	$ 0.40	$ 0.42
South Essex Sewerage District	$ 135.08	$ 143.44	$ 152.31	$ 161.73	$ 171.74	$ 182.36	$ 193.64	$ 205.62	$ 218.34	$ 231.85	$ 246.19	$ 261.42	$ 277.60	$ 294.77	$ 313.01
South Essex Sewerage District	$ 135.08	$ 143.44	$ 152.31	$ 161.73	$ 171.74	$ 182.36	$ 193.64	$ 205.62	$ 218.34	$ 231.85	$ 246.19	$ 261.42	$ 277.60	$ 294.77	$ 313.01
South Essex Sewerage District	$ 135.08	$ 143.44	$ 152.31	$ 161.73	$ 171.74	$ 182.36	$ 193.64	$ 205.62	$ 218.34	$ 231.85	$ 246.19	$ 261.42	$ 277.60	$ 294.77	$ 313.01
South Essex Sewerage District	$ 135.08	$ 143.44	$ 152.31	$ 161.73	$ 171.74	$ 182.36	$ 193.64	$ 205.62	$ 218.34	$ 231.85	$ 246.19	$ 261.42	$ 277.60	$ 294.77	$ 313.01
South Essex Sewerage District	$ 135.08	$ 143.44	$ 152.31	$ 161.73	$ 171.74	$ 182.36	$ 193.64	$ 205.62	$ 218.34	$ 231.85	$ 246.19	$ 261.42	$ 277.60	$ 294.77	$ 313.01
South Hadley WWTP	$ 143.00	$ 151.85	$ 161.24	$ 171.21	$ 181.81	$ 193.05	$ 205.00	$ 217.68	$ 231.15	$ 245.44	$ 260.63	$ 276.75	$ 293.87	$ 312.05	$ 331.36
Southbridge WWTP	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
Spencer WWTP	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.23	$ 0.24	$ 0.25	$ 0.27	$ 0.29	$ 0.31	$ 0.32
Springfield WWTP - Bondi's Island	$ 142.57	$ 151.39	$ 160.76	$ 170.70	$ 181.26	$ 192.47	$ 204.38	$ 217.02	$ 230.45	$ 244.71	$ 259.84	$ 275.92	$ 292.99	$ 311.11	$ 330.36
Springfield WWTP - Bondi's Island	$ 142.57	$ 151.39	$ 160.76	$ 170.70	$ 181.26	$ 192.47	$ 204.38	$ 217.02	$ 230.45	$ 244.71	$ 259.84	$ 275.92	$ 292.99	$ 311.11	$ 330.36
Springfield WWTP - Bondi's Island	$ 142.57	$ 151.39	$ 160.76	$ 170.70	$ 181.26	$ 192.47	$ 204.38	$ 217.02	$ 230.45	$ 244.71	$ 259.84	$ 275.92	$ 292.99	$ 311.11	$ 330.36
Springfield WWTP - Bondi's Island	$ 142.57	$ 151.39	$ 160.76	$ 170.70	$ 181.26	$ 192.47	$ 204.38	$ 217.02	$ 230.45	$ 244.71	$ 259.84	$ 275.92	$ 292.99	$ 311.11	$ 330.36
Springfield WWTP - Bondi's Island	$ 142.57	$ 151.39	$ 160.76	$ 170.70	$ 181.26	$ 192.47	$ 204.38	$ 217.02	$ 230.45	$ 244.71	$ 259.84	$ 275.92	$ 292.99	$ 311.11	$ 330.36
Springfield WWTP - Bondi's Island	$ 142.57	$ 151.39	$ 160.76	$ 170.70	$ 181.26	$ 192.47	$ 204.38	$ 217.02	$ 230.45	$ 244.71	$ 259.84	$ 275.92	$ 292.99	$ 311.11	$ 330.36
Springfield WWTP - Bondi's Island	$ 142.57	$ 151.39	$ 160.76	$ 170.70	$ 181.26	$ 192.47	$ 204.38	$ 217.02	$ 230.45	$ 244.71	$ 259.84	$ 275.92	$ 292.99	$ 311.11	$ 330.36
Springfield WWTP - Bondi's Island	$ 142.57	$ 151.39	$ 160.76	$ 170.70	$ 181.26	$ 192.47	$ 204.38	$ 217.02	$ 230.45	$ 244.71	$ 259.84	$ 275.92	$ 292.99	$ 311.11	$ 330.36
Stockbridge WWTP	$ 0.09	$ 0.10	$ 0.10	$ 0.11	$ 0.11	$ 0.12	$ 0.13	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.20	$ 0.21
Sturbridge WPCF	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31
Sunderland WWTP	$ 0.24	$ 0.25	$ 0.27	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.38	$ 0.41	$ 0.43	$ 0.46	$ 0.49	$ 0.52	$ 0.55
Sunderland WWTP	$ 0.24	$ 0.25	$ 0.27	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.38	$ 0.41	$ 0.43	$ 0.46	$ 0.49	$ 0.52	$ 0.55
Taunton WWTP	$ 133.25	$ 141.50	$ 150.25	$ 159.54	$ 169.41	$ 179.89	$ 191.02	$ 202.84	$ 215.39	$ 228.71	$ 242.86	$ 257.89	$ 273.84	$ 290.78	$ 308.77
Templeton WWTP	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
Tisbury Public Works	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Upper Blackstone WPAD (Worcester area)	$ 156.00	$ 165.65	$ 175.90	$ 186.78	$ 198.33	$ 210.60	$ 223.63	$ 237.47	$ 252.16	$ 267.76	$ 284.32	$ 301.91	$ 320.59	$ 340.42	$ 361.48
Upton WWTP	$ 0.08	$ 0.08	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.11	$ 0.12	$ 0.12	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18
Uxbridge WWTF	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Ware WWTP	$ 0.08	$ 0.09	$ 0.10	$ 0.10	$ 0.11	$ 0.11	$ 0.12	$ 0.13	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.17	$ 0.19	$ 0.20
Wareham WPCF	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Warren WWTP	$ 0.12	$ 0.13	$ 0.13	$ 0.14	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.28
Wayland WWTP	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Webster WWTF	$ 0.11	$ 0.11	$ 0.12	$ 0.13	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.17	$ 0.18	$ 0.20	$ 0.21	$ 0.22	$ 0.23	$ 0.25
West Stockbridge	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.39
Westborough WWTF	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37
Westborough WWTF	$ 0.16	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.22	$ 0.23	$ 0.24	$ 0.26	$ 0.27	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37

Table H-7C: Yearly Unit Prices by Plant and Sludge Load (6.2% escalation)

POTW name	2038	2039	2040	2041	2042	2043	2044
Rockport WWTP	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
Royalston WWTF	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Russell Village WWTF	$ 0.52	$ 0.56	$ 0.59	$ 0.63	$ 0.67	$ 0.71	$ 0.75
Salisbury WWTF	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Scituate WWTF	$ 423.21	$ 449.39	$ 477.19	$ 506.71	$ 538.06	$ 571.35	$ 606.69
Shelburne Falls WWTP	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
Somerset WWTF	$ 0.35	$ 0.37	$ 0.39	$ 0.41	$ 0.44	$ 0.47	$ 0.50
South Deerfield	$ 0.45	$ 0.48	$ 0.51	$ 0.54	$ 0.57	$ 0.61	$ 0.65
South Essex Sewerage District	$ 332.37	$ 352.93	$ 374.76	$ 397.95	$ 422.57	$ 448.71	$ 476.47
South Essex Sewerage District	$ 332.37	$ 352.93	$ 374.76	$ 397.95	$ 422.57	$ 448.71	$ 476.47
South Essex Sewerage District	$ 332.37	$ 352.93	$ 374.76	$ 397.95	$ 422.57	$ 448.71	$ 476.47
South Essex Sewerage District	$ 332.37	$ 352.93	$ 374.76	$ 397.95	$ 422.57	$ 448.71	$ 476.47
South Essex Sewerage District	$ 332.37	$ 352.93	$ 374.76	$ 397.95	$ 422.57	$ 448.71	$ 476.47
South Hadley WWTP	$ 351.86	$ 373.62	$ 396.74	$ 421.28	$ 447.34	$ 475.01	$ 504.40
Southbridge WWTP	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
Spencer WWTP	$ 0.34	$ 0.37	$ 0.39	$ 0.41	$ 0.44	$ 0.46	$ 0.49
Springfield WWTP - Bondi's Island	$ 350.80	$ 372.50	$ 395.54	$ 420.01	$ 446.00	$ 473.59	$ 502.88
Springfield WWTP - Bondi's Island	$ 350.80	$ 372.50	$ 395.54	$ 420.01	$ 446.00	$ 473.59	$ 502.88
Springfield WWTP - Bondi's Island	$ 350.80	$ 372.50	$ 395.54	$ 420.01	$ 446.00	$ 473.59	$ 502.88
Springfield WWTP - Bondi's Island	$ 350.80	$ 372.50	$ 395.54	$ 420.01	$ 446.00	$ 473.59	$ 502.88
Springfield WWTP - Bondi's Island	$ 350.80	$ 372.50	$ 395.54	$ 420.01	$ 446.00	$ 473.59	$ 502.88
Springfield WWTP - Bondi's Island	$ 350.80	$ 372.50	$ 395.54	$ 420.01	$ 446.00	$ 473.59	$ 502.88
Springfield WWTP - Bondi's Island	$ 350.80	$ 372.50	$ 395.54	$ 420.01	$ 446.00	$ 473.59	$ 502.88
Springfield WWTP - Bondi's Island	$ 350.80	$ 372.50	$ 395.54	$ 420.01	$ 446.00	$ 473.59	$ 502.88
Stockbridge WWTP	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.28	$ 0.30	$ 0.32
Sturbridge WPCF	$ 0.33	$ 0.35	$ 0.37	$ 0.39	$ 0.42	$ 0.44	$ 0.47
Sunderland WWTP	$ 0.58	$ 0.62	$ 0.66	$ 0.70	$ 0.74	$ 0.79	$ 0.83
Sunderland WWTP	$ 0.58	$ 0.62	$ 0.66	$ 0.70	$ 0.74	$ 0.79	$ 0.83
Taunton WWTP	$ 327.87	$ 348.15	$ 369.69	$ 392.56	$ 416.85	$ 442.64	$ 470.02
Templeton WWTP	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
Tisbury Public Works	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Upper Blackstone WPAD (Worcester area)	$ 383.84	$ 407.59	$ 432.80	$ 459.58	$ 488.01	$ 518.20	$ 550.26
Upton WWTP	$ 0.19	$ 0.20	$ 0.21	$ 0.23	$ 0.24	$ 0.26	$ 0.27
Uxbridge WWTF	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Ware WWTP	$ 0.21	$ 0.22	$ 0.24	$ 0.25	$ 0.27	$ 0.28	$ 0.30
Wareham WPCF	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Warren WWTP	$ 0.29	$ 0.31	$ 0.33	$ 0.35	$ 0.37	$ 0.40	$ 0.42
Wayland WWTP	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Webster WWTF	$ 0.26	$ 0.28	$ 0.30	$ 0.32	$ 0.34	$ 0.36	$ 0.38
West Stockbridge	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56	$ 0.60
Westborough WWTF	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56
Westborough WWTF	$ 0.39	$ 0.42	$ 0.44	$ 0.47	$ 0.50	$ 0.53	$ 0.56

Table H-7C: Yearly Unit Prices by Plant and Sludge Load (6.2% escalation)

POTW name	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Westfield WPCP	$ 135.00	$ 143.35	$ 152.22	$ 161.64	$ 171.64	$ 182.25	$ 193.53	$ 205.50	$ 218.21	$ 231.71	$ 246.05	$ 261.27	$ 277.43	$ 294.59	$ 312.82
Winchendon WPCF	$ 0.07	$ 0.07	$ 0.08	$ 0.08	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.11	$ 0.12	$ 0.12	$ 0.13	$ 0.14	$ 0.15	$ 0.16

Table H-7C: Yearly Unit Prices by Plant and Sludge Load (6.2% escalation)

POTW name	2038	2039	2040	2041	2042	2043	2044
Westfield WPCP	$ 332.17	$ 352.72	$ 374.54	$ 397.71	$ 422.31	$ 448.44	$ 476.18
Winchendon WPCF	$ 0.17	$ 0.18	$ 0.19	$ 0.20	$ 0.21	$ 0.23	$ 0.24

Calculation Approach

Annual solids hauling costs were calculated for each plant and each load, for each year from 2024 to 2044.

Annual quantities as determined in H-7B were multiplied by unit prices, as determined in H-7C, to get annual solids handling costs.

For example, Adams was projected to produce 983 wt in 2024, and pay $180.52 per wt. 983 wt/yr * $180.52/wt = $178,424. Other years are calculated according to the same logic.

Table H-7D: Annual Solids Hauling Cost per year, per plant (6.2% escalation)

POTW name	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Acton Wastewater Collection	$ 25,030.62	$ 26,712	$ 28,506	$ 30,421	$ 32,465	$ 34,645	$ 36,973	$ 39,456	$ 42,106	$ 44,935	$ 47,953
Adams WWTP	$ 167,193.38	$ 178,424	$ 190,409	$ 203,200	$ 216,849	$ 231,415	$ 246,960	$ 263,549	$ 281,252	$ 300,145	$ 320,306
Amesbury WWTP	$ 330,738.84	$ 352,955	$ 376,664	$ 401,966	$ 428,967	$ 457,782	$ 488,532	$ 521,348	$ 556,368	$ 593,741	$ 633,624
Amherst WWTP	$ 661,600.06	$ 706,041	$ 753,468	$ 804,080	$ 858,092	$ 915,733	$ 977,245	$ 1,042,889	$ 1,112,942	$ 1,187,701	$ 1,267,482
Ashfield	$ 5,044.08	$ 5,383	$ 5,744	$ 6,130	$ 6,542	$ 6,982	$ 7,451	$ 7,951	$ 8,485	$ 9,055	$ 9,663
Athol WWTP	$ 78,635.99	$ 83,918	$ 89,555	$ 95,571	$ 101,991	$ 108,841	$ 116,153	$ 123,955	$ 132,281	$ 141,167	$ 150,649
Athol WWTP	$ 468,308.36	$ 499,766	$ 533,336	$ 569,162	$ 607,394	$ 648,194	$ 691,735	$ 738,200	$ 787,787	$ 840,705	$ 897,177
Attleboro WWTP	$ 1,485,246.20	$ 1,585,014	$ 1,691,483	$ 1,805,104	$ 1,926,358	$ 2,055,756	$ 2,193,846	$ 2,341,212	$ 2,498,477	$ 2,666,306	$ 2,845,409
Ayer WWTP	$ 267,496.12	$ 285,465	$ 304,640	$ 325,103	$ 346,941	$ 370,246	$ 395,117	$ 421,658	$ 449,981	$ 480,208	$ 512,464
Barnstable WWTP WPCD - DPW	$ 859,073.39	$ 916,779	$ 978,362	$ 1,044,081	$ 1,114,214	$ 1,189,059	$ 1,268,931	$ 1,354,168	$ 1,445,131	$ 1,542,204	$ 1,645,798
Barnstable WWTP WPCD - DPW	$ 45,113.35	$ 48,144	$ 51,378	$ 54,829	$ 58,512	$ 62,442	$ 66,637	$ 71,113	$ 75,890	$ 80,987	$ 86,427
Barre WWTP	$ 558.08	$ 596	$ 636	$ 678	$ 724	$ 772	$ 824	$ 880	$ 939	$ 1,002	$ 1,069
Belchertown WWTP	$ 94,252.50	$ 100,584	$ 107,340	$ 114,550	$ 122,245	$ 130,457	$ 139,220	$ 148,571	$ 158,551	$ 169,202	$ 180,567
Billerica WWTP	$ 1,027,368.84	$ 1,096,380	$ 1,170,026	$ 1,248,620	$ 1,332,493	$ 1,422,000	$ 1,517,519	$ 1,619,454	$ 1,728,237	$ 1,844,327	$ 1,968,215
Bridgewater WWTP	$ 89,419.39	$ 95,426	$ 101,836	$ 108,676	$ 115,977	$ 123,767	$ 132,081	$ 140,953	$ 150,421	$ 160,525	$ 171,308
Brockton WWTP	$ 2,574,569.44	$ 2,747,510	$ 2,932,067	$ 3,129,021	$ 3,339,205	$ 3,563,508	$ 3,802,878	$ 4,058,326	$ 4,330,934	$ 4,621,854	$ 4,932,315
Charlemont Sewer District	$ 93.01	$ 99	$ 106	$ 113	$ 121	$ 129	$ 137	$ 147	$ 156	$ 167	$ 178
Charles River PCD	$ 78,236.59	$ 83,492	$ 89,100	$ 95,085	$ 101,473	$ 108,289	$ 115,563	$ 123,325	$ 131,609	$ 140,450	$ 149,884
Charles River PCD	$ 917,709.49	$ 979,354	$ 1,045,140	$ 1,115,345	$ 1,190,265	$ 1,270,218	$ 1,355,542	$ 1,446,597	$ 1,543,769	$ 1,647,467	$ 1,758,132
Charlton WWTP	$ 837.12	$ 893	$ 953	$ 1,017	$ 1,086	$ 1,159	$ 1,237	$ 1,320	$ 1,408	$ 1,503	$ 1,604
Chatham WPCF	$ 42,335.97	$ 45,180	$ 48,215	$ 51,453	$ 54,910	$ 58,598	$ 62,534	$ 66,735	$ 71,217	$ 76,001	$ 81,107
Chicopee WWTP	$ 57,796.23	$ 61,679	$ 65,822	$ 70,243	$ 74,961	$ 79,997	$ 85,370	$ 91,105	$ 97,225	$ 103,755	$ 110,725
Chicopee WWTP	$ 51,363.43	$ 54,814	$ 58,496	$ 62,425	$ 66,618	$ 71,093	$ 75,869	$ 80,965	$ 86,403	$ 92,207	$ 98,401
Chicopee WWTP	$ 482,628.56	$ 515,048	$ 549,645	$ 586,566	$ 625,967	$ 668,015	$ 712,887	$ 760,774	$ 811,877	$ 866,412	$ 924,611
Cohasset WWTF	$ 83,881.30	$ 89,516	$ 95,529	$ 101,946	$ 108,794	$ 116,102	$ 123,900	$ 132,223	$ 141,105	$ 150,583	$ 160,698
Concord WWTF	$ 1,881.75	$ 2,008	$ 2,143	$ 2,287	$ 2,441	$ 2,605	$ 2,780	$ 2,966	$ 3,165	$ 3,378	$ 3,605
Concord WWTF	$ 59,058.00	$ 63,025	$ 67,259	$ 71,777	$ 76,598	$ 81,743	$ 87,234	$ 93,094	$ 99,347	$ 106,021	$ 113,142
Dartmouth WPCF	$ 257,940.54	$ 275,267	$ 293,757	$ 313,490	$ 334,548	$ 357,020	$ 381,002	$ 406,595	$ 433,907	$ 463,054	$ 494,158
Devens WWTP	$ 653,421.09	$ 697,313	$ 744,153	$ 794,140	$ 847,484	$ 904,412	$ 965,163	$ 1,029,996	$ 1,099,183	$ 1,173,018	$ 1,251,813
Douglas WWTP	$ 124,999.85	$ 133,396	$ 142,357	$ 151,919	$ 162,124	$ 173,015	$ 184,636	$ 197,039	$ 210,274	$ 224,399	$ 239,473
Easthampton WWTP	$ 300,000.00	$ 320,152	$ 341,657	$ 364,607	$ 389,099	$ 415,235	$ 443,128	$ 472,894	$ 504,659	$ 538,558	$ 574,735
Edgartown WWTP	$ 120,270.52	$ 128,349	$ 136,971	$ 146,172	$ 155,990	$ 166,469	$ 177,651	$ 189,584	$ 202,319	$ 215,909	$ 230,412
Erving Center WWTP (#2)	$ 6,183,339.34	$ 6,565,860	$ 6,972,045	$ 7,403,358	$ 7,861,354	$ 8,347,682	$ 8,864,096	$ 9,412,457	$ 9,994,742	$ 10,613,048	$ 11,269,605
Erving Center WWTP (#2)	$ 443,377.47	$ 470,806	$ 499,932	$ 530,859	$ 563,700	$ 598,572	$ 635,602	$ 674,922	$ 716,675	$ 761,011	$ 808,089
Erving POTW #1	$ 38,451.27	$ 41,034	$ 43,791	$ 46,732	$ 49,871	$ 53,221	$ 56,796	$ 60,611	$ 64,683	$ 69,028	$ 73,664
Erving POTW #3	$ 793.21	$ 846	$ 903	$ 964	$ 1,029	$ 1,098	$ 1,172	$ 1,250	$ 1,334	$ 1,424	$ 1,520
Fairhaven WPCF	$ 410,177.57	$ 437,730	$ 467,134	$ 498,512	$ 531,998	$ 567,734	$ 605,870	$ 646,568	$ 690,000	$ 736,349	$ 785,811

Table H-7D: Annual Solids Hauling Cost per year, per plant (6.2% escalation)

POTW name	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Acton Wastewater Collection	$ 51,174	$ 54,612	$ 58,280	$ 62,195	$ 66,373	$ 70,831	$ 75,589	$ 80,667	$ 86,085	$ 91,868	$ 98,039
Adams WWTP	$ 341,822	$ 364,783	$ 389,286	$ 415,436	$ 443,342	$ 473,122	$ 504,903	$ 538,818	$ 575,012	$ 613,637	$ 654,857
Amesbury WWTP	$ 676,186	$ 721,607	$ 770,079	$ 821,807	$ 877,010	$ 935,921	$ 998,789	$ 1,065,880	$ 1,137,478	$ 1,213,885	$ 1,295,425
Amherst WWTP	$ 1,352,622	$ 1,443,481	$ 1,540,443	$ 1,643,918	$ 1,754,345	$ 1,872,188	$ 1,997,948	$ 2,132,155	$ 2,275,377	$ 2,428,220	$ 2,591,329
Ashfield	$ 10,312	$ 11,005	$ 11,744	$ 12,533	$ 13,375	$ 14,274	$ 15,232	$ 16,256	$ 17,348	$ 18,513	$ 19,756
Athol WWTP	$ 160,769	$ 171,568	$ 183,093	$ 195,392	$ 208,517	$ 222,523	$ 237,471	$ 253,422	$ 270,445	$ 288,612	$ 307,998
Athol WWTP	$ 957,443	$ 1,021,756	$ 1,090,390	$ 1,163,635	$ 1,241,799	$ 1,325,214	$ 1,414,231	$ 1,509,229	$ 1,610,608	$ 1,718,796	$ 1,834,252
Attleboro WWTP	$ 3,036,542	$ 3,240,514	$ 3,458,188	$ 3,690,483	$ 3,938,382	$ 4,202,933	$ 4,485,254	$ 4,786,540	$ 5,108,064	$ 5,451,185	$ 5,817,355
Ayer WWTP	$ 546,888	$ 583,624	$ 622,827	$ 664,664	$ 709,311	$ 756,957	$ 807,804	$ 862,066	$ 919,974	$ 981,770	$ 1,047,718
Barnstable WWTP WPCD - DPW	$ 1,756,350	$ 1,874,329	$ 2,000,232	$ 2,134,593	$ 2,277,978	$ 2,430,996	$ 2,594,292	$ 2,768,557	$ 2,954,528	$ 3,152,991	$ 3,364,785
Barnstable WWTP WPCD - DPW	$ 92,233	$ 98,428	$ 105,040	$ 112,096	$ 119,626	$ 127,661	$ 136,237	$ 145,388	$ 155,154	$ 165,576	$ 176,698
Barre WWTP	$ 1,141	$ 1,218	$ 1,299	$ 1,387	$ 1,480	$ 1,579	$ 1,685	$ 1,799	$ 1,919	$ 2,048	$ 2,186
Belchertown WWTP	$ 192,696	$ 205,640	$ 219,454	$ 234,195	$ 249,926	$ 266,715	$ 284,631	$ 303,750	$ 324,154	$ 345,928	$ 369,165
Billerica WWTP	$ 2,100,425	$ 2,241,516	$ 2,392,084	$ 2,552,767	$ 2,724,242	$ 2,907,236	$ 3,102,523	$ 3,310,927	$ 3,533,330	$ 3,770,673	$ 4,023,958
Bridgewater WWTP	$ 182,815	$ 195,095	$ 208,201	$ 222,186	$ 237,111	$ 253,038	$ 270,035	$ 288,174	$ 307,531	$ 328,189	$ 350,234
Brockton WWTP	$ 5,263,631	$ 5,617,203	$ 5,994,524	$ 6,397,191	$ 6,826,907	$ 7,285,487	$ 7,774,871	$ 8,297,129	$ 8,854,468	$ 9,449,244	$ 10,083,974
Charlemont Sewer District	$ 190	$ 203	$ 217	$ 231	$ 247	$ 263	$ 281	$ 300	$ 320	$ 341	$ 364
Charles River PCD	$ 159,952	$ 170,697	$ 182,163	$ 194,399	$ 207,458	$ 221,393	$ 236,265	$ 252,135	$ 269,072	$ 287,146	$ 306,434
Charles River PCD	$ 1,876,230	$ 2,002,261	$ 2,136,758	$ 2,280,289	$ 2,433,462	$ 2,596,924	$ 2,771,366	$ 2,957,525	$ 3,156,189	$ 3,368,199	$ 3,594,449
Charlton WWTP	$ 1,711	$ 1,826	$ 1,949	$ 2,080	$ 2,220	$ 2,369	$ 2,528	$ 2,698	$ 2,879	$ 3,072	$ 3,279
Chatham WPCF	$ 86,555	$ 92,369	$ 98,573	$ 105,195	$ 112,261	$ 119,802	$ 127,849	$ 136,437	$ 145,602	$ 155,382	$ 165,820
Chicopee WWTP	$ 118,163	$ 126,100	$ 134,570	$ 143,610	$ 153,256	$ 163,551	$ 174,537	$ 186,261	$ 198,773	$ 212,125	$ 226,374
Chicopee WWTP	$ 105,011	$ 112,065	$ 119,593	$ 127,626	$ 136,199	$ 145,348	$ 155,111	$ 165,530	$ 176,649	$ 188,515	$ 201,178
Chicopee WWTP	$ 986,720	$ 1,053,000	$ 1,123,733	$ 1,199,217	$ 1,279,771	$ 1,365,737	$ 1,457,477	$ 1,555,379	$ 1,659,858	$ 1,771,355	$ 1,890,341
Cohasset WWTF	$ 171,493	$ 183,012	$ 195,306	$ 208,425	$ 222,425	$ 237,366	$ 253,311	$ 270,326	$ 288,485	$ 307,863	$ 328,543
Concord WWTF	$ 3,847	$ 4,106	$ 4,381	$ 4,676	$ 4,990	$ 5,325	$ 5,683	$ 6,064	$ 6,472	$ 6,906	$ 7,370
Concord WWTF	$ 120,742	$ 128,853	$ 137,508	$ 146,745	$ 156,602	$ 167,122	$ 178,348	$ 190,328	$ 203,112	$ 216,756	$ 231,316
Dartmouth WPCF	$ 527,352	$ 562,775	$ 600,578	$ 640,921	$ 683,973	$ 729,917	$ 778,948	$ 831,271	$ 887,110	$ 946,699	$ 1,010,291
Devens WWTP	$ 1,335,900	$ 1,425,636	$ 1,521,399	$ 1,623,596	$ 1,732,657	$ 1,849,043	$ 1,973,248	$ 2,105,796	$ 2,247,248	$ 2,398,201	$ 2,559,294
Douglas WWTP	$ 255,559	$ 272,725	$ 291,045	$ 310,595	$ 331,458	$ 353,723	$ 377,484	$ 402,840	$ 429,900	$ 458,777	$ 489,595
Easthampton WWTP	$ 613,341	$ 654,541	$ 698,508	$ 745,428	$ 795,501	$ 848,937	$ 905,962	$ 966,817	$ 1,031,761	$ 1,101,067	$ 1,175,028
Edgartown WWTP	$ 245,890	$ 262,407	$ 280,033	$ 298,844	$ 318,918	$ 340,340	$ 363,202	$ 387,599	$ 413,635	$ 441,420	$ 471,071
Erving Center WWTP (#2)	$ 11,966,779	$ 12,707,082	$ 13,493,182	$ 14,327,913	$ 15,214,283	$ 16,155,487	$ 17,154,917	$ 18,216,175	$ 19,343,085	$ 20,539,710	$ 21,810,362
Erving Center WWTP (#2)	$ 858,080	$ 911,164	$ 967,531	$ 1,027,386	$ 1,090,943	$ 1,158,432	$ 1,230,096	$ 1,306,194	$ 1,386,999	$ 1,472,804	$ 1,563,916
Erving POTW #1	$ 78,612	$ 83,893	$ 89,528	$ 95,542	$ 101,960	$ 108,809	$ 116,118	$ 123,918	$ 132,242	$ 141,125	$ 150,604
Erving POTW #3	$ 1,622	$ 1,731	$ 1,847	$ 1,971	$ 2,103	$ 2,245	$ 2,395	$ 2,556	$ 2,728	$ 2,911	$ 3,107
Fairhaven WPCF	$ 838,596	$ 894,927	$ 955,041	$ 1,019,193	$ 1,087,655	$ 1,160,716	$ 1,238,684	$ 1,321,889	$ 1,410,684	$ 1,505,443	$ 1,606,568

Table H-7D: Annual Solids Hauling Cost per year, per plant (6.2% escalation)

POTW name	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Fall River Regional WWF	$ 1,863,588.16	$ 1,988,770	$ 2,122,361	$ 2,264,925	$ 2,417,066	$ 2,579,426	$ 2,752,692	$ 2,937,598	$ 3,134,923	$ 3,345,504	$ 3,570,230
Falmouth WWTP	$ 2,232.33	$ 2,382	$ 2,542	$ 2,713	$ 2,895	$ 3,090	$ 3,297	$ 3,519	$ 3,755	$ 4,007	$ 4,277
Fitchburg East WWTP	$ 328,848.71	$ 350,938	$ 374,512	$ 399,669	$ 426,515	$ 455,165	$ 485,740	$ 518,368	$ 553,188	$ 590,348	$ 630,003
Gardner WPCF	$ 8,925.40	$ 9,525	$ 10,165	$ 10,848	$ 11,576	$ 12,354	$ 13,184	$ 14,069	$ 15,014	$ 16,023	$ 17,099
Gloucester WPCF	$ 406,256.35	$ 433,546	$ 462,668	$ 493,747	$ 526,913	$ 562,307	$ 600,078	$ 640,387	$ 683,403	$ 729,309	$ 778,299
Grafton WWTP	$ 301,244.76	$ 321,480	$ 343,075	$ 366,120	$ 390,713	$ 416,958	$ 444,966	$ 474,856	$ 506,753	$ 540,793	$ 577,119
Great Barrington WWTP	$ 141,446.37	$ 150,948	$ 161,087	$ 171,908	$ 183,455	$ 195,778	$ 208,929	$ 222,964	$ 237,941	$ 253,924	$ 270,981
Greater Lawrence Sanitary District	$ 2,377,407.72	$ 2,537,104	$ 2,707,528	$ 2,889,399	$ 3,083,487	$ 3,290,613	$ 3,511,651	$ 3,747,538	$ 3,999,269	$ 4,267,910	$ 4,554,596
Greenfield WPCF	$ 730,182.97	$ 779,231	$ 831,574	$ 887,433	$ 947,044	$ 1,010,659	$ 1,078,548	$ 1,150,997	$ 1,228,312	$ 1,310,821	$ 1,398,872
Hadley WWTP	$ 243,928.17	$ 260,313	$ 277,799	$ 296,460	$ 316,374	$ 337,625	$ 360,305	$ 384,507	$ 410,335	$ 437,899	$ 467,313
Hardwick-Gilbertville WPCF	$ 25,800.00	$ 27,533	$ 29,383	$ 31,356	$ 33,462	$ 35,710	$ 38,109	$ 40,669	$ 43,401	$ 46,316	$ 49,427
Hardwick-Wheelwright WPCF	$ 12,000.00	$ 12,806	$ 13,666	$ 14,584	$ 15,564	$ 16,609	$ 17,725	$ 18,916	$ 20,186	$ 21,542	$ 22,989
Hatfield WWTP	$ 78,397.92	$ 83,664	$ 89,284	$ 95,281	$ 101,682	$ 108,512	$ 115,801	$ 123,580	$ 131,881	$ 140,740	$ 150,193
Haverhill WWTP	$ 2,552,051.78	$ 2,723,479	$ 2,906,422	$ 3,101,654	$ 3,310,000	$ 3,532,341	$ 3,769,617	$ 4,022,832	$ 4,293,055	$ 4,581,430	$ 4,889,176
Holyoke WWTP	$ 59,920.00	$ 63,945	$ 68,240	$ 72,824	$ 77,716	$ 82,936	$ 88,507	$ 94,453	$ 100,797	$ 107,568	$ 114,794
Holyoke WWTP	$ 43,680.00	$ 46,614	$ 49,745	$ 53,087	$ 56,653	$ 60,458	$ 64,519	$ 68,853	$ 73,478	$ 78,414	$ 83,681
Holyoke WWTP	$ 509,390.00	$ 543,607	$ 580,122	$ 619,091	$ 660,677	$ 705,056	$ 752,416	$ 802,958	$ 856,895	$ 914,454	$ 975,881
Holyoke WWTP	$ 732,060.00	$ 781,234	$ 833,712	$ 889,714	$ 949,479	$ 1,013,257	$ 1,081,320	$ 1,153,955	$ 1,231,470	$ 1,314,190	$ 1,402,468
Hoosac WQD	$ 90,705.19	$ 96,798	$ 103,300	$ 110,239	$ 117,644	$ 125,547	$ 133,980	$ 142,980	$ 152,584	$ 162,833	$ 173,771
Hopedale WWTF	$ 109,999.86	$ 117,389	$ 125,274	$ 133,689	$ 142,669	$ 152,253	$ 162,480	$ 173,394	$ 185,041	$ 197,471	$ 210,736
Hudson WWTF	$ 332,773.39	$ 355,127	$ 378,981	$ 404,438	$ 431,606	$ 460,598	$ 491,537	$ 524,555	$ 559,791	$ 597,393	$ 637,521
Hull WWTF	$ 193,837.38	$ 206,858	$ 220,753	$ 235,582	$ 251,406	$ 268,294	$ 286,316	$ 305,548	$ 326,073	$ 347,976	$ 371,350
Huntington WWTP	$ 24,479.97	$ 26,124	$ 27,879	$ 29,752	$ 31,750	$ 33,883	$ 36,159	$ 38,588	$ 41,180	$ 43,946	$ 46,898
Ipswich WWTP	$ 368,759.44	$ 393,530	$ 419,964	$ 448,174	$ 478,279	$ 510,407	$ 544,692	$ 581,280	$ 620,326	$ 661,995	$ 706,463
Kingston Sewer Commission	$ 150,009.81	$ 160,086	$ 170,840	$ 182,315	$ 194,562	$ 207,631	$ 221,578	$ 236,462	$ 252,346	$ 269,297	$ 287,386
Lee WWTP	$ 224,000.00	$ 239,047	$ 255,104	$ 272,240	$ 290,527	$ 310,042	$ 330,869	$ 353,094	$ 376,812	$ 402,124	$ 429,135
Leicester WWTP	$ 688.30	$ 735	$ 784	$ 837	$ 893	$ 953	$ 1,017	$ 1,085	$ 1,158	$ 1,236	$ 1,319
Lenox Center WWTP	$ 3,348.49	$ 3,573	$ 3,813	$ 4,070	$ 4,343	$ 4,635	$ 4,946	$ 5,278	$ 5,633	$ 6,011	$ 6,415
Leominster WPCF	$ 379,114.07	$ 404,580	$ 431,757	$ 460,759	$ 491,709	$ 524,739	$ 559,987	$ 597,602	$ 637,745	$ 680,584	$ 726,300
Lowell Regional WW Utility	$ 1,456,001.94	$ 1,553,805	$ 1,658,178	$ 1,769,562	$ 1,888,428	$ 2,015,278	$ 2,150,650	$ 2,295,114	$ 2,449,283	$ 2,613,807	$ 2,789,383
Lowell Regional WW Utility	$ 466,072.68	$ 497,380	$ 530,790	$ 566,445	$ 604,494	$ 645,100	$ 688,433	$ 734,676	$ 784,026	$ 836,691	$ 892,894
Lowell Regional WW Utility	$ 2,134,202.32	$ 2,277,562	$ 2,430,552	$ 2,593,818	$ 2,768,051	$ 2,953,988	$ 3,152,415	$ 3,364,170	$ 3,590,150	$ 3,831,309	$ 4,088,668
Lowell Regional WW Utility	$ 12,165.03	$ 12,982	$ 13,854	$ 14,785	$ 15,778	$ 16,838	$ 17,969	$ 19,176	$ 20,464	$ 21,839	$ 23,306
Lowell Regional WW Utility	$ 1,094,852.63	$ 1,168,397	$ 1,246,881	$ 1,330,637	$ 1,420,019	$ 1,515,405	$ 1,617,199	$ 1,725,830	$ 1,841,758	$ 1,965,474	$ 2,097,500
Lynn Regional WF	$ 318,271.34	$ 339,650	$ 362,466	$ 386,813	$ 412,797	$ 440,525	$ 470,116	$ 501,695	$ 535,395	$ 571,359	$ 609,739
Lynn Regional WF	$ 743,958.72	$ 793,932	$ 847,263	$ 904,175	$ 964,911	$ 1,029,727	$ 1,098,896	$ 1,172,712	$ 1,251,485	$ 1,335,551	$ 1,425,263
Manchester By the Sea WWTP	$ 17,914.23	$ 19,118	$ 20,402	$ 21,772	$ 23,235	$ 24,795	$ 26,461	$ 28,238	$ 30,135	$ 32,160	$ 34,320
Manchester By the Sea WWTP	$ 20,771.48	$ 22,167	$ 23,656	$ 25,245	$ 26,941	$ 28,750	$ 30,681	$ 32,742	$ 34,942	$ 37,289	$ 39,794
Mansfield WWTP (MFN)	$ 541,356.00	$ 577,720	$ 616,527	$ 657,941	$ 702,136	$ 749,301	$ 799,633	$ 853,346	$ 910,668	$ 971,840	$ 1,037,120
Mansfield WWTP (MFN)	$ 9,680.26	$ 10,331	$ 11,024	$ 11,765	$ 12,555	$ 13,399	$ 14,299	$ 15,259	$ 16,284	$ 17,378	$ 18,545
Marion WWTP - Marion DPW	$ 59,216.57	$ 63,194	$ 67,439	$ 71,969	$ 76,804	$ 81,963	$ 87,468	$ 93,344	$ 99,614	$ 106,305	$ 113,446

Table H-7D: Annual Solids Hauling Cost per year, per plant (6.2% escalation)

POTW name	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Fall River Regional WWF	$ 3,810,051	$ 4,065,982	$ 4,339,104	$ 4,630,572	$ 4,941,619	$ 5,273,560	$ 5,627,798	$ 6,005,832	$ 6,409,258	$ 6,839,784	$ 7,299,230
Falmouth WWTP	$ 4,564	$ 4,870	$ 5,198	$ 5,547	$ 5,919	$ 6,317	$ 6,741	$ 7,194	$ 7,677	$ 8,193	$ 8,743
Fitchburg East WWTP	$ 672,321	$ 717,483	$ 765,678	$ 817,111	$ 871,998	$ 930,572	$ 993,081	$ 1,059,789	$ 1,130,978	$ 1,206,948	$ 1,288,022
Gardner WPCF	$ 18,248	$ 19,473	$ 20,782	$ 22,177	$ 23,667	$ 25,257	$ 26,954	$ 28,764	$ 30,696	$ 32,758	$ 34,959
Gloucester WPCF	$ 830,579	$ 886,371	$ 945,911	$ 1,009,450	$ 1,077,257	$ 1,149,620	$ 1,226,842	$ 1,309,252	$ 1,397,198	$ 1,491,051	$ 1,591,209
Grafton WWTP	$ 615,886	$ 657,257	$ 701,406	$ 748,521	$ 798,801	$ 852,459	$ 909,721	$ 970,829	$ 1,036,042	$ 1,105,635	$ 1,179,904
Great Barrington WWTP	$ 289,183	$ 308,608	$ 329,338	$ 351,461	$ 375,069	$ 400,263	$ 427,150	$ 455,843	$ 486,463	$ 519,140	$ 554,012
Greater Lawrence Sanitary District	$ 4,860,540	$ 5,187,035	$ 5,535,461	$ 5,907,291	$ 6,304,099	$ 6,727,561	$ 7,179,468	$ 7,661,731	$ 8,176,388	$ 8,725,617	$ 9,311,738
Greenfield WPCF	$ 1,492,838	$ 1,593,115	$ 1,700,129	$ 1,814,331	$ 1,936,204	$ 2,066,263	$ 2,205,059	$ 2,353,179	$ 2,511,248	$ 2,679,934	$ 2,859,952
Hadley WWTP	$ 498,704	$ 532,203	$ 567,953	$ 606,103	$ 646,817	$ 690,265	$ 736,632	$ 786,113	$ 838,919	$ 895,271	$ 955,408
Hardwick-Gilbertville WPCF	$ 52,747	$ 56,291	$ 60,072	$ 64,107	$ 68,413	$ 73,009	$ 77,913	$ 83,146	$ 88,731	$ 94,692	$ 101,052
Hardwick-Wheelwright WPCF	$ 24,534	$ 26,182	$ 27,940	$ 29,817	$ 31,820	$ 33,957	$ 36,238	$ 38,673	$ 41,270	$ 44,043	$ 47,001
Hatfield WWTP	$ 160,282	$ 171,049	$ 182,539	$ 194,800	$ 207,885	$ 221,850	$ 236,752	$ 252,655	$ 269,626	$ 287,738	$ 307,066
Haverhill WWTP	$ 5,217,595	$ 5,568,074	$ 5,942,095	$ 6,341,240	$ 6,767,197	$ 7,221,767	$ 7,706,871	$ 8,224,560	$ 8,777,025	$ 9,366,599	$ 9,995,777
Holyoke WWTP	$ 122,505	$ 130,734	$ 139,515	$ 148,887	$ 158,888	$ 169,561	$ 180,951	$ 193,106	$ 206,077	$ 219,920	$ 234,692
Holyoke WWTP	$ 89,302	$ 95,301	$ 101,703	$ 108,534	$ 115,825	$ 123,605	$ 131,908	$ 140,769	$ 150,224	$ 160,315	$ 171,084
Holyoke WWTP	$ 1,041,433	$ 1,111,388	$ 1,186,043	$ 1,265,713	$ 1,350,734	$ 1,441,466	$ 1,538,293	$ 1,641,624	$ 1,751,896	$ 1,869,575	$ 1,995,159
Holyoke WWTP	$ 1,496,675	$ 1,597,210	$ 1,704,499	$ 1,818,995	$ 1,941,181	$ 2,071,575	$ 2,210,728	$ 2,359,228	$ 2,517,703	$ 2,686,824	$ 2,867,304
Hoosac WQD	$ 185,444	$ 197,901	$ 211,194	$ 225,381	$ 240,520	$ 256,676	$ 273,918	$ 292,318	$ 311,954	$ 332,908	$ 355,271
Hopedale WWTF	$ 224,891	$ 239,998	$ 256,119	$ 273,323	$ 291,683	$ 311,276	$ 332,186	$ 354,499	$ 378,312	$ 403,724	$ 430,843
Hudson WWTF	$ 680,345	$ 726,046	$ 774,816	$ 826,863	$ 882,405	$ 941,678	$ 1,004,933	$ 1,072,437	$ 1,144,475	$ 1,221,353	$ 1,303,394
Hull WWTF	$ 396,295	$ 422,915	$ 451,323	$ 481,640	$ 513,993	$ 548,519	$ 585,364	$ 624,685	$ 666,646	$ 711,426	$ 759,215
Huntington WWTP	$ 50,049	$ 53,410	$ 56,998	$ 60,827	$ 64,913	$ 69,273	$ 73,926	$ 78,892	$ 84,192	$ 89,847	$ 95,882
Ipswich WWTP	$ 753,918	$ 804,560	$ 858,605	$ 916,279	$ 977,828	$ 1,043,511	$ 1,113,606	$ 1,188,410	$ 1,268,239	$ 1,353,429	$ 1,444,343
Kingston Sewer Commission	$ 306,691	$ 327,292	$ 349,277	$ 372,739	$ 397,776	$ 424,496	$ 453,011	$ 483,440	$ 515,914	$ 550,569	$ 587,553
Lee WWTP	$ 457,961	$ 488,724	$ 521,553	$ 556,587	$ 593,974	$ 633,873	$ 676,451	$ 721,890	$ 770,382	$ 822,130	$ 877,354
Leicester WWTP	$ 1,407	$ 1,502	$ 1,603	$ 1,710	$ 1,825	$ 1,948	$ 2,079	$ 2,218	$ 2,367	$ 2,526	$ 2,696
Lenox Center WWTP	$ 6,846	$ 7,306	$ 7,796	$ 8,320	$ 8,879	$ 9,476	$ 10,112	$ 10,791	$ 11,516	$ 12,290	$ 13,115
Leominster WPCF	$ 775,088	$ 827,152	$ 882,714	$ 942,008	$ 1,005,285	$ 1,072,813	$ 1,144,876	$ 1,221,780	$ 1,303,850	$ 1,391,433	$ 1,484,899
Lowell Regional WW Utility	$ 2,976,753	$ 3,176,709	$ 3,390,096	$ 3,617,818	$ 3,860,836	$ 4,120,177	$ 4,396,940	$ 4,692,294	$ 5,007,487	$ 5,343,852	$ 5,702,812
Lowell Regional WW Utility	$ 952,872	$ 1,016,879	$ 1,085,185	$ 1,158,079	$ 1,235,871	$ 1,318,887	$ 1,407,480	$ 1,502,024	$ 1,602,919	$ 1,710,591	$ 1,825,495
Lowell Regional WW Utility	$ 4,363,314	$ 4,656,408	$ 4,969,191	$ 5,302,984	$ 5,659,199	$ 6,039,341	$ 6,445,019	$ 6,877,947	$ 7,339,956	$ 7,832,999	$ 8,359,161
Lowell Regional WW Utility	$ 24,871	$ 26,542	$ 28,325	$ 30,227	$ 32,258	$ 34,424	$ 36,737	$ 39,205	$ 41,838	$ 44,648	$ 47,648
Lowell Regional WW Utility	$ 2,238,394	$ 2,388,752	$ 2,549,211	$ 2,720,448	$ 2,903,187	$ 3,098,201	$ 3,306,315	$ 3,528,409	$ 3,765,421	$ 4,018,353	$ 4,288,276
Lynn Regional WF	$ 650,696	$ 694,405	$ 741,050	$ 790,828	$ 843,950	$ 900,641	$ 961,139	$ 1,025,701	$ 1,094,600	$ 1,168,127	$ 1,246,593
Lynn Regional WF	$ 1,521,002	$ 1,623,171	$ 1,732,204	$ 1,848,560	$ 1,972,732	$ 2,105,246	$ 2,246,660	$ 2,397,574	$ 2,558,625	$ 2,730,494	$ 2,913,909
Manchester By the Sea WWTP	$ 36,625	$ 39,085	$ 41,711	$ 44,513	$ 47,503	$ 50,693	$ 54,099	$ 57,733	$ 61,611	$ 65,749	$ 70,166
Manchester By the Sea WWTP	$ 42,467	$ 45,319	$ 48,363	$ 51,612	$ 55,079	$ 58,779	$ 62,727	$ 66,941	$ 71,437	$ 76,236	$ 81,357
Mansfield WWTP (MFN)	$ 1,106,786	$ 1,181,132	$ 1,260,472	$ 1,345,141	$ 1,435,497	$ 1,531,923	$ 1,634,826	$ 1,744,641	$ 1,861,833	$ 1,986,897	$ 2,120,362
Mansfield WWTP (MFN)	$ 19,791	$ 21,120	$ 22,539	$ 24,053	$ 25,669	$ 27,393	$ 29,233	$ 31,197	$ 33,292	$ 35,529	$ 37,915
Marion WWTP - Marion DPW	$ 121,067	$ 129,199	$ 137,877	$ 147,139	$ 157,023	$ 167,570	$ 178,826	$ 190,839	$ 203,658	$ 217,338	$ 231,937

Table H-7D: Annual Solids Hauling Cost per year, per plant (6.2% escalation)

POTW name	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Marlborough East WWTP	$ 916,704.02	$ 978,281	$ 1,043,995	$ 1,114,123	$ 1,188,961	$ 1,268,827	$ 1,354,057	$ 1,445,012	$ 1,542,077	$ 1,645,662	$ 1,756,206
Marlborough West WWTP	$ 521,813.71	$ 556,865	$ 594,271	$ 634,190	$ 676,790	$ 722,252	$ 770,767	$ 822,542	$ 877,794	$ 936,757	$ 999,682
Marshfield WWTF	$ 88,659.08	$ 94,615	$ 100,970	$ 107,752	$ 114,990	$ 122,715	$ 130,958	$ 139,754	$ 149,142	$ 159,160	$ 169,852
Marshfield WWTF	$ 108,392.20	$ 115,673	$ 123,443	$ 131,735	$ 140,584	$ 150,028	$ 160,105	$ 170,860	$ 182,337	$ 194,585	$ 207,656
Maynard WWTP	$ 35,245.72	$ 37,613	$ 40,140	$ 42,836	$ 45,714	$ 48,784	$ 52,061	$ 55,558	$ 59,290	$ 63,273	$ 67,523
Maynard WWTP	$ 2,798,422.33	$ 2,986,399	$ 3,187,003	$ 3,401,082	$ 3,629,541	$ 3,873,347	$ 4,133,529	$ 4,411,189	$ 4,707,499	$ 5,023,714	$ 5,361,169
MCI Bridgewater	$ 70,590.89	$ 75,333	$ 80,393	$ 85,793	$ 91,556	$ 97,706	$ 104,269	$ 111,273	$ 118,748	$ 126,724	$ 135,237
MCI Concord	$ 58,514.93	$ 62,446	$ 66,640	$ 71,117	$ 75,894	$ 80,992	$ 86,432	$ 92,238	$ 98,434	$ 105,046	$ 112,102
MCI Norfolk	$ 48,496.76	$ 51,754	$ 55,231	$ 58,941	$ 62,900	$ 67,125	$ 71,634	$ 76,446	$ 81,581	$ 87,061	$ 92,909
Medfield WWTP	$ 306,201.27	$ 326,770	$ 348,719	$ 372,144	$ 397,142	$ 423,819	$ 452,288	$ 482,669	$ 515,091	$ 549,691	$ 586,615
Merrimac WWTP	$ 108,490.86	$ 115,778	$ 123,556	$ 131,855	$ 140,712	$ 150,164	$ 160,251	$ 171,016	$ 182,503	$ 194,762	$ 207,845
Middleborough WWTP	$ 342,407.47	$ 365,408	$ 389,953	$ 416,147	$ 444,101	$ 473,932	$ 505,768	$ 539,741	$ 575,997	$ 614,688	$ 655,978
Milford WWTP	$ 764,351.80	$ 815,695	$ 870,487	$ 928,960	$ 991,361	$ 1,057,953	$ 1,129,018	$ 1,204,857	$ 1,285,791	$ 1,372,160	$ 1,464,332
Monroe WWTP	$ 78,097.52	$ 83,344	$ 88,942	$ 94,916	$ 101,292	$ 108,096	$ 115,357	$ 123,106	$ 131,375	$ 140,200	$ 149,618
Montague WPCF	$ 173,622.89	$ 185,286	$ 197,732	$ 211,014	$ 225,188	$ 240,315	$ 256,457	$ 273,684	$ 292,068	$ 311,687	$ 332,624
Montague WPCF	$ 4,244.84	$ 4,530	$ 4,834	$ 5,159	$ 5,506	$ 5,875	$ 6,270	$ 6,691	$ 7,141	$ 7,620	$ 8,132
Montague WPCF	$ 22,176.03	$ 23,666	$ 25,255	$ 26,952	$ 28,762	$ 30,694	$ 32,756	$ 34,956	$ 37,304	$ 39,810	$ 42,484
MWRA Clinton WWTP	$ 228,349.66	$ 243,688	$ 260,058	$ 277,526	$ 296,169	$ 316,063	$ 337,294	$ 359,950	$ 384,129	$ 409,932	$ 437,468
MWRA Deer Island WWTP	$ 5,518,160.87	$ 5,888,830	$ 6,284,397	$ 6,706,535	$ 7,157,030	$ 7,637,786	$ 8,150,835	$ 8,698,347	$ 9,282,636	$ 9,906,174	$ 10,571,597
Nantucket Sewer Dept. - Siasconset	$ 102.31	$ 109	$ 117	$ 124	$ 133	$ 142	$ 151	$ 161	$ 172	$ 184	$ 196
Nantucket Sewer Dept. - Surfside	$ 4,925.33	$ 5,256	$ 5,609	$ 5,986	$ 6,388	$ 6,817	$ 7,275	$ 7,764	$ 8,285	$ 8,842	$ 9,436
New Bedford WWTP	$ 4,942,656.63	$ 5,274,667	$ 5,628,980	$ 6,007,092	$ 6,410,604	$ 6,841,220	$ 7,300,762	$ 7,791,172	$ 8,314,525	$ 8,873,032	$ 9,469,056
Newburyport WWTP	$ 425,666.17	$ 454,259	$ 484,773	$ 517,336	$ 552,087	$ 589,172	$ 628,748	$ 670,983	$ 716,055	$ 764,154	$ 815,484
North Attleborough WPCF	$ 4,777.34	$ 5,098	$ 5,441	$ 5,806	$ 6,196	$ 6,612	$ 7,057	$ 7,531	$ 8,036	$ 8,576	$ 9,152
North Attleborough WPCF	$ 4,777.34	$ 5,098	$ 5,441	$ 5,806	$ 6,196	$ 6,612	$ 7,057	$ 7,531	$ 8,036	$ 8,576	$ 9,152
North Brookfield WWTP	$ 1,401.64	$ 1,496	$ 1,596	$ 1,703	$ 1,818	$ 1,940	$ 2,070	$ 2,209	$ 2,358	$ 2,516	$ 2,685
Northampton WWTF	$ 4,527,319.45	$ 4,831,431	$ 5,155,970	$ 5,502,309	$ 5,871,913	$ 6,266,344	$ 6,687,270	$ 7,136,471	$ 7,615,845	$ 8,127,421	$ 8,673,360
Northbridge WWTF	$ 176,937.18	$ 188,822	$ 201,506	$ 215,042	$ 229,487	$ 244,902	$ 261,353	$ 278,908	$ 297,643	$ 317,637	$ 338,973
Northfield WPCF	$ 4,190.58	$ 4,472	$ 4,772	$ 5,093	$ 5,435	$ 5,800	$ 6,190	$ 6,606	$ 7,049	$ 7,523	$ 8,028
Oak Bluffs WWTP	$ 9,916.67	$ 10,583	$ 11,294	$ 12,052	$ 12,862	$ 13,726	$ 14,648	$ 15,632	$ 16,682	$ 17,802	$ 18,998
Old Deerfield - Historic WWTP	$ 29,678.65	$ 31,672	$ 33,800	$ 36,070	$ 38,493	$ 41,079	$ 43,838	$ 46,783	$ 49,925	$ 53,279	$ 56,858
Orange WWTP	$ 83,205.53	$ 88,795	$ 94,759	$ 101,124	$ 107,917	$ 115,166	$ 122,902	$ 131,158	$ 139,968	$ 149,370	$ 159,404
Orange WWTP	$ 26,456.86	$ 28,234	$ 30,131	$ 32,155	$ 34,314	$ 36,619	$ 39,079	$ 41,704	$ 44,506	$ 47,495	$ 50,686
Otis DPW	$ 55.81	$ 60	$ 64	$ 68	$ 72	$ 77	$ 82	$ 88	$ 94	$ 100	$ 107
Oxford-Rochdale SD WPCP	$ 47,268.34	$ 50,443	$ 53,832	$ 57,448	$ 61,307	$ 65,425	$ 69,820	$ 74,510	$ 79,515	$ 84,856	$ 90,556
Palmer WWTF	$ 3,266,961.88	$ 3,486,412	$ 3,720,603	$ 3,970,525	$ 4,237,235	$ 4,521,861	$ 4,825,605	$ 5,149,753	$ 5,495,675	$ 5,864,833	$ 6,258,789
Pepperell WWTF	$ 929.51	$ 992	$ 1,059	$ 1,130	$ 1,206	$ 1,287	$ 1,373	$ 1,465	$ 1,564	$ 1,669	$ 1,781
Pittsfield WWTP	$ 8,473,747.32	$ 9,042,950	$ 9,650,388	$ 10,298,628	$ 10,990,413	$ 11,728,666	$ 12,516,510	$ 13,357,275	$ 14,254,517	$ 15,212,028	$ 16,233,858
Plymouth WWTF	$ 253,795.64	$ 270,844	$ 289,037	$ 308,452	$ 329,172	$ 351,283	$ 374,880	$ 400,061	$ 426,934	$ 455,613	$ 486,217
Provincetown Public Works	$ 38,488.20	$ 41,074	$ 43,833	$ 46,777	$ 49,919	$ 53,272	$ 56,851	$ 60,669	$ 64,745	$ 69,094	$ 73,735
Rockland WWTP	$ 303,626.50	$ 324,022	$ 345,787	$ 369,015	$ 393,802	$ 420,255	$ 448,484	$ 478,610	$ 510,760	$ 545,069	$ 581,682

Table H-7D: Annual Solids Hauling Cost per year, per plant (6.2% escalation)

POTW name	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Marlborough East WWTP	$ 1,874,174	$ 2,000,067	$ 2,134,417	$ 2,277,791	$ 2,430,796	$ 2,594,078	$ 2,768,329	$ 2,954,285	$ 3,152,731	$ 3,364,508	$ 3,590,511
Marlborough West WWTP	$ 1,066,833	$ 1,138,495	$ 1,214,970	$ 1,296,583	$ 1,383,677	$ 1,476,622	$ 1,575,811	$ 1,681,662	$ 1,794,623	$ 1,915,173	$ 2,043,820
Marshfield WWTF	$ 181,261	$ 193,437	$ 206,430	$ 220,297	$ 235,095	$ 250,886	$ 267,739	$ 285,724	$ 304,917	$ 325,399	$ 347,256
Marshfield WWTF	$ 221,605	$ 236,490	$ 252,376	$ 269,329	$ 287,420	$ 306,727	$ 327,331	$ 349,318	$ 372,783	$ 397,824	$ 424,546
Maynard WWTP	$ 72,059	$ 76,899	$ 82,065	$ 87,577	$ 93,460	$ 99,738	$ 106,438	$ 113,587	$ 121,217	$ 129,360	$ 138,049
Maynard WWTP	$ 5,721,292	$ 6,105,605	$ 6,515,734	$ 6,953,412	$ 7,420,490	$ 7,918,943	$ 8,450,878	$ 9,018,545	$ 9,624,343	$ 10,270,834	$ 10,960,752
MCI Bridgewater	$ 144,321	$ 154,015	$ 164,361	$ 175,402	$ 187,184	$ 199,757	$ 213,175	$ 227,495	$ 242,776	$ 259,084	$ 276,488
MCI Concord	$ 119,632	$ 127,668	$ 136,244	$ 145,396	$ 155,162	$ 165,585	$ 176,708	$ 188,578	$ 201,245	$ 214,763	$ 229,189
MCI Norfolk	$ 99,150	$ 105,810	$ 112,918	$ 120,503	$ 128,597	$ 137,236	$ 146,454	$ 156,292	$ 166,790	$ 177,994	$ 189,950
Medfield WWTP	$ 626,019	$ 668,071	$ 712,947	$ 760,837	$ 811,944	$ 866,485	$ 924,689	$ 986,802	$ 1,053,088	$ 1,123,827	$ 1,199,317
Merrimac WWTP	$ 221,806	$ 236,706	$ 252,606	$ 269,574	$ 287,682	$ 307,006	$ 327,629	$ 349,636	$ 373,122	$ 398,186	$ 424,933
Middleborough WWTP	$ 700,042	$ 747,066	$ 797,248	$ 850,801	$ 907,951	$ 968,941	$ 1,034,027	$ 1,103,485	$ 1,177,609	$ 1,256,712	$ 1,341,128
Milford WWTP	$ 1,562,695	$ 1,667,665	$ 1,779,686	$ 1,899,232	$ 2,026,808	$ 2,162,954	$ 2,308,245	$ 2,463,295	$ 2,628,761	$ 2,805,342	$ 2,993,783
Monroe WWTP	$ 159,668	$ 170,393	$ 181,839	$ 194,054	$ 207,089	$ 220,999	$ 235,845	$ 251,687	$ 268,593	$ 286,635	$ 305,889
Montague WPCF	$ 354,967	$ 378,811	$ 404,257	$ 431,411	$ 460,390	$ 491,316	$ 524,319	$ 559,539	$ 597,124	$ 637,235	$ 680,039
Montague WPCF	$ 8,678	$ 9,261	$ 9,884	$ 10,547	$ 11,256	$ 12,012	$ 12,819	$ 13,680	$ 14,599	$ 15,580	$ 16,626
Montague WPCF	$ 45,338	$ 48,384	$ 51,634	$ 55,102	$ 58,803	$ 62,753	$ 66,969	$ 71,467	$ 76,268	$ 81,391	$ 86,858
MWRA Clinton WWTP	$ 466,854	$ 498,214	$ 531,680	$ 567,394	$ 605,508	$ 646,181	$ 689,587	$ 735,908	$ 785,341	$ 838,094	$ 894,391
MWRA Deer Island WWTP	$ 11,281,717	$ 12,039,538	$ 12,848,264	$ 13,711,314	$ 14,632,337	$ 15,615,228	$ 16,664,142	$ 17,783,514	$ 18,978,077	$ 20,252,881	$ 21,613,318
Nantucket Sewer Dept. - Siasconset	$ 209	$ 223	$ 238	$ 254	$ 271	$ 290	$ 309	$ 330	$ 352	$ 376	$ 401
Nantucket Sewer Dept. - Surfside	$ 10,070	$ 10,746	$ 11,468	$ 12,238	$ 13,060	$ 13,938	$ 14,874	$ 15,873	$ 16,939	$ 18,077	$ 19,291
New Bedford WWTP	$ 10,105,116	$ 10,783,902	$ 11,508,283	$ 12,281,323	$ 13,106,290	$ 13,986,673	$ 14,926,192	$ 15,928,822	$ 16,998,801	$ 18,140,652	$ 19,359,205
Newburyport WWTP	$ 870,262	$ 928,720	$ 991,104	$ 1,057,679	$ 1,128,726	$ 1,204,545	$ 1,285,458	$ 1,371,805	$ 1,463,952	$ 1,562,290	$ 1,667,233
North Attleborough WPCF	$ 9,767	$ 10,423	$ 11,123	$ 11,871	$ 12,668	$ 13,519	$ 14,427	$ 15,396	$ 16,430	$ 17,534	$ 18,712
North Attleborough WPCF	$ 9,767	$ 10,423	$ 11,123	$ 11,871	$ 12,668	$ 13,519	$ 14,427	$ 15,396	$ 16,430	$ 17,534	$ 18,712
North Brookfield WWTP	$ 2,866	$ 3,058	$ 3,264	$ 3,483	$ 3,717	$ 3,966	$ 4,233	$ 4,517	$ 4,821	$ 5,144	$ 5,490
Northampton WWTF	$ 9,255,971	$ 9,877,718	$ 10,541,229	$ 11,249,309	$ 12,004,954	$ 12,811,356	$ 13,671,927	$ 14,590,305	$ 15,570,372	$ 16,616,272	$ 17,732,429
Northbridge WWTF	$ 361,743	$ 386,042	$ 411,973	$ 439,647	$ 469,179	$ 500,695	$ 534,328	$ 570,220	$ 608,523	$ 649,399	$ 693,021
Northfield WPCF	$ 8,568	$ 9,143	$ 9,757	$ 10,413	$ 11,112	$ 11,858	$ 12,655	$ 13,505	$ 14,412	$ 15,380	$ 16,413
Oak Bluffs WWTP	$ 20,274	$ 21,636	$ 23,090	$ 24,641	$ 26,296	$ 28,062	$ 29,947	$ 31,959	$ 34,105	$ 36,396	$ 38,841
Old Deerfield - Historic WWTP	$ 60,677	$ 64,753	$ 69,103	$ 73,744	$ 78,698	$ 83,984	$ 89,626	$ 95,646	$ 102,071	$ 108,927	$ 116,244
Orange WWTP	$ 170,111	$ 181,538	$ 193,732	$ 206,746	$ 220,634	$ 235,454	$ 251,270	$ 268,149	$ 286,161	$ 305,383	$ 325,896
Orange WWTP	$ 54,090	$ 57,724	$ 61,601	$ 65,739	$ 70,155	$ 74,867	$ 79,896	$ 85,263	$ 90,991	$ 97,103	$ 103,625
Otis DPW	$ 114	$ 122	$ 130	$ 139	$ 148	$ 158	$ 169	$ 180	$ 192	$ 205	$ 219
Oxford-Rochdale SD WPCP	$ 96,639	$ 103,130	$ 110,058	$ 117,451	$ 125,340	$ 133,759	$ 142,744	$ 152,333	$ 162,565	$ 173,485	$ 185,139
Palmer WWTF	$ 6,679,207	$ 7,127,866	$ 7,606,663	$ 8,117,621	$ 8,662,902	$ 9,244,811	$ 9,865,808	$ 10,528,519	$ 11,235,746	$ 11,990,479	$ 12,795,909
Pepperell WWTF	$ 1,900	$ 2,028	$ 2,164	$ 2,310	$ 2,465	$ 2,630	$ 2,807	$ 2,996	$ 3,197	$ 3,412	$ 3,641
Pittsfield WWTP	$ 17,324,327	$ 18,488,045	$ 19,729,933	$ 21,055,242	$ 22,469,575	$ 23,978,912	$ 25,589,636	$ 27,308,555	$ 29,142,939	$ 31,100,543	$ 33,189,644
Plymouth WWTF	$ 518,878	$ 553,732	$ 590,928	$ 630,622	$ 672,982	$ 718,188	$ 766,430	$ 817,914	$ 872,855	$ 931,487	$ 994,057
Provincetown Public Works	$ 78,688	$ 83,974	$ 89,614	$ 95,634	$ 102,058	$ 108,913	$ 116,229	$ 124,037	$ 132,369	$ 141,260	$ 150,749
Rockland WWTP	$ 620,755	$ 662,453	$ 706,952	$ 754,439	$ 805,117	$ 859,199	$ 916,913	$ 978,505	$ 1,044,233	$ 1,114,377	$ 1,189,232

Table H-7D: Annual Solids Hauling Cost per year, per plant (6.2% escalation)

POTW name	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Rockport WWTP	$ 276,899.66	$ 295,500	$ 315,349	$ 336,532	$ 359,138	$ 383,262	$ 409,006	$ 436,480	$ 465,800	$ 497,089	$ 530,480
Royalston WWTF	$ 72.55	$ 77	$ 83	$ 88	$ 94	$ 100	$ 107	$ 114	$ 122	$ 130	$ 139
Russell Village WWTF	$ 2,118.64	$ 2,261	$ 2,413	$ 2,575	$ 2,748	$ 2,932	$ 3,129	$ 3,340	$ 3,564	$ 3,803	$ 4,059
Salisbury WWTF	$ 2,418.35	$ 2,581	$ 2,754	$ 2,939	$ 3,137	$ 3,347	$ 3,572	$ 3,812	$ 4,068	$ 4,341	$ 4,633
Scituate WWTF	$ 2,227.53	$ 2,377	$ 2,537	$ 2,707	$ 2,889	$ 3,083	$ 3,290	$ 3,511	$ 3,747	$ 3,999	$ 4,267
Shelburne Falls WWTP	$ 12,985.84	$ 13,858	$ 14,789	$ 15,782	$ 16,843	$ 17,974	$ 19,181	$ 20,470	$ 21,845	$ 23,312	$ 24,878
Somerset WWTF	$ 3,257.95	$ 3,477	$ 3,710	$ 3,960	$ 4,226	$ 4,509	$ 4,812	$ 5,136	$ 5,481	$ 5,849	$ 6,242
South Deerfield	$ 31,696.21	$ 33,825	$ 36,097	$ 38,522	$ 41,110	$ 43,871	$ 46,818	$ 49,963	$ 53,319	$ 56,901	$ 60,723
South Essex Sewerage District	$ 45,841.03	$ 48,920	$ 52,206	$ 55,713	$ 59,456	$ 63,449	$ 67,711	$ 72,260	$ 77,114	$ 82,294	$ 87,821
South Essex Sewerage District	$ 1,009,936.09	$ 1,077,776	$ 1,150,173	$ 1,227,433	$ 1,309,883	$ 1,397,871	$ 1,491,769	$ 1,591,975	$ 1,698,912	$ 1,813,032	$ 1,934,818
South Essex Sewerage District	$ 7,403,309.40	$ 7,900,608	$ 8,431,312	$ 8,997,664	$ 9,602,059	$ 10,247,054	$ 10,935,374	$ 11,669,930	$ 12,453,829	$ 13,290,383	$ 14,183,132
South Essex Sewerage District	$ 767,319.09	$ 818,862	$ 873,867	$ 932,567	$ 995,209	$ 1,062,060	$ 1,133,401	$ 1,209,535	$ 1,290,782	$ 1,377,487	$ 1,470,017
South Essex Sewerage District	$ 342,787.64	$ 365,814	$ 390,386	$ 416,609	$ 444,594	$ 474,459	$ 506,329	$ 540,341	$ 576,637	$ 615,371	$ 656,707
South Hadley WWTP	$ 520,319.58	$ 555,271	$ 592,570	$ 632,374	$ 674,852	$ 720,184	$ 768,560	$ 820,186	$ 875,280	$ 934,075	$ 996,819
Southbridge WWTP	$ 147,730.86	$ 157,654	$ 168,244	$ 179,546	$ 191,606	$ 204,477	$ 218,212	$ 232,870	$ 248,512	$ 265,206	$ 283,020
Spencer WWTP	$ 39,062.39	$ 41,686	$ 44,486	$ 47,475	$ 50,664	$ 54,067	$ 57,699	$ 61,575	$ 65,711	$ 70,125	$ 74,835
Springfield WWTP - Bondi's Island	$ 854,285.73	$ 911,670	$ 972,909	$ 1,038,262	$ 1,108,005	$ 1,182,432	$ 1,261,859	$ 1,346,621	$ 1,437,077	$ 1,533,609	$ 1,636,626
Springfield WWTP - Bondi's Island	$ 254,981.74	$ 272,110	$ 290,388	$ 309,894	$ 330,710	$ 352,925	$ 376,632	$ 401,931	$ 428,930	$ 457,742	$ 488,490
Springfield WWTP - Bondi's Island	$ 2,508,786.61	$ 2,677,308	$ 2,857,150	$ 3,049,071	$ 3,253,885	$ 3,472,457	$ 3,705,710	$ 3,954,632	$ 4,220,275	$ 4,503,761	$ 4,806,290
Springfield WWTP - Bondi's Island	$ 2,501,648.45	$ 2,669,690	$ 2,849,020	$ 3,040,396	$ 3,244,627	$ 3,462,577	$ 3,695,167	$ 3,943,380	$ 4,208,267	$ 4,490,947	$ 4,792,615
Springfield WWTP - Bondi's Island	$ 362,803.29	$ 387,174	$ 413,181	$ 440,936	$ 470,554	$ 502,163	$ 535,894	$ 571,891	$ 610,307	$ 651,303	$ 695,052
Springfield WWTP - Bondi's Island	$ 231,937.05	$ 247,517	$ 264,143	$ 281,886	$ 300,821	$ 321,028	$ 342,593	$ 365,605	$ 390,164	$ 416,372	$ 444,341
Springfield WWTP - Bondi's Island	$ 911,974.13	$ 973,234	$ 1,038,608	$ 1,108,374	$ 1,182,826	$ 1,262,280	$ 1,347,070	$ 1,437,556	$ 1,534,121	$ 1,637,171	$ 1,747,144
Stockbridge WWTP	$ 2,644.41	$ 2,822	$ 3,012	$ 3,214	$ 3,430	$ 3,660	$ 3,906	$ 4,168	$ 4,448	$ 4,747	$ 5,066
Sturbridge WPCF	$ 37,721.48	$ 40,255	$ 42,959	$ 45,845	$ 48,925	$ 52,211	$ 55,718	$ 59,461	$ 63,455	$ 67,717	$ 72,266
Sunderland WWTP	$ 1,131.10	$ 1,207	$ 1,288	$ 1,375	$ 1,467	$ 1,566	$ 1,671	$ 1,783	$ 1,903	$ 2,031	$ 2,167
Sunderland WWTP	$ 54,415.02	$ 58,070	$ 61,971	$ 66,134	$ 70,576	$ 75,317	$ 80,376	$ 85,775	$ 91,537	$ 97,686	$ 104,247
Taunton WWTP	$ 5,763,509.72	$ 6,150,659	$ 6,563,814	$ 7,004,722	$ 7,475,247	$ 7,977,378	$ 8,513,238	$ 9,085,093	$ 9,695,362	$ 10,346,623	$ 11,041,632
Templeton WWTP	$ 187,270.87	$ 199,850	$ 213,275	$ 227,601	$ 242,889	$ 259,205	$ 276,616	$ 295,197	$ 315,027	$ 336,188	$ 358,770
Tisbury Public Works	$ 258.58	$ 276	$ 294	$ 314	$ 335	$ 358	$ 382	$ 408	$ 435	$ 464	$ 495
Upper Blackstone WPAD (Worcester area)	$ 13,362,597.39	$ 14,260,196	$ 15,218,089	$ 16,240,326	$ 17,331,230	$ 18,495,412	$ 19,737,794	$ 21,063,631	$ 22,478,528	$ 23,988,467	$ 25,599,832
Upton WWTP	$ 6,637.47	$ 7,083	$ 7,559	$ 8,067	$ 8,609	$ 9,187	$ 9,804	$ 10,463	$ 11,166	$ 11,916	$ 12,716
Uxbridge WWTF	$ 4,142.85	$ 4,421	$ 4,718	$ 5,035	$ 5,373	$ 5,734	$ 6,119	$ 6,530	$ 6,969	$ 7,437	$ 7,937
Ware WWTP	$ 15,170.81	$ 16,190	$ 17,277	$ 18,438	$ 19,676	$ 20,998	$ 22,409	$ 23,914	$ 25,520	$ 27,235	$ 29,064
Wareham WPCF	$ 2,976.43	$ 3,176	$ 3,390	$ 3,617	$ 3,860	$ 4,120	$ 4,396	$ 4,692	$ 5,007	$ 5,343	$ 5,702
Warren WWTP	$ 35,026.67	$ 37,380	$ 39,890	$ 42,570	$ 45,429	$ 48,481	$ 51,738	$ 55,213	$ 58,922	$ 62,880	$ 67,103
Wayland WWTP	$ 167.42	$ 179	$ 191	$ 203	$ 217	$ 232	$ 247	$ 264	$ 282	$ 301	$ 321
Webster WWTF	$ 3,594.25	$ 3,836	$ 4,093	$ 4,368	$ 4,662	$ 4,975	$ 5,309	$ 5,666	$ 6,046	$ 6,452	$ 6,886
West Stockbridge	$ 15,724.68	$ 16,781	$ 17,908	$ 19,111	$ 20,395	$ 21,765	$ 23,227	$ 24,787	$ 26,452	$ 28,229	$ 30,125
Westborough WWTF	$ 5,349.58	$ 5,709	$ 6,092	$ 6,502	$ 6,938	$ 7,404	$ 7,902	$ 8,433	$ 8,999	$ 9,604	$ 10,249
Westborough WWTF	$ 1,973,559.61	$ 2,106,129	$ 2,247,602	$ 2,398,580	$ 2,559,698	$ 2,731,639	$ 2,915,130	$ 3,110,947	$ 3,319,917	$ 3,542,924	$ 3,780,911

Table H-7D: Annual Solids Hauling Cost per year, per plant (6.2% escalation)

POTW name	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Rockport WWTP	$ 566,113	$ 604,140	$ 644,722	$ 688,030	$ 734,246	$ 783,567	$ 836,202	$ 892,371	$ 952,314	$ 1,016,284	$ 1,084,550
Royalston WWTF	$ 148	$ 158	$ 169	$ 180	$ 192	$ 205	$ 219	$ 234	$ 250	$ 266	$ 284
Russell Village WWTF	$ 4,332	$ 4,622	$ 4,933	$ 5,264	$ 5,618	$ 5,995	$ 6,398	$ 6,828	$ 7,286	$ 7,776	$ 8,298
Salisbury WWTF	$ 4,944	$ 5,276	$ 5,631	$ 6,009	$ 6,413	$ 6,843	$ 7,303	$ 7,794	$ 8,317	$ 8,876	$ 9,472
Scituate WWTF	$ 4,554	$ 4,860	$ 5,186	$ 5,535	$ 5,907	$ 6,303	$ 6,727	$ 7,179	$ 7,661	$ 8,176	$ 8,725
Shelburne Falls WWTP	$ 26,549	$ 28,333	$ 30,236	$ 32,267	$ 34,434	$ 36,747	$ 39,216	$ 41,850	$ 44,661	$ 47,661	$ 50,862
Somerset WWTF	$ 6,661	$ 7,108	$ 7,586	$ 8,095	$ 8,639	$ 9,219	$ 9,839	$ 10,499	$ 11,205	$ 11,957	$ 12,761
South Deerfield	$ 64,802	$ 69,155	$ 73,800	$ 78,758	$ 84,048	$ 89,694	$ 95,719	$ 102,148	$ 109,010	$ 116,332	$ 124,146
South Essex Sewerage District	$ 93,721	$ 100,016	$ 106,734	$ 113,904	$ 121,555	$ 129,720	$ 138,434	$ 147,733	$ 157,657	$ 168,247	$ 179,548
South Essex Sewerage District	$ 2,064,785	$ 2,203,481	$ 2,351,495	$ 2,509,450	$ 2,678,016	$ 2,857,905	$ 3,049,878	$ 3,254,746	$ 3,473,375	$ 3,706,691	$ 3,955,678
South Essex Sewerage District	$ 15,135,848	$ 16,152,561	$ 17,237,568	$ 18,395,459	$ 19,631,128	$ 20,949,799	$ 22,357,050	$ 23,858,829	$ 25,461,486	$ 27,171,797	$ 28,996,994
South Essex Sewerage District	$ 1,568,761	$ 1,674,139	$ 1,786,595	$ 1,906,605	$ 2,034,676	$ 2,171,351	$ 2,317,206	$ 2,472,858	$ 2,638,966	$ 2,816,232	$ 3,005,406
South Essex Sewerage District	$ 700,819	$ 747,895	$ 798,133	$ 851,746	$ 908,959	$ 970,017	$ 1,035,175	$ 1,104,710	$ 1,178,916	$ 1,258,107	$ 1,342,617
South Hadley WWTP	$ 1,063,778	$ 1,135,235	$ 1,211,491	$ 1,292,870	$ 1,379,715	$ 1,472,394	$ 1,571,299	$ 1,676,847	$ 1,789,485	$ 1,909,689	$ 2,037,968
Southbridge WWTP	$ 302,031	$ 322,320	$ 343,971	$ 367,076	$ 391,733	$ 418,047	$ 446,128	$ 476,096	$ 508,076	$ 542,205	$ 578,626
Spencer WWTP	$ 79,862	$ 85,226	$ 90,951	$ 97,061	$ 103,581	$ 110,538	$ 117,963	$ 125,887	$ 134,344	$ 143,368	$ 152,998
Springfield WWTP - Bondi's Island	$ 1,746,562	$ 1,863,883	$ 1,989,085	$ 2,122,696	$ 2,265,283	$ 2,417,448	$ 2,579,834	$ 2,753,128	$ 2,938,062	$ 3,135,419	$ 3,346,033
Springfield WWTP - Bondi's Island	$ 521,303	$ 556,320	$ 593,689	$ 633,569	$ 676,127	$ 721,544	$ 770,012	$ 821,736	$ 876,934	$ 935,840	$ 998,703
Springfield WWTP - Bondi's Island	$ 5,129,140	$ 5,473,677	$ 5,841,358	$ 6,233,737	$ 6,652,472	$ 7,099,335	$ 7,576,215	$ 8,085,129	$ 8,628,227	$ 9,207,807	$ 9,826,318
Springfield WWTP - Bondi's Island	$ 5,114,547	$ 5,458,103	$ 5,824,738	$ 6,216,000	$ 6,633,544	$ 7,079,136	$ 7,554,659	$ 8,062,124	$ 8,603,677	$ 9,181,608	$ 9,798,359
Springfield WWTP - Bondi's Island	$ 741,741	$ 791,565	$ 844,737	$ 901,480	$ 962,034	$ 1,026,657	$ 1,095,620	$ 1,169,215	$ 1,247,754	$ 1,331,569	$ 1,421,014
Springfield WWTP - Bondi's Island	$ 474,188	$ 506,041	$ 540,033	$ 576,308	$ 615,020	$ 656,333	$ 700,420	$ 747,469	$ 797,679	$ 851,261	$ 908,442
Springfield WWTP - Bondi's Island	$ 1,864,504	$ 1,989,748	$ 2,123,404	$ 2,266,038	$ 2,418,254	$ 2,580,694	$ 2,754,046	$ 2,939,042	$ 3,136,464	$ 3,347,149	$ 3,571,985
Stockbridge WWTP	$ 5,406	$ 5,770	$ 6,157	$ 6,571	$ 7,012	$ 7,483	$ 7,986	$ 8,522	$ 9,095	$ 9,706	$ 10,358
Sturbridge WPCF	$ 77,120	$ 82,301	$ 87,829	$ 93,729	$ 100,025	$ 106,744	$ 113,914	$ 121,566	$ 129,732	$ 138,446	$ 147,746
Sunderland WWTP	$ 2,312	$ 2,468	$ 2,634	$ 2,811	$ 2,999	$ 3,201	$ 3,416	$ 3,645	$ 3,890	$ 4,151	$ 4,430
Sunderland WWTP	$ 111,250	$ 118,723	$ 126,698	$ 135,208	$ 144,291	$ 153,983	$ 164,326	$ 175,365	$ 187,144	$ 199,715	$ 213,131
Taunton WWTP	$ 11,783,326	$ 12,574,841	$ 13,419,525	$ 14,320,948	$ 15,282,921	$ 16,309,513	$ 17,405,064	$ 18,574,206	$ 19,821,881	$ 21,153,366	$ 22,574,291
Templeton WWTP	$ 382,870	$ 408,588	$ 436,034	$ 465,323	$ 496,580	$ 529,937	$ 565,534	$ 603,522	$ 644,063	$ 687,326	$ 733,495
Tisbury Public Works	$ 529	$ 564	$ 602	$ 643	$ 686	$ 732	$ 781	$ 833	$ 889	$ 949	$ 1,013
Upper Blackstone WPAD (Worcester area)	$ 27,319,437	$ 29,154,551	$ 31,112,935	$ 33,202,869	$ 35,433,188	$ 37,813,324	$ 40,353,339	$ 43,063,974	$ 45,956,688	$ 49,043,713	$ 52,338,102
Upton WWTP	$ 13,570	$ 14,482	$ 15,454	$ 16,493	$ 17,600	$ 18,783	$ 20,044	$ 21,391	$ 22,828	$ 24,361	$ 25,997
Uxbridge WWTF	$ 8,470	$ 9,039	$ 9,646	$ 10,294	$ 10,985	$ 11,723	$ 12,511	$ 13,351	$ 14,248	$ 15,205	$ 16,227
Ware WWTP	$ 31,016	$ 33,100	$ 35,323	$ 37,696	$ 40,228	$ 42,930	$ 45,814	$ 48,891	$ 52,176	$ 55,680	$ 59,420
Wareham WPCF	$ 6,085	$ 6,494	$ 6,930	$ 7,396	$ 7,893	$ 8,423	$ 8,988	$ 9,592	$ 10,237	$ 10,924	$ 11,658
Warren WWTP	$ 71,611	$ 76,421	$ 81,555	$ 87,033	$ 92,879	$ 99,118	$ 105,776	$ 112,881	$ 120,464	$ 128,556	$ 137,191
Wayland WWTP	$ 342	$ 365	$ 390	$ 416	$ 444	$ 474	$ 506	$ 540	$ 576	$ 614	$ 656
Webster WWTF	$ 7,348	$ 7,842	$ 8,369	$ 8,931	$ 9,531	$ 10,171	$ 10,854	$ 11,583	$ 12,361	$ 13,192	$ 14,078
West Stockbridge	$ 32,149	$ 34,308	$ 36,613	$ 39,072	$ 41,697	$ 44,498	$ 47,487	$ 50,676	$ 54,080	$ 57,713	$ 61,590
Westborough WWTF	$ 10,937	$ 11,672	$ 12,456	$ 13,292	$ 14,185	$ 15,138	$ 16,155	$ 17,240	$ 18,398	$ 19,634	$ 20,953
Westborough WWTF	$ 4,034,884	$ 4,305,918	$ 4,595,157	$ 4,903,825	$ 5,233,227	$ 5,584,756	$ 5,959,898	$ 6,360,239	$ 6,787,473	$ 7,243,404	$ 7,729,962

Table H-7D: Annual Solids Hauling Cost per year, per plant (6.2% escalation)

POTW name	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Westfield WPCP	$ 5,260,566.42	$ 5,613,932	$ 5,991,034	$ 6,393,466	$ 6,822,931	$ 7,281,245	$ 7,770,344	$ 8,292,297	$ 8,849,312	$ 9,443,742	$ 10,078,102
Winchendon WPCF	$ 76,633.49	$ 81,781	$ 87,275	$ 93,137	$ 99,393	$ 106,070	$ 113,195	$ 120,798	$ 128,913	$ 137,572	$ 146,813
Sum	$ 117,521,106.50	$ 125,380,109	$ 133,764,844	$ 142,710,491	$ 152,254,585	$ 162,437,174	$ 173,300,986	$ 184,891,609	$ 197,257,682	$ 210,451,103	$ 224,527,240
Discounted at 2.2%	$ 117,521,106.50	$ 122,681,124	$ 128,067,873	$ 133,691,321	$ 139,561,876	$ 145,690,404	$ 152,088,249	$ 158,767,253	$ 165,739,781	$ 173,018,739	$ 180,617,605
		GRAND TOTAL	**$ 4,095,145,000**								

Table H-7D: Annual Solids Hauling Cost per year, per plant (6.2% escalation)

POTW name	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Westfield WPCP	$ 10,755,073	$ 11,477,518	$ 12,248,492	$ 13,071,253	$ 13,949,282	$ 14,886,290	$ 15,886,239	$ 16,953,358	$ 18,092,157	$ 19,307,452	$ 20,604,382
Winchendon WPCF	$ 156,675	$ 167,199	$ 178,430	$ 190,416	$ 203,207	$ 216,857	$ 231,423	$ 246,969	$ 263,558	$ 281,262	$ 300,155
Sum	$ 239,545,170	$ 255,567,926	$ 272,662,757	$ 290,901,418	$ 310,360,466	$ 331,121,583	$ 353,271,921	$ 376,904,465	$ 402,118,428	$ 429,019,663	$ 457,721,112
Discounted at 2.2%	$ 188,550,446	$ 196,831,951	$ 205,477,454	$ 214,502,964	$ 223,925,193	$ 233,761,592	$ 244,030,377	$ 254,750,566	$ 265,942,015	$ 277,625,454	$ 289,822,523

Calculation Approach

Unit prices were calculated for each plant and each load, for each year from 2024 to 2044.

2023 was used as the baseline. Unit prices were increased by 3.1% (ie, multiplied by 103.1%) each year to reflect escalation under current conditions.

For example, Adams paid $170/wt in 2023. In 2024, this increases to 170 * 1.031 = $175.27/wt. Subsequent years are calculated according to the same logic.

Table H-7E: Yearly Unit Prices by Plant and Sludge Load (3.1% escalation)

POTW name	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Acton Wastewater Collection	$ 0.11	$ 0.11	$ 0.11	$ 0.12	$ 0.12	$ 0.12	$ 0.13	$ 0.13	$ 0.14	$ 0.14	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.16
Adams WWTP	$ 170.00	$ 175.27	$ 180.70	$ 186.31	$ 192.08	$ 198.04	$ 204.17	$ 210.50	$ 217.03	$ 223.76	$ 230.69	$ 237.85	$ 245.22	$ 252.82	$ 260.66
Amesbury WWTP	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
Amherst WWTP	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.24	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29
Ashfield	$ 0.24	$ 0.25	$ 0.26	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.30	$ 0.31	$ 0.32	$ 0.33	$ 0.34	$ 0.35	$ 0.36	$ 0.37
Athol WWTP	$ 0.26	$ 0.27	$ 0.28	$ 0.28	$ 0.29	$ 0.30	$ 0.31	$ 0.32	$ 0.33	$ 0.34	$ 0.35	$ 0.36	$ 0.37	$ 0.39	$ 0.40
Athol WWTP	$ 0.26	$ 0.27	$ 0.28	$ 0.28	$ 0.29	$ 0.30	$ 0.31	$ 0.32	$ 0.33	$ 0.34	$ 0.35	$ 0.36	$ 0.37	$ 0.39	$ 0.40
Attleboro WWTP	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
Ayer WWTP	$ 0.14	$ 0.14	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.17	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.20	$ 0.20	$ 0.21
Barnstable WWTP WPCD - DPW	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.21	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25	$ 0.25	$ 0.26	$ 0.27	$ 0.28
Barnstable WWTP WPCD - DPW	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.21	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25	$ 0.25	$ 0.26	$ 0.27	$ 0.28
Barre WWTP	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Belchertown WWTP	$ 0.17	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25	$ 0.25
Billerica WWTP	$ 146.70	$ 151.25	$ 155.94	$ 160.77	$ 165.75	$ 170.89	$ 176.19	$ 181.65	$ 187.28	$ 193.09	$ 199.08	$ 205.25	$ 211.61	$ 218.17	$ 224.93
Bridgewater WWTP	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
Brockton WWTP	$ 148.52	$ 153.12	$ 157.87	$ 162.76	$ 167.81	$ 173.01	$ 178.38	$ 183.91	$ 189.61	$ 195.48	$ 201.54	$ 207.79	$ 214.23	$ 220.88	$ 227.72
Charlemont Sewer District	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Charles River PCD	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.17	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.21	$ 0.21	$ 0.22	$ 0.23
Charles River PCD	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.17	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.21	$ 0.21	$ 0.22	$ 0.23
Charlton WWTP	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Chatham WPCF	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
Chicopee WWTP	$ 140.17	$ 144.52	$ 149.00	$ 153.61	$ 158.38	$ 163.29	$ 168.35	$ 173.57	$ 178.95	$ 184.49	$ 190.21	$ 196.11	$ 202.19	$ 208.46	$ 214.92
Chicopee WWTP	$ 140.17	$ 144.52	$ 149.00	$ 153.61	$ 158.38	$ 163.29	$ 168.35	$ 173.57	$ 178.95	$ 184.49	$ 190.21	$ 196.11	$ 202.19	$ 208.46	$ 214.92
Chicopee WWTP	$ 140.17	$ 144.52	$ 149.00	$ 153.61	$ 158.38	$ 163.29	$ 168.35	$ 173.57	$ 178.95	$ 184.49	$ 190.21	$ 196.11	$ 202.19	$ 208.46	$ 214.92
Cohasset WWTF	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Concord WWTF	$ 0.06	$ 0.06	$ 0.06	$ 0.07	$ 0.07	$ 0.07	$ 0.07	$ 0.07	$ 0.08	$ 0.08	$ 0.08	$ 0.08	$ 0.09	$ 0.09	$ 0.09
Concord WWTF	$ 0.06	$ 0.06	$ 0.06	$ 0.07	$ 0.07	$ 0.07	$ 0.07	$ 0.07	$ 0.08	$ 0.08	$ 0.08	$ 0.08	$ 0.09	$ 0.09	$ 0.09
Dartmouth WPCF	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
Devens WWTP	$ 170.00	$ 175.27	$ 180.70	$ 186.31	$ 192.08	$ 198.04	$ 204.17	$ 210.50	$ 217.03	$ 223.76	$ 230.69	$ 237.85	$ 245.22	$ 252.82	$ 260.66
Douglas WWTP	$ 0.10	$ 0.10	$ 0.11	$ 0.11	$ 0.11	$ 0.12	$ 0.12	$ 0.13	$ 0.13	$ 0.13	$ 0.14	$ 0.14	$ 0.15	$ 0.15	$ 0.16
Easthampton WWTP	$ 118.17	$ 121.83	$ 125.61	$ 129.51	$ 133.52	$ 137.66	$ 141.93	$ 146.33	$ 150.86	$ 155.54	$ 160.36	$ 165.33	$ 170.46	$ 175.74	$ 181.19
Edgartown WWTP	$ 119.00	$ 122.69	$ 126.49	$ 130.41	$ 134.46	$ 138.62	$ 142.92	$ 147.35	$ 151.92	$ 156.63	$ 161.49	$ 166.49	$ 171.65	$ 176.97	$ 182.46
Erving Center WWTP (#2)	$ 200.00	$ 206.20	$ 212.59	$ 219.18	$ 225.98	$ 232.98	$ 240.20	$ 247.65	$ 255.33	$ 263.24	$ 271.40	$ 279.82	$ 288.49	$ 297.44	$ 306.66
Erving Center WWTP (#2)	$ 200.00	$ 206.20	$ 212.59	$ 219.18	$ 225.98	$ 232.98	$ 240.20	$ 247.65	$ 255.33	$ 263.24	$ 271.40	$ 279.82	$ 288.49	$ 297.44	$ 306.66
Erving POTW #1	$ 0.20	$ 0.21	$ 0.21	$ 0.22	$ 0.23	$ 0.23	$ 0.24	$ 0.25	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.30	$ 0.31
Erving POTW #3	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Fairhaven WPCF	$ 0.09	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.10	$ 0.11	$ 0.11	$ 0.11	$ 0.12	$ 0.12	$ 0.12	$ 0.13	$ 0.13	$ 0.14
Fall River Regional WWF	$ 0.05	$ 0.06	$ 0.06	$ 0.06	$ 0.06	$ 0.06	$ 0.07	$ 0.07	$ 0.07	$ 0.07	$ 0.07	$ 0.08	$ 0.08	$ 0.08	$ 0.08

Table H-7E: Yearly Unit Prices by Plant and Sludge Load (3.1% escalation)

POTW name	2038	2039	2040	2041	2042	2043	2044
Acton Wastewater Collection	$ 0.17	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.20	$ 0.20
Adams WWTP	$ 268.74	$ 277.07	$ 285.66	$ 294.51	$ 303.64	$ 313.06	$ 322.76
Amesbury WWTP	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
Amherst WWTP	$ 0.30	$ 0.31	$ 0.32	$ 0.33	$ 0.34	$ 0.35	$ 0.36
Ashfield	$ 0.38	$ 0.39	$ 0.41	$ 0.42	$ 0.43	$ 0.45	$ 0.46
Athol WWTP	$ 0.41	$ 0.42	$ 0.44	$ 0.45	$ 0.46	$ 0.48	$ 0.49
Athol WWTP	$ 0.41	$ 0.42	$ 0.44	$ 0.45	$ 0.46	$ 0.48	$ 0.49
Attleboro WWTP	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
Ayer WWTP	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.24	$ 0.25	$ 0.26
Barnstable WWTP WPCD - DPW	$ 0.29	$ 0.30	$ 0.31	$ 0.31	$ 0.32	$ 0.33	$ 0.34
Barnstable WWTP WPCD - DPW	$ 0.29	$ 0.30	$ 0.31	$ 0.31	$ 0.32	$ 0.33	$ 0.34
Barre WWTP	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Belchertown WWTP	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.30	$ 0.30	$ 0.31
Billerica WWTP	$ 231.90	$ 239.09	$ 246.51	$ 254.15	$ 262.03	$ 270.15	$ 278.52
Bridgewater WWTP	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
Brockton WWTP	$ 234.78	$ 242.06	$ 249.56	$ 257.30	$ 265.28	$ 273.50	$ 281.98
Charlemont Sewer District	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Charles River PCD	$ 0.23	$ 0.24	$ 0.25	$ 0.25	$ 0.26	$ 0.27	$ 0.28
Charles River PCD	$ 0.23	$ 0.24	$ 0.25	$ 0.25	$ 0.26	$ 0.27	$ 0.28
Charlton WWTP	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Chatham WPCF	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
Chicopee WWTP	$ 221.58	$ 228.45	$ 235.53	$ 242.83	$ 250.36	$ 258.12	$ 266.13
Chicopee WWTP	$ 221.58	$ 228.45	$ 235.53	$ 242.83	$ 250.36	$ 258.12	$ 266.13
Chicopee WWTP	$ 221.58	$ 228.45	$ 235.53	$ 242.83	$ 250.36	$ 258.12	$ 266.13
Cohasset WWTF	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Concord WWTF	$ 0.10	$ 0.10	$ 0.10	$ 0.10	$ 0.11	$ 0.11	$ 0.11
Concord WWTF	$ 0.10	$ 0.10	$ 0.10	$ 0.10	$ 0.11	$ 0.11	$ 0.11
Dartmouth WPCF	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
Devens WWTP	$ 268.74	$ 277.07	$ 285.66	$ 294.51	$ 303.64	$ 313.06	$ 322.76
Douglas WWTP	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19
Easthampton WWTP	$ 186.81	$ 192.60	$ 198.57	$ 204.72	$ 211.07	$ 217.61	$ 224.36
Edgartown WWTP	$ 188.12	$ 193.95	$ 199.96	$ 206.16	$ 212.55	$ 219.14	$ 225.93
Erving Center WWTP (#2)	$ 316.16	$ 325.96	$ 336.07	$ 346.49	$ 357.23	$ 368.30	$ 379.72
Erving Center WWTP (#2)	$ 316.16	$ 325.96	$ 336.07	$ 346.49	$ 357.23	$ 368.30	$ 379.72
Erving POTW #1	$ 0.31	$ 0.32	$ 0.33	$ 0.35	$ 0.36	$ 0.37	$ 0.38
Erving POTW #3	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Fairhaven WPCF	$ 0.14	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.17
Fall River Regional WWF	$ 0.09	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.10	$ 0.10

Table H-7E: Yearly Unit Prices by Plant and Sludge Load (3.1% escalation)

POTW name	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Falmouth WWTP	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Fitchburg East WWTP	$ 37.59	$ 38.76	$ 39.96	$ 41.20	$ 42.47	$ 43.79	$ 45.15	$ 46.55	$ 47.99	$ 49.48	$ 51.01	$ 52.59	$ 54.22	$ 55.90	$ 57.64
Gardner WPCF	$ 2.72	$ 2.81	$ 2.90	$ 2.99	$ 3.08	$ 3.17	$ 3.27	$ 3.37	$ 3.48	$ 3.59	$ 3.70	$ 3.81	$ 3.93	$ 4.05	$ 4.18
Gloucester WPCF	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
Grafton WWTP	$ 0.11	$ 0.11	$ 0.12	$ 0.12	$ 0.12	$ 0.13	$ 0.13	$ 0.13	$ 0.14	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.17
Great Barrington WWTP	$ 151.00	$ 155.68	$ 160.51	$ 165.48	$ 170.61	$ 175.90	$ 181.35	$ 186.98	$ 192.77	$ 198.75	$ 204.91	$ 211.26	$ 217.81	$ 224.56	$ 231.53
Greater Lawrence Sanitary District	$ 366.90	$ 378.27	$ 390.00	$ 402.09	$ 414.56	$ 427.41	$ 440.66	$ 454.32	$ 468.40	$ 482.92	$ 497.89	$ 513.33	$ 529.24	$ 545.65	$ 562.56
Greenfield WPCF	$ 0.23	$ 0.24	$ 0.25	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.30	$ 0.31	$ 0.32	$ 0.33	$ 0.34	$ 0.35	$ 0.36
Hadley WWTP	$ 0.23	$ 0.24	$ 0.25	$ 0.26	$ 0.27	$ 0.27	$ 0.28	$ 0.29	$ 0.30	$ 0.31	$ 0.32	$ 0.33	$ 0.34	$ 0.35	$ 0.36
Hardwick-Gilbertville WPCF	$ 0.11	$ 0.11	$ 0.11	$ 0.12	$ 0.12	$ 0.13	$ 0.13	$ 0.13	$ 0.14	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.17
Hardwick-Wheelwright WPCF	$ 0.08	$ 0.08	$ 0.09	$ 0.09	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.10	$ 0.11	$ 0.11	$ 0.11	$ 0.12	$ 0.12	$ 0.12
Hatfield WWTP	$ 0.24	$ 0.25	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.30	$ 0.30	$ 0.31	$ 0.32	$ 0.33	$ 0.34	$ 0.35	$ 0.37
Haverhill WWTP	$ 175.00	$ 180.43	$ 186.02	$ 191.78	$ 197.73	$ 203.86	$ 210.18	$ 216.69	$ 223.41	$ 230.34	$ 237.48	$ 244.84	$ 252.43	$ 260.26	$ 268.32
Holyoke WWTP	$ 140.00	$ 144.34	$ 148.81	$ 153.43	$ 158.18	$ 163.09	$ 168.14	$ 173.36	$ 178.73	$ 184.27	$ 189.98	$ 195.87	$ 201.94	$ 208.20	$ 214.66
Holyoke WWTP	$ 140.00	$ 144.34	$ 148.81	$ 153.43	$ 158.18	$ 163.09	$ 168.14	$ 173.36	$ 178.73	$ 184.27	$ 189.98	$ 195.87	$ 201.94	$ 208.20	$ 214.66
Holyoke WWTP	$ 140.00	$ 144.34	$ 148.81	$ 153.43	$ 158.18	$ 163.09	$ 168.14	$ 173.36	$ 178.73	$ 184.27	$ 189.98	$ 195.87	$ 201.94	$ 208.20	$ 214.66
Holyoke WWTP	$ 140.00	$ 144.34	$ 148.81	$ 153.43	$ 158.18	$ 163.09	$ 168.14	$ 173.36	$ 178.73	$ 184.27	$ 189.98	$ 195.87	$ 201.94	$ 208.20	$ 214.66
Hoosac WQD	$ 195.15	$ 201.20	$ 207.43	$ 213.86	$ 220.49	$ 227.33	$ 234.37	$ 241.64	$ 249.13	$ 256.85	$ 264.82	$ 273.03	$ 281.49	$ 290.22	$ 299.21
Hopedale WWTF	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.10	$ 0.10	$ 0.11	$ 0.11	$ 0.11	$ 0.12	$ 0.12	$ 0.13	$ 0.13	$ 0.13	$ 0.14
Hudson WWTF	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
Hull WWTF	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Huntington WWTP	$ 0.34	$ 0.35	$ 0.36	$ 0.37	$ 0.38	$ 0.40	$ 0.41	$ 0.42	$ 0.43	$ 0.45	$ 0.46	$ 0.48	$ 0.49	$ 0.51	$ 0.52
Ipswich WWTP	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
Kingston Sewer Commission	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Lee WWTP	$ 0.19	$ 0.20	$ 0.21	$ 0.21	$ 0.22	$ 0.23	$ 0.23	$ 0.24	$ 0.25	$ 0.26	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.30
Leicester WWTP	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Lenox Center WWTP	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Leominster WPCF	$ 0.06	$ 0.06	$ 0.06	$ 0.07	$ 0.07	$ 0.07	$ 0.07	$ 0.07	$ 0.08	$ 0.08	$ 0.08	$ 0.08	$ 0.09	$ 0.09	$ 0.09
Lowell Regional WW Utility	$ 190.37	$ 196.27	$ 202.36	$ 208.63	$ 215.10	$ 221.76	$ 228.64	$ 235.73	$ 243.03	$ 250.57	$ 258.34	$ 266.34	$ 274.60	$ 283.11	$ 291.89
Lowell Regional WW Utility	$ 190.37	$ 196.27	$ 202.36	$ 208.63	$ 215.10	$ 221.76	$ 228.64	$ 235.73	$ 243.03	$ 250.57	$ 258.34	$ 266.34	$ 274.60	$ 283.11	$ 291.89
Lowell Regional WW Utility	$ 190.37	$ 196.27	$ 202.36	$ 208.63	$ 215.10	$ 221.76	$ 228.64	$ 235.73	$ 243.03	$ 250.57	$ 258.34	$ 266.34	$ 274.60	$ 283.11	$ 291.89
Lowell Regional WW Utility	$ 190.37	$ 196.27	$ 202.36	$ 208.63	$ 215.10	$ 221.76	$ 228.64	$ 235.73	$ 243.03	$ 250.57	$ 258.34	$ 266.34	$ 274.60	$ 283.11	$ 291.89
Lowell Regional WW Utility	$ 190.37	$ 196.27	$ 202.36	$ 208.63	$ 215.10	$ 221.76	$ 228.64	$ 235.73	$ 243.03	$ 250.57	$ 258.34	$ 266.34	$ 274.60	$ 283.11	$ 291.89
Lynn Regional WF	$ 225.00	$ 231.98	$ 239.17	$ 246.58	$ 254.22	$ 262.11	$ 270.23	$ 278.61	$ 287.24	$ 296.15	$ 305.33	$ 314.80	$ 324.55	$ 334.61	$ 344.99
Lynn Regional WF	$ 225.00	$ 231.98	$ 239.17	$ 246.58	$ 254.22	$ 262.11	$ 270.23	$ 278.61	$ 287.24	$ 296.15	$ 305.33	$ 314.80	$ 324.55	$ 334.61	$ 344.99
Manchester By the Sea WWTP	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Manchester By the Sea WWTP	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Mansfield WWTP (MFN)	$ 0.11	$ 0.12	$ 0.12	$ 0.12	$ 0.13	$ 0.13	$ 0.14	$ 0.14	$ 0.15	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.17	$ 0.17
Mansfield WWTP (MFN)	$ 0.11	$ 0.12	$ 0.12	$ 0.12	$ 0.13	$ 0.13	$ 0.14	$ 0.14	$ 0.15	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.17	$ 0.17
Marion WWTP - Marion DPW	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
Marlborough East WWTP	$ 163.75	$ 168.83	$ 174.06	$ 179.46	$ 185.02	$ 190.75	$ 196.67	$ 202.76	$ 209.05	$ 215.53	$ 222.21	$ 229.10	$ 236.20	$ 243.53	$ 251.07
Marlborough West WWTP	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19

Table H-7E: Yearly Unit Prices by Plant and Sludge Load (3.1% escalation)

POTW name	2038	2039	2040	2041	2042	2043	2044
Falmouth WWTP	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Fitchburg East WWTP	$ 59.42	$ 61.26	$ 63.16	$ 65.12	$ 67.14	$ 69.22	$ 71.37
Gardner WPCF	$ 4.31	$ 4.44	$ 4.58	$ 4.72	$ 4.87	$ 5.02	$ 5.17
Gloucester WPCF	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
Grafton WWTP	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.21
Great Barrington WWTP	$ 238.70	$ 246.10	$ 253.73	$ 261.60	$ 269.71	$ 278.07	$ 286.69
Greater Lawrence Sanitary District	$ 580.00	$ 597.98	$ 616.52	$ 635.63	$ 655.33	$ 675.65	$ 696.59
Greenfield WPCF	$ 0.37	$ 0.38	$ 0.39	$ 0.40	$ 0.42	$ 0.43	$ 0.44
Hadley WWTP	$ 0.37	$ 0.38	$ 0.39	$ 0.41	$ 0.42	$ 0.43	$ 0.45
Hardwick-Gilbertville WPCF	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.21
Hardwick-Wheelwright WPCF	$ 0.13	$ 0.13	$ 0.14	$ 0.14	$ 0.14	$ 0.15	$ 0.15
Hatfield WWTP	$ 0.38	$ 0.39	$ 0.40	$ 0.41	$ 0.43	$ 0.44	$ 0.45
Haverhill WWTP	$ 276.64	$ 285.22	$ 294.06	$ 303.18	$ 312.57	$ 322.26	$ 332.25
Holyoke WWTP	$ 221.31	$ 228.17	$ 235.25	$ 242.54	$ 250.06	$ 257.81	$ 265.80
Holyoke WWTP	$ 221.31	$ 228.17	$ 235.25	$ 242.54	$ 250.06	$ 257.81	$ 265.80
Holyoke WWTP	$ 221.31	$ 228.17	$ 235.25	$ 242.54	$ 250.06	$ 257.81	$ 265.80
Holyoke WWTP	$ 221.31	$ 228.17	$ 235.25	$ 242.54	$ 250.06	$ 257.81	$ 265.80
Hoosac WQD	$ 308.49	$ 318.05	$ 327.91	$ 338.08	$ 348.56	$ 359.36	$ 370.50
Hopedale WWTF	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.17	$ 0.17
Hudson WWTF	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
Hull WWTF	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Huntington WWTP	$ 0.54	$ 0.55	$ 0.57	$ 0.59	$ 0.61	$ 0.63	$ 0.65
Ipswich WWTP	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
Kingston Sewer Commission	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Lee WWTP	$ 0.31	$ 0.32	$ 0.33	$ 0.34	$ 0.35	$ 0.36	$ 0.37
Leicester WWTP	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Lenox Center WWTP	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Leominster WPCF	$ 0.09	$ 0.10	$ 0.10	$ 0.10	$ 0.11	$ 0.11	$ 0.11
Lowell Regional WW Utility	$ 300.94	$ 310.27	$ 319.89	$ 329.80	$ 340.03	$ 350.57	$ 361.44
Lowell Regional WW Utility	$ 300.94	$ 310.27	$ 319.89	$ 329.80	$ 340.03	$ 350.57	$ 361.44
Lowell Regional WW Utility	$ 300.94	$ 310.27	$ 319.89	$ 329.80	$ 340.03	$ 350.57	$ 361.44
Lowell Regional WW Utility	$ 300.94	$ 310.27	$ 319.89	$ 329.80	$ 340.03	$ 350.57	$ 361.44
Lowell Regional WW Utility	$ 300.94	$ 310.27	$ 319.89	$ 329.80	$ 340.03	$ 350.57	$ 361.44
Lynn Regional WF	$ 355.68	$ 366.71	$ 378.08	$ 389.80	$ 401.88	$ 414.34	$ 427.18
Lynn Regional WF	$ 355.68	$ 366.71	$ 378.08	$ 389.80	$ 401.88	$ 414.34	$ 427.18
Manchester By the Sea WWTP	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Manchester By the Sea WWTP	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Mansfield WWTP (MFN)	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22
Mansfield WWTP (MFN)	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22
Marion WWTP - Marion DPW	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
Marlborough East WWTP	$ 258.86	$ 266.88	$ 275.16	$ 283.69	$ 292.48	$ 301.55	$ 310.89
Marlborough West WWTP	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18

Table H-7E: Yearly Unit Prices by Plant and Sludge Load (3.1% escalation)

POTW name	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Marshfield WWTF	$ 0.17	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25	$ 0.25
Marshfield WWTF	$ 0.17	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25	$ 0.25
Maynard WWTP	$ 1.00	$ 1.03	$ 1.06	$ 1.10	$ 1.13	$ 1.16	$ 1.20	$ 1.24	$ 1.28	$ 1.32	$ 1.36	$ 1.40	$ 1.44	$ 1.49	$ 1.53
Maynard WWTP	$ 1.00	$ 1.03	$ 1.06	$ 1.10	$ 1.13	$ 1.16	$ 1.20	$ 1.24	$ 1.28	$ 1.32	$ 1.36	$ 1.40	$ 1.44	$ 1.49	$ 1.53
MCI Bridgewater	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.24	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29
MCI Concord	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.06	$ 0.06	$ 0.06	$ 0.06	$ 0.06	$ 0.07	$ 0.07	$ 0.07	$ 0.07	$ 0.07
MCI Norfolk	$ 0.13	$ 0.14	$ 0.14	$ 0.15	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.17	$ 0.17	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20
Medfield WWTP	$ 0.13	$ 0.13	$ 0.13	$ 0.14	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.17	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19
Merrimac WWTP	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Middleborough WWTP	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
Milford WWTP	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Monroe WWTP	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Montague WPCF	$ 178.65	$ 184.19	$ 189.90	$ 195.78	$ 201.85	$ 208.11	$ 214.56	$ 221.21	$ 228.07	$ 235.14	$ 242.43	$ 249.94	$ 257.69	$ 265.68	$ 273.92
Montague WPCF	$ 178.65	$ 184.19	$ 189.90	$ 195.78	$ 201.85	$ 208.11	$ 214.56	$ 221.21	$ 228.07	$ 235.14	$ 242.43	$ 249.94	$ 257.69	$ 265.68	$ 273.92
Montague WPCF	$ 178.65	$ 184.19	$ 189.90	$ 195.78	$ 201.85	$ 208.11	$ 214.56	$ 221.21	$ 228.07	$ 235.14	$ 242.43	$ 249.94	$ 257.69	$ 265.68	$ 273.92
MWRA Clinton WWTP	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
MWRA Deer Island WWTP	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
Nantucket Sewer Dept. - Siasconset	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Nantucket Sewer Dept. - Surfside	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
New Bedford WWTP	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.21	$ 0.22	$ 0.23	$ 0.23	$ 0.24	$ 0.25	$ 0.26	$ 0.27	$ 0.27	$ 0.28	$ 0.29
Newburyport WWTP	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
North Attleborough WPCF	$ 0.11	$ 0.12	$ 0.12	$ 0.12	$ 0.13	$ 0.13	$ 0.14	$ 0.14	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.17	$ 0.17
North Attleborough WPCF	$ 0.11	$ 0.12	$ 0.12	$ 0.12	$ 0.13	$ 0.13	$ 0.14	$ 0.14	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.17	$ 0.17
North Brookfield WWTP	$ 203.01	$ 209.30	$ 215.79	$ 222.48	$ 229.37	$ 236.48	$ 243.82	$ 251.37	$ 259.17	$ 267.20	$ 275.48	$ 284.02	$ 292.83	$ 301.91	$ 311.27
Northampton WWTF	$ 157.00	$ 161.87	$ 166.88	$ 172.06	$ 177.39	$ 182.89	$ 188.56	$ 194.41	$ 200.43	$ 206.65	$ 213.05	$ 219.66	$ 226.47	$ 233.49	$ 240.72
Northbridge WWTF	$ 0.06	$ 0.06	$ 0.06	$ 0.07	$ 0.07	$ 0.07	$ 0.07	$ 0.07	$ 0.08	$ 0.08	$ 0.08	$ 0.08	$ 0.09	$ 0.09	$ 0.09
Northfield WPCF	$ 0.25	$ 0.26	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.30	$ 0.31	$ 0.32	$ 0.33	$ 0.34	$ 0.35	$ 0.36	$ 0.37	$ 0.38
Oak Bluffs WWTP	$ 0.30	$ 0.31	$ 0.32	$ 0.33	$ 0.34	$ 0.35	$ 0.36	$ 0.37	$ 0.38	$ 0.39	$ 0.40	$ 0.42	$ 0.43	$ 0.44	$ 0.46
Old Deerfield - Historic WWTP	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.30	$ 0.31	$ 0.32	$ 0.33	$ 0.34	$ 0.35	$ 0.36	$ 0.37	$ 0.38	$ 0.39
Orange WWTP	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.24	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.28	$ 0.29	$ 0.30	$ 0.31	$ 0.32	$ 0.33
Orange WWTP	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.24	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.28	$ 0.29	$ 0.30	$ 0.31	$ 0.32	$ 0.33
Otis DPW	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Oxford-Rochdale SD WPCP	$ 0.08	$ 0.08	$ 0.09	$ 0.09	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.10	$ 0.11	$ 0.11	$ 0.11	$ 0.12	$ 0.12	$ 0.12
Palmer WWTF	$ 160.07	$ 165.03	$ 170.15	$ 175.42	$ 180.86	$ 186.47	$ 192.25	$ 198.21	$ 204.35	$ 210.69	$ 217.22	$ 223.95	$ 230.89	$ 238.05	$ 245.43
Pepperell WWTF	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
Pittsfield WWTP	$ 161.00	$ 165.99	$ 171.14	$ 176.44	$ 181.91	$ 187.55	$ 193.37	$ 199.36	$ 205.54	$ 211.91	$ 218.48	$ 225.25	$ 232.24	$ 239.44	$ 246.86
Plymouth WWTF	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Provincetown Public Works	$ 0.17	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25	$ 0.25
Rockland WWTP	$ 190.00	$ 195.89	$ 201.96	$ 208.22	$ 214.68	$ 221.33	$ 228.19	$ 235.27	$ 242.56	$ 250.08	$ 257.83	$ 265.83	$ 274.07	$ 282.56	$ 291.32
Rockport WWTP	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
Royalston WWTF	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Russell Village WWTF	$ 0.21	$ 0.22	$ 0.23	$ 0.23	$ 0.24	$ 0.25	$ 0.26	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.30	$ 0.31	$ 0.32	$ 0.33

Table H-7E: Yearly Unit Prices by Plant and Sludge Load (3.1% escalation)

POTW name	2038	2039	2040	2041	2042	2043	2044
Marshfield WWTF	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.30	$ 0.30	$ 0.31
Marshfield WWTF	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.30	$ 0.30	$ 0.31
Maynard WWTP	$ 1.58	$ 1.63	$ 1.68	$ 1.73	$ 1.79	$ 1.84	$ 1.90
Maynard WWTP	$ 1.58	$ 1.63	$ 1.68	$ 1.73	$ 1.79	$ 1.84	$ 1.90
MCI Bridgewater	$ 0.29	$ 0.30	$ 0.31	$ 0.32	$ 0.33	$ 0.34	$ 0.35
MCI Concord	$ 0.08	$ 0.08	$ 0.08	$ 0.08	$ 0.09	$ 0.09	$ 0.09
MCI Norfolk	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.24	$ 0.25
Medfield WWTP	$ 0.20	$ 0.21	$ 0.21	$ 0.22	$ 0.23	$ 0.23	$ 0.24
Merrimac WWTP	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Middleborough WWTP	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
Milford WWTP	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Monroe WWTP	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Montague WPCF	$ 282.41	$ 291.16	$ 300.19	$ 309.50	$ 319.09	$ 328.98	$ 339.18
Montague WPCF	$ 282.41	$ 291.16	$ 300.19	$ 309.50	$ 319.09	$ 328.98	$ 339.18
Montague WPCF	$ 282.41	$ 291.16	$ 300.19	$ 309.50	$ 319.09	$ 328.98	$ 339.18
MWRA Clinton WWTP	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
MWRA Deer Island WWTP	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
Nantucket Sewer Dept. - Siasconset	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Nantucket Sewer Dept. - Surfside	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
New Bedford WWTP	$ 0.30	$ 0.31	$ 0.32	$ 0.33	$ 0.34	$ 0.35	$ 0.36
Newburyport WWTP	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
North Attleborough WPCF	$ 0.18	$ 0.18	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.21
North Attleborough WPCF	$ 0.18	$ 0.18	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.21
North Brookfield WWTP	$ 320.92	$ 330.86	$ 341.12	$ 351.69	$ 362.60	$ 373.84	$ 385.43
Northampton WWTF	$ 248.19	$ 255.88	$ 263.81	$ 271.99	$ 280.42	$ 289.12	$ 298.08
Northbridge WWTF	$ 0.10	$ 0.10	$ 0.10	$ 0.10	$ 0.11	$ 0.11	$ 0.11
Northfield WPCF	$ 0.39	$ 0.40	$ 0.42	$ 0.43	$ 0.44	$ 0.46	$ 0.47
Oak Bluffs WWTP	$ 0.47	$ 0.48	$ 0.50	$ 0.52	$ 0.53	$ 0.55	$ 0.56
Old Deerfield - Historic WWTP	$ 0.40	$ 0.42	$ 0.43	$ 0.44	$ 0.45	$ 0.47	$ 0.48
Orange WWTP	$ 0.34	$ 0.35	$ 0.36	$ 0.37	$ 0.38	$ 0.40	$ 0.41
Orange WWTP	$ 0.34	$ 0.35	$ 0.36	$ 0.37	$ 0.38	$ 0.40	$ 0.41
Otis DPW	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Oxford-Rochdale SD WPCP	$ 0.13	$ 0.13	$ 0.14	$ 0.14	$ 0.14	$ 0.15	$ 0.15
Palmer WWTF	$ 253.04	$ 260.88	$ 268.97	$ 277.31	$ 285.91	$ 294.77	$ 303.91
Pepperell WWTF	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
Pittsfield WWTP	$ 254.51	$ 262.40	$ 270.53	$ 278.92	$ 287.57	$ 296.48	$ 305.67
Plymouth WWTF	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Provincetown Public Works	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.30	$ 0.30	$ 0.31
Rockland WWTP	$ 300.35	$ 309.67	$ 319.26	$ 329.16	$ 339.37	$ 349.89	$ 360.73
Rockport WWTP	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
Royalston WWTF	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Russell Village WWTF	$ 0.34	$ 0.35	$ 0.36	$ 0.37	$ 0.38	$ 0.39	$ 0.40

Table H-7E: Yearly Unit Prices by Plant and Sludge Load (3.1% escalation)

POTW name	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Salisbury WWTF	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Scituate WWTF	$ 172.00	$ 177.33	$ 182.83	$ 188.50	$ 194.34	$ 200.36	$ 206.58	$ 212.98	$ 219.58	$ 226.39	$ 233.41	$ 240.64	$ 248.10	$ 255.79	$ 263.72
Shelburne Falls WWTP	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
Somerset WWTF	$ 0.14	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.17	$ 0.17	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22
South Deerfield	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.21	$ 0.21	$ 0.22	$ 0.23	$ 0.23	$ 0.24	$ 0.25	$ 0.26	$ 0.26	$ 0.27	$ 0.28
South Essex Sewerage District	$ 135.08	$ 139.27	$ 143.59	$ 148.04	$ 152.63	$ 157.36	$ 162.24	$ 167.26	$ 172.45	$ 177.80	$ 183.31	$ 188.99	$ 194.85	$ 200.89	$ 207.12
South Essex Sewerage District	$ 135.08	$ 139.27	$ 143.59	$ 148.04	$ 152.63	$ 157.36	$ 162.24	$ 167.26	$ 172.45	$ 177.80	$ 183.31	$ 188.99	$ 194.85	$ 200.89	$ 207.12
South Essex Sewerage District	$ 135.08	$ 139.27	$ 143.59	$ 148.04	$ 152.63	$ 157.36	$ 162.24	$ 167.26	$ 172.45	$ 177.80	$ 183.31	$ 188.99	$ 194.85	$ 200.89	$ 207.12
South Essex Sewerage District	$ 135.08	$ 139.27	$ 143.59	$ 148.04	$ 152.63	$ 157.36	$ 162.24	$ 167.26	$ 172.45	$ 177.80	$ 183.31	$ 188.99	$ 194.85	$ 200.89	$ 207.12
South Essex Sewerage District	$ 135.08	$ 139.27	$ 143.59	$ 148.04	$ 152.63	$ 157.36	$ 162.24	$ 167.26	$ 172.45	$ 177.80	$ 183.31	$ 188.99	$ 194.85	$ 200.89	$ 207.12
South Hadley WWTP	$ 143.00	$ 147.43	$ 152.00	$ 156.72	$ 161.57	$ 166.58	$ 171.75	$ 177.07	$ 182.56	$ 188.22	$ 194.05	$ 200.07	$ 206.27	$ 212.67	$ 219.26
Southbridge WWTP	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
Spencer WWTP	$ 0.14	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.17	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.21
Springfield WWTP - Bondi's Island	$ 142.57	$ 146.99	$ 151.55	$ 156.24	$ 161.09	$ 166.08	$ 171.23	$ 176.54	$ 182.01	$ 187.65	$ 193.47	$ 199.47	$ 205.65	$ 212.03	$ 218.60
Springfield WWTP - Bondi's Island	$ 142.57	$ 146.99	$ 151.55	$ 156.24	$ 161.09	$ 166.08	$ 171.23	$ 176.54	$ 182.01	$ 187.65	$ 193.47	$ 199.47	$ 205.65	$ 212.03	$ 218.60
Springfield WWTP - Bondi's Island	$ 142.57	$ 146.99	$ 151.55	$ 156.24	$ 161.09	$ 166.08	$ 171.23	$ 176.54	$ 182.01	$ 187.65	$ 193.47	$ 199.47	$ 205.65	$ 212.03	$ 218.60
Springfield WWTP - Bondi's Island	$ 142.57	$ 146.99	$ 151.55	$ 156.24	$ 161.09	$ 166.08	$ 171.23	$ 176.54	$ 182.01	$ 187.65	$ 193.47	$ 199.47	$ 205.65	$ 212.03	$ 218.60
Springfield WWTP - Bondi's Island	$ 142.57	$ 146.99	$ 151.55	$ 156.24	$ 161.09	$ 166.08	$ 171.23	$ 176.54	$ 182.01	$ 187.65	$ 193.47	$ 199.47	$ 205.65	$ 212.03	$ 218.60
Springfield WWTP - Bondi's Island	$ 142.57	$ 146.99	$ 151.55	$ 156.24	$ 161.09	$ 166.08	$ 171.23	$ 176.54	$ 182.01	$ 187.65	$ 193.47	$ 199.47	$ 205.65	$ 212.03	$ 218.60
Springfield WWTP - Bondi's Island	$ 142.57	$ 146.99	$ 151.55	$ 156.24	$ 161.09	$ 166.08	$ 171.23	$ 176.54	$ 182.01	$ 187.65	$ 193.47	$ 199.47	$ 205.65	$ 212.03	$ 218.60
Stockbridge WWTP	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.10	$ 0.10	$ 0.11	$ 0.11	$ 0.11	$ 0.12	$ 0.12	$ 0.13	$ 0.13	$ 0.13	$ 0.14
Sturbridge WPCF	$ 0.13	$ 0.14	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20
Sunderland WWTP	$ 0.24	$ 0.24	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.28	$ 0.29	$ 0.30	$ 0.31	$ 0.32	$ 0.33	$ 0.34	$ 0.35	$ 0.36
Sunderland WWTP	$ 0.24	$ 0.24	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.28	$ 0.29	$ 0.30	$ 0.31	$ 0.32	$ 0.33	$ 0.34	$ 0.35	$ 0.36
Taunton WWTP	$ 133.25	$ 137.38	$ 141.64	$ 146.03	$ 150.56	$ 155.23	$ 160.04	$ 165.00	$ 170.12	$ 175.39	$ 180.83	$ 186.43	$ 192.21	$ 198.17	$ 204.31
Templeton WWTP	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
Tisbury Public Works	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Upper Blackstone WPAD (Worcester area)	$ 156.00	$ 160.84	$ 165.82	$ 170.96	$ 176.26	$ 181.73	$ 187.36	$ 193.17	$ 199.16	$ 205.33	$ 211.70	$ 218.26	$ 225.02	$ 232.00	$ 239.19
Upton WWTP	$ 0.08	$ 0.08	$ 0.08	$ 0.08	$ 0.09	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.10	$ 0.10	$ 0.11	$ 0.11	$ 0.11	$ 0.12
Uxbridge WWTF	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Ware WWTP	$ 0.08	$ 0.09	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.10	$ 0.11	$ 0.11	$ 0.11	$ 0.12	$ 0.12	$ 0.12	$ 0.13	$ 0.13
Wareham WPCF	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Warren WWTP	$ 0.12	$ 0.12	$ 0.13	$ 0.13	$ 0.13	$ 0.14	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.17	$ 0.17	$ 0.18	$ 0.18
Wayland WWTP	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Webster WWTF	$ 0.11	$ 0.11	$ 0.11	$ 0.12	$ 0.12	$ 0.13	$ 0.13	$ 0.13	$ 0.14	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.16
West Stockbridge	$ 0.17	$ 0.17	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.24	$ 0.25	$ 0.26
Westborough WWTF	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Westborough WWTF	$ 0.16	$ 0.16	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25
Westfield WPCP	$ 135.00	$ 139.19	$ 143.50	$ 147.95	$ 152.53	$ 157.26	$ 162.14	$ 167.16	$ 172.35	$ 177.69	$ 183.20	$ 188.88	$ 194.73	$ 200.77	$ 206.99
Winchendon WPCF	$ 0.07	$ 0.07	$ 0.07	$ 0.07	$ 0.08	$ 0.08	$ 0.08	$ 0.08	$ 0.09	$ 0.09	$ 0.09	$ 0.10	$ 0.10	$ 0.10	$ 0.10

Table H-7E: Yearly Unit Prices by Plant and Sludge Load (3.1% escalation)

POTW name	2038	2039	2040	2041	2042	2043	2044
Salisbury WWTF	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Scituate WWTF	$ 271.90	$ 280.33	$ 289.02	$ 297.98	$ 307.22	$ 316.74	$ 326.56
Shelburne Falls WWTP	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
Somerset WWTF	$ 0.22	$ 0.23	$ 0.24	$ 0.24	$ 0.25	$ 0.26	$ 0.27
South Deerfield	$ 0.29	$ 0.30	$ 0.31	$ 0.32	$ 0.33	$ 0.34	$ 0.35
South Essex Sewerage District	$ 213.54	$ 220.16	$ 226.98	$ 234.02	$ 241.27	$ 248.75	$ 256.46
South Essex Sewerage District	$ 213.54	$ 220.16	$ 226.98	$ 234.02	$ 241.27	$ 248.75	$ 256.46
South Essex Sewerage District	$ 213.54	$ 220.16	$ 226.98	$ 234.02	$ 241.27	$ 248.75	$ 256.46
South Essex Sewerage District	$ 213.54	$ 220.16	$ 226.98	$ 234.02	$ 241.27	$ 248.75	$ 256.46
South Essex Sewerage District	$ 213.54	$ 220.16	$ 226.98	$ 234.02	$ 241.27	$ 248.75	$ 256.46
South Hadley WWTP	$ 226.06	$ 233.06	$ 240.29	$ 247.74	$ 255.42	$ 263.34	$ 271.50
Southbridge WWTP	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
Spencer WWTP	$ 0.22	$ 0.23	$ 0.24	$ 0.24	$ 0.25	$ 0.26	$ 0.27
Springfield WWTP - Bondi's Island	$ 225.38	$ 232.36	$ 239.57	$ 246.99	$ 254.65	$ 262.54	$ 270.68
Springfield WWTP - Bondi's Island	$ 225.38	$ 232.36	$ 239.57	$ 246.99	$ 254.65	$ 262.54	$ 270.68
Springfield WWTP - Bondi's Island	$ 225.38	$ 232.36	$ 239.57	$ 246.99	$ 254.65	$ 262.54	$ 270.68
Springfield WWTP - Bondi's Island	$ 225.38	$ 232.36	$ 239.57	$ 246.99	$ 254.65	$ 262.54	$ 270.68
Springfield WWTP - Bondi's Island	$ 225.38	$ 232.36	$ 239.57	$ 246.99	$ 254.65	$ 262.54	$ 270.68
Springfield WWTP - Bondi's Island	$ 225.38	$ 232.36	$ 239.57	$ 246.99	$ 254.65	$ 262.54	$ 270.68
Springfield WWTP - Bondi's Island	$ 225.38	$ 232.36	$ 239.57	$ 246.99	$ 254.65	$ 262.54	$ 270.68
Springfield WWTP - Bondi's Island	$ 225.38	$ 232.36	$ 239.57	$ 246.99	$ 254.65	$ 262.54	$ 270.68
Stockbridge WWTP	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.16	$ 0.17	$ 0.17
Sturbridge WPCF	$ 0.21	$ 0.22	$ 0.22	$ 0.23	$ 0.24	$ 0.25	$ 0.25
Sunderland WWTP	$ 0.37	$ 0.39	$ 0.40	$ 0.41	$ 0.42	$ 0.44	$ 0.45
Sunderland WWTP	$ 0.37	$ 0.39	$ 0.40	$ 0.41	$ 0.42	$ 0.44	$ 0.45
Taunton WWTP	$ 210.65	$ 217.18	$ 223.91	$ 230.85	$ 238.01	$ 245.39	$ 252.99
Templeton WWTP	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
Tisbury Public Works	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Upper Blackstone WPAD (Worcester area)	$ 246.61	$ 254.25	$ 262.13	$ 270.26	$ 278.64	$ 287.28	$ 296.18
Upton WWTP	$ 0.12	$ 0.13	$ 0.13	$ 0.13	$ 0.14	$ 0.14	$ 0.15
Uxbridge WWTF	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Ware WWTP	$ 0.13	$ 0.14	$ 0.14	$ 0.15	$ 0.15	$ 0.16	$ 0.16
Wareham WPCF	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Warren WWTP	$ 0.19	$ 0.19	$ 0.20	$ 0.21	$ 0.21	$ 0.22	$ 0.23
Wayland WWTP	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Webster WWTF	$ 0.17	$ 0.18	$ 0.18	$ 0.19	$ 0.19	$ 0.20	$ 0.20
West Stockbridge	$ 0.27	$ 0.28	$ 0.28	$ 0.29	$ 0.30	$ 0.31	$ 0.32
Westborough WWTF	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Westborough WWTF	$ 0.25	$ 0.26	$ 0.27	$ 0.28	$ 0.29	$ 0.29	$ 0.30
Westfield WPCP	$ 213.41	$ 220.03	$ 226.85	$ 233.88	$ 241.13	$ 248.60	$ 256.31
Winchendon WPCF	$ 0.11	$ 0.11	$ 0.11	$ 0.12	$ 0.12	$ 0.13	$ 0.13

Calculation Approach

Annual solids hauling costs were calculated for each plant and each load, for each year from 2024 to 2044.

Annual quantities as determined in H-7B were multiplied by unit prices, as determined in H-7E, to get annual solids handling costs.

For example, Adams was projected to produce 983 wt in 2024, and pay $175.27 per wt. 983 wt/yr * $175.27/wt = $173,238. Subsequent years are calculated according to the same logic.

Annual costs were summed for each year from 2024 to 2044. These annual costs were brought back to present-day costs (2023 dollars) by applying a discount rate of 2.2%.

Finally, present day costs for each year were summed to obtain a grand total present cost representing the increase in solids handling costs that could be expected by all plants, from years 2024-2044.

Table H-7F: Annual Solids Hauling Cost per year, per plant (3.1% escalation)

POTW name	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Acton Wastewater Collection	$ 25,936	$ 26,873	$ 27,845	$ 28,852	$ 29,895	$ 30,976	$ 32,096	$ 33,256	$ 34,458	$ 35,704	$ 36,995	$ 38,333
Adams WWTP	$ 173,238	$ 179,502	$ 185,992	$ 192,716	$ 199,684	$ 206,903	$ 214,384	$ 222,135	$ 230,166	$ 238,488	$ 247,110	$ 256,045
Amesbury WWTP	$ 342,697	$ 355,087	$ 367,925	$ 381,227	$ 395,011	$ 409,292	$ 424,090	$ 439,423	$ 455,311	$ 471,772	$ 488,829	$ 506,503
Amherst WWTP	$ 685,520	$ 710,305	$ 735,986	$ 762,596	$ 790,168	$ 818,736	$ 848,337	$ 879,009	$ 910,790	$ 943,719	$ 977,839	$ 1,013,193
Ashfield	$ 5,226	$ 5,415	$ 5,611	$ 5,814	$ 6,024	$ 6,242	$ 6,468	$ 6,702	$ 6,944	$ 7,195	$ 7,455	$ 7,725
Athol WWTP	$ 81,479	$ 84,425	$ 87,477	$ 90,640	$ 93,917	$ 97,313	$ 100,831	$ 104,477	$ 108,254	$ 112,168	$ 116,223	$ 120,425
Athol WWTP	$ 485,240	$ 502,784	$ 520,962	$ 539,797	$ 559,314	$ 579,536	$ 600,489	$ 622,200	$ 644,695	$ 668,004	$ 692,156	$ 717,181
Attleboro WWTP	$ 1,538,945	$ 1,594,586	$ 1,652,238	$ 1,711,975	$ 1,773,871	$ 1,838,006	$ 1,904,459	$ 1,973,314	$ 2,044,659	$ 2,118,584	$ 2,195,182	$ 2,274,548
Ayer WWTP	$ 277,167	$ 287,188	$ 297,572	$ 308,330	$ 319,478	$ 331,029	$ 342,997	$ 355,398	$ 368,248	$ 381,562	$ 395,357	$ 409,651
Barnstable WWTP WPCD - DPW	$ 890,133	$ 922,316	$ 955,662	$ 990,214	$ 1,026,015	$ 1,063,111	$ 1,101,548	$ 1,141,374	$ 1,182,641	$ 1,225,399	$ 1,269,703	$ 1,315,609
Barnstable WWTP WPCD - DPW	$ 46,744	$ 48,434	$ 50,186	$ 52,000	$ 53,880	$ 55,828	$ 57,847	$ 59,938	$ 62,105	$ 64,351	$ 66,677	$ 69,088
Barre WWTP	$ 578	$ 599	$ 621	$ 643	$ 667	$ 691	$ 716	$ 741	$ 768	$ 796	$ 825	$ 855
Belchertown WWTP	$ 97,660	$ 101,191	$ 104,850	$ 108,641	$ 112,568	$ 116,638	$ 120,855	$ 125,225	$ 129,752	$ 134,444	$ 139,304	$ 144,341
Billerica WWTP	$ 1,064,513	$ 1,103,001	$ 1,142,880	$ 1,184,201	$ 1,227,015	$ 1,271,378	$ 1,317,345	$ 1,364,973	$ 1,414,324	$ 1,465,459	$ 1,518,443	$ 1,573,342
Bridgewater WWTP	$ 92,652	$ 96,002	$ 99,473	$ 103,070	$ 106,796	$ 110,657	$ 114,658	$ 118,804	$ 123,099	$ 127,550	$ 132,161	$ 136,939
Brockton WWTP	$ 2,667,653	$ 2,764,102	$ 2,864,038	$ 2,967,587	$ 3,074,881	$ 3,186,053	$ 3,301,245	$ 3,420,601	$ 3,544,273	$ 3,672,416	$ 3,805,192	$ 3,942,769
Charlemont Sewer District	$ 96	$ 100	$ 103	$ 107	$ 111	$ 115	$ 119	$ 124	$ 128	$ 133	$ 137	$ 142
Charles River PCD	$ 81,065	$ 83,996	$ 87,033	$ 90,180	$ 93,440	$ 96,818	$ 100,319	$ 103,946	$ 107,704	$ 111,598	$ 115,633	$ 119,814
Charles River PCD	$ 950,889	$ 985,269	$ 1,020,891	$ 1,057,801	$ 1,096,046	$ 1,135,674	$ 1,176,734	$ 1,219,279	$ 1,263,362	$ 1,309,039	$ 1,356,367	$ 1,405,406
Charlton WWTP	$ 867	$ 899	$ 931	$ 965	$ 1,000	$ 1,036	$ 1,073	$ 1,112	$ 1,152	$ 1,194	$ 1,237	$ 1,282
Chatham WPCF	$ 43,867	$ 45,453	$ 47,096	$ 48,799	$ 50,563	$ 52,391	$ 54,285	$ 56,248	$ 58,282	$ 60,389	$ 62,572	$ 64,835
Chicopee WWTP	$ 59,886	$ 62,051	$ 64,294	$ 66,619	$ 69,028	$ 71,523	$ 74,109	$ 76,789	$ 79,565	$ 82,442	$ 85,422	$ 88,511
Chicopee WWTP	$ 53,220	$ 55,145	$ 57,138	$ 59,204	$ 61,345	$ 63,563	$ 65,861	$ 68,242	$ 70,709	$ 73,266	$ 75,915	$ 78,659
Chicopee WWTP	$ 500,078	$ 518,158	$ 536,892	$ 556,304	$ 576,417	$ 597,257	$ 618,851	$ 641,226	$ 664,409	$ 688,431	$ 713,321	$ 739,111
Cohasset WWTF	$ 86,914	$ 90,056	$ 93,312	$ 96,686	$ 100,182	$ 103,804	$ 107,557	$ 111,446	$ 115,475	$ 119,650	$ 123,976	$ 128,458
Concord WWTF	$ 1,950	$ 2,020	$ 2,093	$ 2,169	$ 2,247	$ 2,329	$ 2,413	$ 2,500	$ 2,591	$ 2,684	$ 2,781	$ 2,882
Concord WWTF	$ 61,193	$ 63,406	$ 65,698	$ 68,073	$ 70,535	$ 73,085	$ 75,727	$ 78,465	$ 81,302	$ 84,241	$ 87,287	$ 90,443
Dartmouth WPCF	$ 267,266	$ 276,929	$ 286,942	$ 297,316	$ 308,066	$ 319,204	$ 330,745	$ 342,703	$ 355,093	$ 367,931	$ 381,234	$ 395,017
Devens WWTP	$ 677,046	$ 701,524	$ 726,888	$ 753,168	$ 780,399	$ 808,614	$ 837,850	$ 868,142	$ 899,530	$ 932,053	$ 965,751	$ 1,000,668
Douglas WWTP	$ 129,519	$ 134,202	$ 139,054	$ 144,082	$ 149,291	$ 154,688	$ 160,281	$ 166,076	$ 172,081	$ 178,302	$ 184,749	$ 191,428
Easthampton WWTP	$ 310,846	$ 322,085	$ 333,730	$ 345,796	$ 358,298	$ 371,253	$ 384,675	$ 398,583	$ 412,994	$ 427,926	$ 443,398	$ 459,429
Edgartown WWTP	$ 124,619	$ 129,124	$ 133,793	$ 138,630	$ 143,642	$ 148,836	$ 154,217	$ 159,793	$ 165,570	$ 171,556	$ 177,759	$ 184,186
Erving Center WWTP (#2)	$ 6,375,023	$ 6,572,649	$ 6,776,401	$ 6,986,469	$ 7,203,050	$ 7,426,344	$ 7,656,561	$ 7,893,914	$ 8,138,626	$ 8,390,923	$ 8,651,042	$ 8,919,224
Erving Center WWTP (#2)	$ 457,122	$ 471,293	$ 485,903	$ 500,966	$ 516,496	$ 532,507	$ 549,015	$ 566,035	$ 583,582	$ 601,673	$ 620,325	$ 639,555
Erving POTW #1	$ 39,841	$ 41,282	$ 42,774	$ 44,321	$ 45,923	$ 47,584	$ 49,304	$ 51,087	$ 52,934	$ 54,848	$ 56,831	$ 58,885
Erving POTW #3	$ 822	$ 852	$ 882	$ 914	$ 947	$ 982	$ 1,017	$ 1,054	$ 1,092	$ 1,131	$ 1,172	$ 1,215

Table H-7F: Annual Solids Hauling Cost per year, per plant (3.1% escalation)

POTW name	2036	2037	2038	2039	2040	2041	2042	2043	2044
Acton Wastewater Collection	$ 39,719	$ 41,155	$ 42,642	$ 44,184	$ 45,782	$ 47,437	$ 49,152	$ 50,929	$ 52,770
Adams WWTP	$ 265,302	$ 274,894	$ 284,833	$ 295,131	$ 305,801	$ 316,858	$ 328,314	$ 340,184	$ 352,483
Amesbury WWTP	$ 524,816	$ 543,790	$ 563,451	$ 583,823	$ 604,931	$ 626,802	$ 649,464	$ 672,945	$ 697,276
Amherst WWTP	$ 1,049,825	$ 1,087,782	$ 1,127,110	$ 1,167,861	$ 1,210,085	$ 1,253,836	$ 1,299,168	$ 1,346,140	$ 1,394,809
Ashfield	$ 8,004	$ 8,293	$ 8,593	$ 8,904	$ 9,226	$ 9,559	$ 9,905	$ 10,263	$ 10,634
Athol WWTP	$ 124,779	$ 129,291	$ 133,965	$ 138,809	$ 143,827	$ 149,028	$ 154,416	$ 159,999	$ 165,783
Athol WWTP	$ 743,110	$ 769,978	$ 797,816	$ 826,661	$ 856,549	$ 887,518	$ 919,606	$ 952,854	$ 987,305
Attleboro WWTP	$ 2,356,785	$ 2,441,994	$ 2,530,284	$ 2,621,767	$ 2,716,557	$ 2,814,774	$ 2,916,542	$ 3,021,990	$ 3,131,250
Ayer WWTP	$ 424,462	$ 439,809	$ 455,710	$ 472,186	$ 489,258	$ 506,947	$ 525,276	$ 544,267	$ 563,945
Barnstable WWTP WPCD - DPW	$ 1,363,175	$ 1,412,461	$ 1,463,528	$ 1,516,442	$ 1,571,269	$ 1,628,079	$ 1,686,942	$ 1,747,933	$ 1,811,130
Barnstable WWTP WPCD - DPW	$ 71,586	$ 74,174	$ 76,856	$ 79,634	$ 82,514	$ 85,497	$ 88,588	$ 91,791	$ 95,110
Barre WWTP	$ 886	$ 918	$ 951	$ 985	$ 1,021	$ 1,058	$ 1,096	$ 1,136	$ 1,177
Belchertown WWTP	$ 149,560	$ 154,967	$ 160,570	$ 166,375	$ 172,390	$ 178,623	$ 185,081	$ 191,773	$ 198,707
Billerica WWTP	$ 1,630,226	$ 1,689,167	$ 1,750,239	$ 1,813,519	$ 1,879,086	$ 1,947,025	$ 2,017,419	$ 2,090,359	$ 2,165,936
Bridgewater WWTP	$ 141,890	$ 147,020	$ 152,336	$ 157,844	$ 163,551	$ 169,464	$ 175,591	$ 181,939	$ 188,517
Brockton WWTP	$ 4,085,320	$ 4,233,025	$ 4,386,070	$ 4,544,648	$ 4,708,960	$ 4,879,212	$ 5,055,620	$ 5,238,406	$ 5,427,801
Charlemont Sewer District	$ 148	$ 153	$ 158	$ 164	$ 170	$ 176	$ 183	$ 189	$ 196
Charles River PCD	$ 124,146	$ 128,634	$ 133,285	$ 138,104	$ 143,097	$ 148,271	$ 153,631	$ 159,186	$ 164,941
Charles River PCD	$ 1,456,219	$ 1,508,869	$ 1,563,422	$ 1,619,947	$ 1,678,516	$ 1,739,203	$ 1,802,084	$ 1,867,238	$ 1,934,748
Charlton WWTP	$ 1,328	$ 1,376	$ 1,426	$ 1,478	$ 1,531	$ 1,586	$ 1,644	$ 1,703	$ 1,765
Chatham WPCF	$ 67,179	$ 69,607	$ 72,124	$ 74,732	$ 77,434	$ 80,233	$ 83,134	$ 86,140	$ 89,254
Chicopee WWTP	$ 91,711	$ 95,027	$ 98,462	$ 102,022	$ 105,711	$ 109,533	$ 113,493	$ 117,596	$ 121,848
Chicopee WWTP	$ 81,503	$ 84,450	$ 87,503	$ 90,667	$ 93,945	$ 97,342	$ 100,861	$ 104,508	$ 108,286
Chicopee WWTP	$ 765,834	$ 793,522	$ 822,212	$ 851,939	$ 882,741	$ 914,657	$ 947,726	$ 981,991	$ 1,017,495
Cohasset WWTF	$ 133,103	$ 137,915	$ 142,901	$ 148,068	$ 153,421	$ 158,968	$ 164,716	$ 170,671	$ 176,842
Concord WWTF	$ 2,986	$ 3,094	$ 3,206	$ 3,322	$ 3,442	$ 3,566	$ 3,695	$ 3,829	$ 3,967
Concord WWTF	$ 93,713	$ 97,101	$ 100,612	$ 104,250	$ 108,019	$ 111,924	$ 115,971	$ 120,164	$ 124,508
Dartmouth WPCF	$ 409,299	$ 424,098	$ 439,431	$ 455,318	$ 471,780	$ 488,838	$ 506,512	$ 524,825	$ 543,800
Devens WWTP	$ 1,036,847	$ 1,074,334	$ 1,113,177	$ 1,153,423	$ 1,195,125	$ 1,238,335	$ 1,283,107	$ 1,329,498	$ 1,377,566
Douglas WWTP	$ 198,349	$ 205,521	$ 212,951	$ 220,651	$ 228,628	$ 236,894	$ 245,459	$ 254,334	$ 263,529
Easthampton WWTP	$ 476,039	$ 493,250	$ 511,084	$ 529,562	$ 548,708	$ 568,547	$ 589,103	$ 610,402	$ 632,471
Edgartown WWTP	$ 190,845	$ 197,745	$ 204,894	$ 212,302	$ 219,978	$ 227,931	$ 236,172	$ 244,711	$ 253,559
Erving Center WWTP (#2)	$ 9,195,720	$ 9,480,787	$ 9,774,692	$ 10,077,707	$ 10,390,116	$ 10,712,209	$ 11,044,288	$ 11,386,661	$ 11,739,647
Erving Center WWTP (#2)	$ 659,381	$ 679,822	$ 700,896	$ 722,624	$ 745,025	$ 768,121	$ 791,933	$ 816,483	$ 841,794
Erving POTW #1	$ 61,014	$ 63,220	$ 65,506	$ 67,874	$ 70,328	$ 72,871	$ 75,506	$ 78,236	$ 81,064
Erving POTW #3	$ 1,259	$ 1,304	$ 1,351	$ 1,400	$ 1,451	$ 1,503	$ 1,558	$ 1,614	$ 1,672

Table H-7F: Annual Solids Hauling Cost per year, per plant (3.1% escalation)

POTW name	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Fairhaven WPCF	$ 425,008	$ 440,374	$ 456,295	$ 472,793	$ 489,887	$ 507,598	$ 525,951	$ 544,966	$ 564,670	$ 585,085	$ 606,239	$ 628,158
Fall River Regional WWF	$ 1,930,966	$ 2,000,780	$ 2,073,118	$ 2,148,072	$ 2,225,736	$ 2,306,207	$ 2,389,588	$ 2,475,984	$ 2,565,503	$ 2,658,259	$ 2,754,368	$ 2,853,952
Falmouth WWTP	$ 2,313	$ 2,397	$ 2,483	$ 2,573	$ 2,666	$ 2,763	$ 2,862	$ 2,966	$ 3,073	$ 3,184	$ 3,299	$ 3,419
Fitchburg East WWTP	$ 340,738	$ 353,058	$ 365,822	$ 379,049	$ 392,753	$ 406,953	$ 421,667	$ 436,912	$ 452,709	$ 469,076	$ 486,036	$ 503,608
Gardner WPCF	$ 9,248	$ 9,582	$ 9,929	$ 10,288	$ 10,660	$ 11,045	$ 11,445	$ 11,858	$ 12,287	$ 12,731	$ 13,192	$ 13,669
Gloucester WPCF	$ 420,945	$ 436,164	$ 451,933	$ 468,273	$ 485,203	$ 502,746	$ 520,923	$ 539,757	$ 559,272	$ 579,492	$ 600,444	$ 622,153
Grafton WWTP	$ 312,136	$ 323,422	$ 335,115	$ 347,231	$ 359,785	$ 372,793	$ 386,271	$ 400,237	$ 414,708	$ 429,701	$ 445,237	$ 461,335
Great Barrington WWTP	$ 146,560	$ 151,859	$ 157,350	$ 163,039	$ 168,933	$ 175,041	$ 181,370	$ 187,927	$ 194,722	$ 201,762	$ 209,057	$ 216,615
Greater Lawrence Sanitary Distri	$ 2,463,363	$ 2,552,426	$ 2,644,709	$ 2,740,328	$ 2,839,405	$ 2,942,063	$ 3,048,434	$ 3,158,650	$ 3,272,851	$ 3,391,181	$ 3,513,789	$ 3,640,830
Greenfield WPCF	$ 756,583	$ 783,937	$ 812,280	$ 841,648	$ 872,078	$ 903,608	$ 936,278	$ 970,129	$ 1,005,204	$ 1,041,547	$ 1,079,204	$ 1,118,223
Hadley WWTP	$ 252,747	$ 261,885	$ 271,354	$ 281,165	$ 291,330	$ 301,863	$ 312,777	$ 324,086	$ 335,803	$ 347,944	$ 360,524	$ 373,559
Hardwick-Gilbertville WPCF	$ 26,733	$ 27,699	$ 28,701	$ 29,738	$ 30,814	$ 31,928	$ 33,082	$ 34,278	$ 35,517	$ 36,802	$ 38,132	$ 39,511
Hardwick-Wheelwright WPCF	$ 12,434	$ 12,883	$ 13,349	$ 13,832	$ 14,332	$ 14,850	$ 15,387	$ 15,943	$ 16,520	$ 17,117	$ 17,736	$ 18,377
Hatfield WWTP	$ 81,232	$ 84,169	$ 87,213	$ 90,366	$ 93,633	$ 97,018	$ 100,526	$ 104,160	$ 107,926	$ 111,828	$ 115,871	$ 120,061
Haverhill WWTP	$ 2,644,321	$ 2,739,927	$ 2,838,989	$ 2,941,632	$ 3,047,987	$ 3,158,187	$ 3,272,371	$ 3,390,684	$ 3,513,274	$ 3,640,296	$ 3,771,911	$ 3,908,285
Holyoke WWTP	$ 62,086	$ 64,331	$ 66,657	$ 69,067	$ 71,564	$ 74,152	$ 76,832	$ 79,610	$ 82,489	$ 85,471	$ 88,561	$ 91,763
Holyoke WWTP	$ 45,259	$ 46,896	$ 48,591	$ 50,348	$ 52,168	$ 54,054	$ 56,009	$ 58,034	$ 60,132	$ 62,306	$ 64,559	$ 66,893
Holyoke WWTP	$ 527,807	$ 546,890	$ 566,663	$ 587,150	$ 608,379	$ 630,375	$ 653,166	$ 676,781	$ 701,250	$ 726,604	$ 752,874	$ 780,094
Holyoke WWTP	$ 758,528	$ 785,952	$ 814,368	$ 843,812	$ 874,320	$ 905,931	$ 938,685	$ 972,623	$ 1,007,788	$ 1,044,225	$ 1,081,979	$ 1,121,098
Hoosac WQD	$ 93,985	$ 97,383	$ 100,904	$ 104,552	$ 108,332	$ 112,248	$ 116,307	$ 120,512	$ 124,869	$ 129,384	$ 134,062	$ 138,909
Hopedale WWTF	$ 113,977	$ 118,098	$ 122,368	$ 126,792	$ 131,376	$ 136,126	$ 141,047	$ 146,147	$ 151,431	$ 156,906	$ 162,579	$ 168,457
Hudson WWTF	$ 344,805	$ 357,271	$ 370,188	$ 383,573	$ 397,441	$ 411,810	$ 426,699	$ 442,126	$ 458,111	$ 474,674	$ 491,836	$ 509,619
Hull WWTF	$ 200,846	$ 208,107	$ 215,631	$ 223,427	$ 231,505	$ 239,876	$ 248,548	$ 257,534	$ 266,846	$ 276,493	$ 286,490	$ 296,848
Huntington WWTP	$ 25,365	$ 26,282	$ 27,232	$ 28,217	$ 29,237	$ 30,294	$ 31,389	$ 32,524	$ 33,700	$ 34,919	$ 36,181	$ 37,489
Ipswich WWTP	$ 382,092	$ 395,906	$ 410,220	$ 425,052	$ 440,420	$ 456,343	$ 472,842	$ 489,938	$ 507,652	$ 526,006	$ 545,023	$ 564,729
Kingston Sewer Commission	$ 155,433	$ 161,053	$ 166,876	$ 172,909	$ 179,161	$ 185,638	$ 192,350	$ 199,305	$ 206,511	$ 213,977	$ 221,713	$ 229,729
Lee WWTP	$ 232,099	$ 240,490	$ 249,185	$ 258,194	$ 267,529	$ 277,202	$ 287,224	$ 297,609	$ 308,369	$ 319,518	$ 331,070	$ 343,040
Leicester WWTP	$ 713	$ 739	$ 766	$ 793	$ 822	$ 852	$ 883	$ 914	$ 948	$ 982	$ 1,017	$ 1,054
Lenox Center WWTP	$ 3,470	$ 3,595	$ 3,725	$ 3,860	$ 3,999	$ 4,144	$ 4,294	$ 4,449	$ 4,610	$ 4,776	$ 4,949	$ 5,128
Leominster WPCF	$ 392,821	$ 407,023	$ 421,739	$ 436,987	$ 452,787	$ 469,157	$ 486,119	$ 503,695	$ 521,906	$ 540,776	$ 560,327	$ 580,586
Lowell Regional WW Utility	$ 1,508,644	$ 1,563,189	$ 1,619,706	$ 1,678,266	$ 1,738,944	$ 1,801,815	$ 1,866,960	$ 1,934,460	$ 2,004,400	$ 2,076,870	$ 2,151,959	$ 2,229,763
Lowell Regional WW Utility	$ 482,924	$ 500,384	$ 518,475	$ 537,220	$ 556,644	$ 576,769	$ 597,622	$ 619,229	$ 641,617	$ 664,815	$ 688,852	$ 713,757
Lowell Regional WW Utility	$ 2,211,364	$ 2,291,316	$ 2,374,159	$ 2,459,997	$ 2,548,938	$ 2,641,095	$ 2,736,583	$ 2,835,524	$ 2,938,043	$ 3,044,268	$ 3,154,333	$ 3,268,378
Lowell Regional WW Utility	$ 12,605	$ 13,061	$ 13,533	$ 14,022	$ 14,529	$ 15,054	$ 15,599	$ 16,163	$ 16,747	$ 17,352	$ 17,980	$ 18,630
Lowell Regional WW Utility	$ 1,134,437	$ 1,175,453	$ 1,217,951	$ 1,261,986	$ 1,307,613	$ 1,354,890	$ 1,403,876	$ 1,454,633	$ 1,507,225	$ 1,561,719	$ 1,618,183	$ 1,676,689
Lynn Regional WF	$ 329,778	$ 341,702	$ 354,056	$ 366,857	$ 380,120	$ 393,864	$ 408,104	$ 422,859	$ 438,147	$ 453,988	$ 470,402	$ 487,410
Lynn Regional WF	$ 770,857	$ 798,727	$ 827,605	$ 857,527	$ 888,531	$ 920,656	$ 953,942	$ 988,432	$ 1,024,168	$ 1,061,197	$ 1,099,565	$ 1,139,320
Manchester By the Sea WWTP	$ 18,562	$ 19,233	$ 19,928	$ 20,649	$ 21,395	$ 22,169	$ 22,971	$ 23,801	$ 24,662	$ 25,553	$ 26,477	$ 27,434
Manchester By the Sea WWTP	$ 21,522	$ 22,301	$ 23,107	$ 23,942	$ 24,808	$ 25,705	$ 26,634	$ 27,597	$ 28,595	$ 29,629	$ 30,700	$ 31,810
Mansfield WWTP (MFN)	$ 560,929	$ 581,209	$ 602,223	$ 623,996	$ 646,557	$ 669,933	$ 694,154	$ 719,251	$ 745,256	$ 772,201	$ 800,120	$ 829,048
Mansfield WWTP (MFN)	$ 10,030	$ 10,393	$ 10,769	$ 11,158	$ 11,561	$ 11,979	$ 12,413	$ 12,861	$ 13,326	$ 13,808	$ 14,307	$ 14,825
Marion WWTP - Marion DPW	$ 61,358	$ 63,576	$ 65,875	$ 68,256	$ 70,724	$ 73,281	$ 75,931	$ 78,676	$ 81,520	$ 84,468	$ 87,522	$ 90,686

Table H-7F: Annual Solids Hauling Cost per year, per plant (3.1% escalation)

POTW name	2036	2037	2038	2039	2040	2041	2042	2043	2044
Fairhaven WPCF	$ 650,869	$ 674,401	$ 698,784	$ 724,048	$ 750,226	$ 777,351	$ 805,456	$ 834,577	$ 864,751
Fall River Regional WWF	$ 2,957,137	$ 3,064,052	$ 3,174,833	$ 3,289,619	$ 3,408,555	$ 3,531,791	$ 3,659,483	$ 3,791,792	$ 3,928,884
Falmouth WWTP	$ 3,542	$ 3,670	$ 3,803	$ 3,941	$ 4,083	$ 4,231	$ 4,384	$ 4,542	$ 4,706
Fitchburg East WWTP	$ 521,816	$ 540,683	$ 560,231	$ 580,486	$ 601,474	$ 623,220	$ 645,752	$ 669,099	$ 693,291
Gardner WPCF	$ 14,163	$ 14,675	$ 15,205	$ 15,755	$ 16,325	$ 16,915	$ 17,527	$ 18,160	$ 18,817
Gloucester WPCF	$ 644,646	$ 667,954	$ 692,104	$ 717,127	$ 743,054	$ 769,919	$ 797,756	$ 826,599	$ 856,484
Grafton WWTP	$ 478,014	$ 495,297	$ 513,204	$ 531,759	$ 550,985	$ 570,906	$ 591,547	$ 612,934	$ 635,095
Great Barrington WWTP	$ 224,447	$ 232,562	$ 240,970	$ 249,682	$ 258,709	$ 268,063	$ 277,755	$ 287,797	$ 298,202
Greater Lawrence Sanitary Distri	$ 3,772,464	$ 3,908,858	$ 4,050,182	$ 4,196,617	$ 4,348,345	$ 4,505,560	$ 4,668,458	$ 4,837,246	$ 5,012,137
Greenfield WPCF	$ 1,158,652	$ 1,200,543	$ 1,243,949	$ 1,288,924	$ 1,335,525	$ 1,383,811	$ 1,433,843	$ 1,485,683	$ 1,539,398
Hadley WWTP	$ 387,065	$ 401,059	$ 415,559	$ 430,584	$ 446,151	$ 462,282	$ 478,996	$ 496,314	$ 514,258
Hardwick-Gilbertville WPCF	$ 40,939	$ 42,420	$ 43,953	$ 45,542	$ 47,189	$ 48,895	$ 50,663	$ 52,495	$ 54,392
Hardwick-Wheelwright WPCF	$ 19,042	$ 19,730	$ 20,443	$ 21,182	$ 21,948	$ 22,742	$ 23,564	$ 24,416	$ 25,299
Hatfield WWTP	$ 124,402	$ 128,899	$ 133,560	$ 138,389	$ 143,392	$ 148,576	$ 153,948	$ 159,514	$ 165,281
Haverhill WWTP	$ 4,049,589	$ 4,196,002	$ 4,347,708	$ 4,504,900	$ 4,667,774	$ 4,836,538	$ 5,011,403	$ 5,192,590	$ 5,380,328
Holyoke WWTP	$ 95,081	$ 98,519	$ 102,080	$ 105,771	$ 109,595	$ 113,558	$ 117,663	$ 121,918	$ 126,326
Holyoke WWTP	$ 69,311	$ 71,817	$ 74,414	$ 77,104	$ 79,892	$ 82,780	$ 85,773	$ 88,875	$ 92,088
Holyoke WWTP	$ 808,299	$ 837,523	$ 867,803	$ 899,179	$ 931,689	$ 965,374	$ 1,000,277	$ 1,036,442	$ 1,073,914
Holyoke WWTP	$ 1,161,631	$ 1,203,630	$ 1,247,147	$ 1,292,237	$ 1,338,958	$ 1,387,368	$ 1,437,529	$ 1,489,502	$ 1,543,355
Hoosac WQD	$ 143,931	$ 149,135	$ 154,527	$ 160,113	$ 165,902	$ 171,901	$ 178,116	$ 184,555	$ 191,228
Hopedale WWTF	$ 174,547	$ 180,858	$ 187,397	$ 194,173	$ 201,193	$ 208,467	$ 216,004	$ 223,814	$ 231,906
Hudson WWTF	$ 528,044	$ 547,135	$ 566,917	$ 587,414	$ 608,652	$ 630,658	$ 653,459	$ 677,085	$ 701,565
Hull WWTF	$ 307,581	$ 318,701	$ 330,224	$ 342,163	$ 354,534	$ 367,352	$ 380,634	$ 394,396	$ 408,655
Huntington WWTP	$ 38,845	$ 40,249	$ 41,704	$ 43,212	$ 44,775	$ 46,393	$ 48,071	$ 49,809	$ 51,610
Ipswich WWTP	$ 585,146	$ 606,302	$ 628,223	$ 650,937	$ 674,471	$ 698,857	$ 724,124	$ 750,305	$ 777,432
Kingston Sewer Commission	$ 238,035	$ 246,641	$ 255,559	$ 264,798	$ 274,372	$ 284,292	$ 294,571	$ 305,221	$ 316,256
Lee WWTP	$ 355,443	$ 368,294	$ 381,609	$ 395,406	$ 409,702	$ 424,515	$ 439,863	$ 455,767	$ 472,245
Leicester WWTP	$ 1,092	$ 1,132	$ 1,173	$ 1,215	$ 1,259	$ 1,304	$ 1,352	$ 1,400	$ 1,451
Lenox Center WWTP	$ 5,313	$ 5,505	$ 5,705	$ 5,911	$ 6,124	$ 6,346	$ 6,575	$ 6,813	$ 7,059
Leominster WPCF	$ 601,577	$ 623,327	$ 645,864	$ 669,215	$ 693,410	$ 718,481	$ 744,457	$ 771,373	$ 799,262
Lowell Regional WW Utility	$ 2,310,380	$ 2,393,912	$ 2,480,464	$ 2,570,145	$ 2,663,068	$ 2,759,352	$ 2,859,116	$ 2,962,487	$ 3,069,596
Lowell Regional WW Utility	$ 739,563	$ 766,302	$ 794,007	$ 822,715	$ 852,460	$ 883,281	$ 915,216	$ 948,305	$ 982,591
Lowell Regional WW Utility	$ 3,386,546	$ 3,508,987	$ 3,635,854	$ 3,767,309	$ 3,903,516	$ 4,044,647	$ 4,190,882	$ 4,342,403	$ 4,499,403
Lowell Regional WW Utility	$ 19,303	$ 20,001	$ 20,725	$ 21,474	$ 22,250	$ 23,055	$ 23,888	$ 24,752	$ 25,647
Lowell Regional WW Utility	$ 1,737,309	$ 1,800,122	$ 1,865,205	$ 1,932,641	$ 2,002,516	$ 2,074,917	$ 2,149,936	$ 2,227,667	$ 2,308,208
Lynn Regional WF	$ 505,032	$ 523,292	$ 542,211	$ 561,815	$ 582,127	$ 603,174	$ 624,982	$ 647,578	$ 670,991
Lynn Regional WF	$ 1,180,512	$ 1,223,193	$ 1,267,418	$ 1,313,241	$ 1,360,721	$ 1,409,918	$ 1,460,894	$ 1,513,712	$ 1,568,441
Manchester By the Sea WWTP	$ 28,426	$ 29,454	$ 30,519	$ 31,622	$ 32,766	$ 33,950	$ 35,178	$ 36,450	$ 37,767
Manchester By the Sea WWTP	$ 32,960	$ 34,152	$ 35,387	$ 36,666	$ 37,992	$ 39,365	$ 40,788	$ 42,263	$ 43,791
Mansfield WWTP (MFN)	$ 859,022	$ 890,080	$ 922,261	$ 955,605	$ 990,155	$ 1,025,954	$ 1,063,048	$ 1,101,482	$ 1,141,306
Mansfield WWTP (MFN)	$ 15,361	$ 15,916	$ 16,491	$ 17,088	$ 17,705	$ 18,346	$ 19,009	$ 19,696	$ 20,408
Marion WWTP - Marion DPW	$ 93,965	$ 97,362	$ 100,882	$ 104,529	$ 108,309	$ 112,225	$ 116,282	$ 120,486	$ 124,843

Table H-7F: Annual Solids Hauling Cost per year, per plant (3.1% escalation)

POTW name	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Marlborough East WWTP	$ 949,847	$ 984,189	$ 1,019,773	$ 1,056,642	$ 1,094,845	$ 1,134,429	$ 1,175,445	$ 1,217,943	$ 1,261,978	$ 1,307,604	$ 1,354,881	$ 1,403,867
Marlborough West WWTP	$ 540,680	$ 560,228	$ 580,483	$ 601,471	$ 623,217	$ 645,749	$ 669,096	$ 693,287	$ 718,353	$ 744,325	$ 771,236	$ 799,120
Marshfield WWTF	$ 91,865	$ 95,186	$ 98,627	$ 102,193	$ 105,888	$ 109,716	$ 113,683	$ 117,793	$ 122,052	$ 126,465	$ 131,037	$ 135,775
Marshfield WWTF	$ 112,311	$ 116,372	$ 120,579	$ 124,939	$ 129,456	$ 134,136	$ 138,986	$ 144,011	$ 149,218	$ 154,613	$ 160,203	$ 165,995
Maynard WWTP	$ 36,520	$ 37,840	$ 39,209	$ 40,626	$ 42,095	$ 43,617	$ 45,194	$ 46,828	$ 48,521	$ 50,275	$ 52,093	$ 53,976
Maynard WWTP	$ 2,899,599	$ 3,004,434	$ 3,113,060	$ 3,225,612	$ 3,342,234	$ 3,463,073	$ 3,588,280	$ 3,718,014	$ 3,852,439	$ 3,991,724	$ 4,136,045	$ 4,285,584
MCI Bridgewater	$ 73,143	$ 75,788	$ 78,528	$ 81,367	$ 84,309	$ 87,357	$ 90,515	$ 93,788	$ 97,179	$ 100,692	$ 104,333	$ 108,105
MCI Concord	$ 60,631	$ 62,823	$ 65,094	$ 67,447	$ 69,886	$ 72,413	$ 75,031	$ 77,744	$ 80,554	$ 83,467	$ 86,485	$ 89,611
MCI Norfolk	$ 50,250	$ 52,067	$ 53,949	$ 55,900	$ 57,921	$ 60,015	$ 62,185	$ 64,433	$ 66,763	$ 69,177	$ 71,678	$ 74,269
Medfield WWTP	$ 317,272	$ 328,743	$ 340,629	$ 352,944	$ 365,705	$ 378,927	$ 392,627	$ 406,822	$ 421,531	$ 436,771	$ 452,563	$ 468,925
Merrimac WWTP	$ 112,413	$ 116,478	$ 120,689	$ 125,052	$ 129,574	$ 134,258	$ 139,113	$ 144,142	$ 149,354	$ 154,753	$ 160,349	$ 166,146
Middleborough WWTP	$ 354,787	$ 367,615	$ 380,906	$ 394,677	$ 408,947	$ 423,732	$ 439,052	$ 454,926	$ 471,374	$ 488,417	$ 506,075	$ 524,373
Milford WWTP	$ 791,987	$ 820,621	$ 850,291	$ 881,033	$ 912,887	$ 945,892	$ 980,091	$ 1,015,526	$ 1,052,242	$ 1,090,286	$ 1,129,706	$ 1,170,550
Monroe WWTP	$ 80,921	$ 83,847	$ 86,878	$ 90,019	$ 93,274	$ 96,646	$ 100,141	$ 103,761	$ 107,513	$ 111,400	$ 115,427	$ 119,601
Montague WPCF	$ 179,900	$ 186,405	$ 193,144	$ 200,127	$ 207,363	$ 214,860	$ 222,628	$ 230,677	$ 239,017	$ 247,659	$ 256,613	$ 265,891
Montague WPCF	$ 4,398	$ 4,557	$ 4,722	$ 4,893	$ 5,070	$ 5,253	$ 5,443	$ 5,640	$ 5,844	$ 6,055	$ 6,274	$ 6,501
Montague WPCF	$ 22,978	$ 23,809	$ 24,669	$ 25,561	$ 26,485	$ 27,443	$ 28,435	$ 29,463	$ 30,529	$ 31,632	$ 32,776	$ 33,961
MWRA Clinton WWTP	$ 236,606	$ 245,160	$ 254,024	$ 263,208	$ 272,724	$ 282,585	$ 292,802	$ 303,388	$ 314,357	$ 325,722	$ 337,499	$ 349,701
MWRA Deer Island WWTP	$ 5,717,670	$ 5,924,392	$ 6,138,589	$ 6,360,529	$ 6,590,494	$ 6,828,774	$ 7,075,668	$ 7,331,489	$ 7,596,559	$ 7,871,212	$ 8,155,796	$ 8,450,669
Nantucket Sewer Dept. - Siascon	$ 106	$ 110	$ 114	$ 118	$ 122	$ 127	$ 131	$ 136	$ 141	$ 146	$ 151	$ 157
Nantucket Sewer Dept. - Surfside	$ 5,103	$ 5,288	$ 5,479	$ 5,677	$ 5,882	$ 6,095	$ 6,316	$ 6,544	$ 6,780	$ 7,026	$ 7,280	$ 7,543
New Bedford WWTP	$ 5,121,358	$ 5,306,521	$ 5,498,378	$ 5,697,172	$ 5,903,153	$ 6,116,582	$ 6,337,727	$ 6,566,868	$ 6,804,293	$ 7,050,302	$ 7,305,206	$ 7,569,325
Newburyport WWTP	$ 441,056	$ 457,003	$ 473,525	$ 490,646	$ 508,385	$ 526,766	$ 545,811	$ 565,545	$ 585,992	$ 607,179	$ 629,131	$ 651,877
North Attleborough WPCF	$ 4,950	$ 5,129	$ 5,314	$ 5,507	$ 5,706	$ 5,912	$ 6,126	$ 6,347	$ 6,577	$ 6,814	$ 7,061	$ 7,316
North Attleborough WPCF	$ 4,950	$ 5,129	$ 5,314	$ 5,507	$ 5,706	$ 5,912	$ 6,126	$ 6,347	$ 6,577	$ 6,814	$ 7,061	$ 7,316
North Brookfield WWTP	$ 1,452	$ 1,505	$ 1,559	$ 1,616	$ 1,674	$ 1,735	$ 1,797	$ 1,862	$ 1,930	$ 1,999	$ 2,072	$ 2,147
Northampton WWTF	$ 4,691,005	$ 4,860,608	$ 5,036,343	$ 5,218,432	$ 5,407,105	$ 5,602,599	$ 5,805,160	$ 6,015,046	$ 6,232,520	$ 6,457,857	$ 6,691,341	$ 6,933,266
Northbridge WWTF	$ 183,334	$ 189,963	$ 196,831	$ 203,947	$ 211,321	$ 218,961	$ 226,878	$ 235,081	$ 243,580	$ 252,387	$ 261,512	$ 270,967
Northfield WPCF	$ 4,342	$ 4,499	$ 4,662	$ 4,830	$ 5,005	$ 5,186	$ 5,373	$ 5,568	$ 5,769	$ 5,978	$ 6,194	$ 6,418
Oak Bluffs WWTP	$ 10,275	$ 10,647	$ 11,032	$ 11,430	$ 11,844	$ 12,272	$ 12,716	$ 13,175	$ 13,652	$ 14,145	$ 14,657	$ 15,187
Old Deerfield - Historic WWTP	$ 30,752	$ 31,864	$ 33,016	$ 34,209	$ 35,446	$ 36,728	$ 38,055	$ 39,431	$ 40,857	$ 42,334	$ 43,865	$ 45,451
Orange WWTP	$ 86,214	$ 89,331	$ 92,561	$ 95,907	$ 99,375	$ 102,968	$ 106,690	$ 110,548	$ 114,545	$ 118,686	$ 122,977	$ 127,423
Orange WWTP	$ 27,413	$ 28,405	$ 29,432	$ 30,496	$ 31,598	$ 32,741	$ 33,924	$ 35,151	$ 36,422	$ 37,739	$ 39,103	$ 40,517
Otis DPW	$ 58	$ 60	$ 62	$ 64	$ 67	$ 69	$ 72	$ 74	$ 77	$ 80	$ 82	$ 85
Oxford-Rochdale SD WPCP	$ 48,977	$ 50,748	$ 52,583	$ 54,484	$ 56,454	$ 58,495	$ 60,610	$ 62,801	$ 65,072	$ 67,424	$ 69,862	$ 72,388
Palmer WWTF	$ 3,385,079	$ 3,507,466	$ 3,634,279	$ 3,765,676	$ 3,901,824	$ 4,042,895	$ 4,189,066	$ 4,340,521	$ 4,497,453	$ 4,660,058	$ 4,828,543	$ 5,003,119
Pepperell WWTF	$ 963	$ 998	$ 1,034	$ 1,071	$ 1,110	$ 1,150	$ 1,192	$ 1,235	$ 1,280	$ 1,326	$ 1,374	$ 1,423
Pittsfield WWTP	$ 8,780,116	$ 9,097,561	$ 9,426,483	$ 9,767,298	$ 10,120,434	$ 10,486,338	$ 10,865,472	$ 11,258,313	$ 11,665,358	$ 12,087,119	$ 12,524,128	$ 12,976,938
Plymouth WWTF	$ 262,972	$ 272,479	$ 282,331	$ 292,539	$ 303,115	$ 314,074	$ 325,430	$ 337,196	$ 349,387	$ 362,019	$ 375,108	$ 388,670
Provincetown Public Works	$ 39,880	$ 41,322	$ 42,816	$ 44,364	$ 45,968	$ 47,629	$ 49,352	$ 51,136	$ 52,985	$ 54,900	$ 56,885	$ 58,942
Rockland WWTP	$ 314,604	$ 325,979	$ 337,764	$ 349,976	$ 362,630	$ 375,741	$ 389,325	$ 403,401	$ 417,986	$ 433,099	$ 448,757	$ 464,982
Rockport WWTP	$ 286,911	$ 297,284	$ 308,033	$ 319,169	$ 330,709	$ 342,666	$ 355,055	$ 367,892	$ 381,193	$ 394,975	$ 409,255	$ 424,052

Table H-7F: Annual Solids Hauling Cost per year, per plant (3.1% escalation)

POTW name	2036	2037	2038	2039	2040	2041	2042	2043	2044
Marlborough East WWTP	$ 1,454,623	$ 1,507,215	$ 1,561,709	$ 1,618,172	$ 1,676,677	$ 1,737,298	$ 1,800,110	$ 1,865,193	$ 1,932,629
Marlborough West WWTP	$ 828,013	$ 857,949	$ 888,969	$ 921,109	$ 954,412	$ 988,919	$ 1,024,673	$ 1,061,720	$ 1,100,107
Marshfield WWTF	$ 140,684	$ 145,770	$ 151,041	$ 156,502	$ 162,160	$ 168,023	$ 174,098	$ 180,392	$ 186,914
Marshfield WWTF	$ 171,996	$ 178,215	$ 184,658	$ 191,335	$ 198,252	$ 205,420	$ 212,847	$ 220,543	$ 228,516
Maynard WWTP	$ 55,928	$ 57,950	$ 60,045	$ 62,216	$ 64,465	$ 66,796	$ 69,211	$ 71,714	$ 74,306
Maynard WWTP	$ 4,440,529	$ 4,601,076	$ 4,767,428	$ 4,939,795	$ 5,118,393	$ 5,303,448	$ 5,495,195	$ 5,693,873	$ 5,899,735
MCI Bridgewater	$ 112,013	$ 116,063	$ 120,260	$ 124,608	$ 129,113	$ 133,781	$ 138,618	$ 143,629	$ 148,822
MCI Concord	$ 92,851	$ 96,208	$ 99,687	$ 103,291	$ 107,025	$ 110,895	$ 114,904	$ 119,059	$ 123,363
MCI Norfolk	$ 76,955	$ 79,737	$ 82,620	$ 85,607	$ 88,702	$ 91,909	$ 95,232	$ 98,675	$ 102,243
Medfield WWTP	$ 485,879	$ 503,446	$ 521,648	$ 540,509	$ 560,051	$ 580,299	$ 601,280	$ 623,019	$ 645,545
Merrimac WWTP	$ 172,153	$ 178,377	$ 184,826	$ 191,509	$ 198,433	$ 205,607	$ 213,041	$ 220,743	$ 228,724
Middleborough WWTP	$ 543,331	$ 562,975	$ 583,330	$ 604,420	$ 626,273	$ 648,916	$ 672,377	$ 696,687	$ 721,876
Milford WWTP	$ 1,212,871	$ 1,256,723	$ 1,302,160	$ 1,349,239	$ 1,398,021	$ 1,448,566	$ 1,500,939	$ 1,555,206	$ 1,611,434
Monroe WWTP	$ 123,925	$ 128,405	$ 133,048	$ 137,858	$ 142,843	$ 148,007	$ 153,358	$ 158,903	$ 164,648
Montague WPCF	$ 275,504	$ 285,465	$ 295,786	$ 306,480	$ 317,561	$ 329,043	$ 340,939	$ 353,266	$ 366,038
Montague WPCF	$ 6,736	$ 6,979	$ 7,232	$ 7,493	$ 7,764	$ 8,045	$ 8,335	$ 8,637	$ 8,949
Montague WPCF	$ 35,189	$ 36,461	$ 37,779	$ 39,145	$ 40,561	$ 42,027	$ 43,547	$ 45,121	$ 46,752
MWRA Clinton WWTP	$ 362,345	$ 375,445	$ 389,019	$ 403,084	$ 417,658	$ 432,758	$ 448,405	$ 464,617	$ 481,415
MWRA Deer Island WWTP	$ 8,756,203	$ 9,072,783	$ 9,400,810	$ 9,740,696	$ 10,092,871	$ 10,457,779	$ 10,835,880	$ 11,227,651	$ 11,633,587
Nantucket Sewer Dept. - Siascon	$ 162	$ 168	$ 174	$ 181	$ 187	$ 194	$ 201	$ 208	$ 216
Nantucket Sewer Dept. - Surfside	$ 7,815	$ 8,098	$ 8,391	$ 8,694	$ 9,009	$ 9,334	$ 9,672	$ 10,021	$ 10,384
New Bedford WWTP	$ 7,842,994	$ 8,126,558	$ 8,420,373	$ 8,724,812	$ 9,040,257	$ 9,367,108	$ 9,705,776	$ 10,056,688	$ 10,420,288
Newburyport WWTP	$ 675,446	$ 699,867	$ 725,170	$ 751,389	$ 778,555	$ 806,704	$ 835,870	$ 866,091	$ 897,405
North Attleborough WPCF	$ 7,581	$ 7,855	$ 8,139	$ 8,433	$ 8,738	$ 9,054	$ 9,381	$ 9,720	$ 10,072
North Attleborough WPCF	$ 7,581	$ 7,855	$ 8,139	$ 8,433	$ 8,738	$ 9,054	$ 9,381	$ 9,720	$ 10,072
North Brookfield WWTP	$ 2,224	$ 2,305	$ 2,388	$ 2,474	$ 2,564	$ 2,656	$ 2,752	$ 2,852	$ 2,955
Northampton WWTF	$ 7,183,938	$ 7,443,674	$ 7,712,800	$ 7,991,656	$ 8,280,594	$ 8,579,979	$ 8,890,188	$ 9,211,613	$ 9,544,659
Northbridge WWTF	$ 280,763	$ 290,914	$ 301,432	$ 312,331	$ 323,623	$ 335,324	$ 347,447	$ 360,009	$ 373,025
Northfield WPCF	$ 6,650	$ 6,890	$ 7,139	$ 7,397	$ 7,665	$ 7,942	$ 8,229	$ 8,526	$ 8,835
Oak Bluffs WWTP	$ 15,736	$ 16,305	$ 16,894	$ 17,505	$ 18,138	$ 18,794	$ 19,473	$ 20,177	$ 20,907
Old Deerfield - Historic WWTP	$ 47,094	$ 48,797	$ 50,561	$ 52,389	$ 54,283	$ 56,246	$ 58,279	$ 60,386	$ 62,570
Orange WWTP	$ 132,030	$ 136,804	$ 141,750	$ 146,875	$ 152,185	$ 157,688	$ 163,389	$ 169,296	$ 175,417
Orange WWTP	$ 41,982	$ 43,500	$ 45,072	$ 46,702	$ 48,390	$ 50,140	$ 51,953	$ 53,831	$ 55,777
Otis DPW	$ 89	$ 92	$ 95	$ 99	$ 102	$ 106	$ 110	$ 114	$ 118
Oxford-Rochdale SD WPCP	$ 75,005	$ 77,717	$ 80,527	$ 83,438	$ 86,455	$ 89,581	$ 92,820	$ 96,176	$ 99,653
Palmer WWTF	$ 5,184,006	$ 5,371,434	$ 5,565,638	$ 5,766,864	$ 5,975,365	$ 6,191,404	$ 6,415,254	$ 6,647,198	$ 6,887,527
Pepperell WWTF	$ 1,475	$ 1,528	$ 1,584	$ 1,641	$ 1,700	$ 1,762	$ 1,825	$ 1,891	$ 1,960
Pittsfield WWTP	$ 13,446,119	$ 13,932,264	$ 14,435,985	$ 14,957,918	$ 15,498,721	$ 16,059,078	$ 16,639,694	$ 17,241,302	$ 17,864,661
Plymouth WWTF	$ 402,722	$ 417,283	$ 432,370	$ 448,002	$ 464,199	$ 480,982	$ 498,372	$ 516,391	$ 535,061
Provincetown Public Works	$ 61,073	$ 63,281	$ 65,569	$ 67,940	$ 70,396	$ 72,941	$ 75,578	$ 78,311	$ 81,142
Rockland WWTP	$ 481,794	$ 499,213	$ 517,262	$ 535,964	$ 555,341	$ 575,420	$ 596,224	$ 617,781	$ 640,116
Rockport WWTP	$ 439,384	$ 455,270	$ 471,730	$ 488,785	$ 506,457	$ 524,768	$ 543,741	$ 563,400	$ 583,770

Table H-7F: Annual Solids Hauling Cost per year, per plant (3.1% escalation)

POTW name	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Royalston WWTF	$ 75	$ 78	$ 81	$ 84	$ 87	$ 90	$ 93	$ 96	$ 100	$ 103	$ 107	$ 111
Russell Village WWTF	$ 2,195	$ 2,275	$ 2,357	$ 2,442	$ 2,530	$ 2,622	$ 2,717	$ 2,815	$ 2,917	$ 3,022	$ 3,131	$ 3,245
Salisbury WWTF	$ 2,506	$ 2,596	$ 2,690	$ 2,788	$ 2,888	$ 2,993	$ 3,101	$ 3,213	$ 3,329	$ 3,450	$ 3,574	$ 3,704
Scituate WWTF	$ 2,308	$ 2,392	$ 2,478	$ 2,568	$ 2,660	$ 2,757	$ 2,856	$ 2,960	$ 3,067	$ 3,177	$ 3,292	$ 3,411
Shelburne Falls WWTP	$ 13,455	$ 13,942	$ 14,446	$ 14,968	$ 15,509	$ 16,070	$ 16,651	$ 17,253	$ 17,877	$ 18,523	$ 19,193	$ 19,887
Somerset WWTF	$ 3,376	$ 3,498	$ 3,624	$ 3,755	$ 3,891	$ 4,032	$ 4,178	$ 4,329	$ 4,485	$ 4,647	$ 4,815	$ 4,989
South Deerfield	$ 32,842	$ 34,030	$ 35,260	$ 36,535	$ 37,856	$ 39,224	$ 40,643	$ 42,112	$ 43,634	$ 45,212	$ 46,847	$ 48,540
South Essex Sewerage District	$ 47,498	$ 49,216	$ 50,995	$ 52,839	$ 54,749	$ 56,729	$ 58,780	$ 60,905	$ 63,107	$ 65,389	$ 67,753	$ 70,202
South Essex Sewerage District	$ 1,046,450	$ 1,084,285	$ 1,123,487	$ 1,164,107	$ 1,206,195	$ 1,249,805	$ 1,294,992	$ 1,341,812	$ 1,390,325	$ 1,440,593	$ 1,492,677	$ 1,546,645
South Essex Sewerage District	$ 7,670,976	$ 7,948,320	$ 8,235,692	$ 8,533,453	$ 8,841,980	$ 9,161,662	$ 9,492,902	$ 9,836,118	$ 10,191,743	$ 10,560,225	$ 10,942,030	$ 11,337,639
South Essex Sewerage District	$ 795,062	$ 823,807	$ 853,592	$ 884,453	$ 916,431	$ 949,564	$ 983,896	$ 1,019,469	$ 1,056,327	$ 1,094,519	$ 1,134,091	$ 1,175,094
South Essex Sewerage District	$ 355,181	$ 368,023	$ 381,329	$ 395,116	$ 409,401	$ 424,203	$ 439,540	$ 455,431	$ 471,898	$ 488,959	$ 506,637	$ 524,955
South Hadley WWTP	$ 539,132	$ 558,624	$ 578,821	$ 599,748	$ 621,432	$ 643,900	$ 667,180	$ 691,302	$ 716,296	$ 742,194	$ 769,028	$ 796,832
Southbridge WWTP	$ 153,072	$ 158,606	$ 164,341	$ 170,283	$ 176,439	$ 182,818	$ 189,428	$ 196,277	$ 203,373	$ 210,726	$ 218,345	$ 226,239
Spencer WWTP	$ 40,475	$ 41,938	$ 43,454	$ 45,025	$ 46,653	$ 48,340	$ 50,088	$ 51,899	$ 53,775	$ 55,719	$ 57,734	$ 59,821
Springfield WWTP - Bondi's Islan	$ 885,172	$ 917,176	$ 950,336	$ 984,696	$ 1,020,297	$ 1,057,186	$ 1,095,409	$ 1,135,013	$ 1,176,050	$ 1,218,570	$ 1,262,627	$ 1,308,278
Springfield WWTP - Bondi's Islan	$ 264,201	$ 273,753	$ 283,650	$ 293,906	$ 304,532	$ 315,542	$ 326,951	$ 338,772	$ 351,020	$ 363,711	$ 376,861	$ 390,486
Springfield WWTP - Bondi's Islan	$ 2,599,492	$ 2,693,476	$ 2,790,859	$ 2,891,763	$ 2,996,314	$ 3,104,646	$ 3,216,894	$ 3,333,201	$ 3,453,713	$ 3,578,582	$ 3,707,966	$ 3,842,027
Springfield WWTP - Bondi's Islan	$ 2,592,096	$ 2,685,813	$ 2,782,918	$ 2,883,535	$ 2,987,789	$ 3,095,812	$ 3,207,742	$ 3,323,717	$ 3,443,886	$ 3,568,400	$ 3,697,416	$ 3,831,096
Springfield WWTP - Bondi's Islan	$ 375,920	$ 389,512	$ 403,595	$ 418,187	$ 433,306	$ 448,972	$ 465,205	$ 482,024	$ 499,452	$ 517,510	$ 536,220	$ 555,607
Springfield WWTP - Bondi's Islan	$ 240,323	$ 249,012	$ 258,015	$ 267,343	$ 277,009	$ 287,024	$ 297,402	$ 308,154	$ 319,295	$ 330,840	$ 342,801	$ 355,195
Springfield WWTP - Bondi's Islan	$ 944,947	$ 979,111	$ 1,014,511	$ 1,051,191	$ 1,089,196	$ 1,128,576	$ 1,169,380	$ 1,211,659	$ 1,255,466	$ 1,300,858	$ 1,347,890	$ 1,396,623
Stockbridge WWTP	$ 2,740	$ 2,839	$ 2,942	$ 3,048	$ 3,158	$ 3,272	$ 3,391	$ 3,513	$ 3,640	$ 3,772	$ 3,908	$ 4,050
Sturbridge WPCF	$ 39,085	$ 40,498	$ 41,963	$ 43,480	$ 45,052	$ 46,681	$ 48,368	$ 50,117	$ 51,929	$ 53,807	$ 55,752	$ 57,768
Sunderland WWTP	$ 1,172	$ 1,214	$ 1,258	$ 1,304	$ 1,351	$ 1,400	$ 1,450	$ 1,503	$ 1,557	$ 1,613	$ 1,672	$ 1,732
Sunderland WWTP	$ 56,382	$ 58,421	$ 60,533	$ 62,722	$ 64,989	$ 67,339	$ 69,774	$ 72,296	$ 74,910	$ 77,619	$ 80,425	$ 83,333
Taunton WWTP	$ 5,971,889	$ 6,187,803	$ 6,411,523	$ 6,643,332	$ 6,883,521	$ 7,132,395	$ 7,390,267	$ 7,657,462	$ 7,934,317	$ 8,221,183	$ 8,518,420	$ 8,826,403
Templeton WWTP	$ 194,042	$ 201,057	$ 208,326	$ 215,858	$ 223,663	$ 231,749	$ 240,128	$ 248,810	$ 257,806	$ 267,127	$ 276,785	$ 286,792
Tisbury Public Works	$ 268	$ 278	$ 288	$ 298	$ 309	$ 320	$ 332	$ 344	$ 356	$ 369	$ 382	$ 396
Upper Blackstone WPAD (Worce	$ 13,845,722	$ 14,346,314	$ 14,865,005	$ 15,402,449	$ 15,959,325	$ 16,536,334	$ 17,134,206	$ 17,753,693	$ 18,395,578	$ 19,060,670	$ 19,749,808	$ 20,463,862
Upton WWTP	$ 6,877	$ 7,126	$ 7,384	$ 7,651	$ 7,927	$ 8,214	$ 8,511	$ 8,819	$ 9,137	$ 9,468	$ 9,810	$ 10,165
Uxbridge WWTF	$ 4,293	$ 4,448	$ 4,609	$ 4,775	$ 4,948	$ 5,127	$ 5,312	$ 5,504	$ 5,703	$ 5,909	$ 6,123	$ 6,344
Ware WWTP	$ 15,719	$ 16,288	$ 16,877	$ 17,487	$ 18,119	$ 18,774	$ 19,453	$ 20,156	$ 20,885	$ 21,640	$ 22,422	$ 23,233
Wareham WPCF	$ 3,084	$ 3,196	$ 3,311	$ 3,431	$ 3,555	$ 3,683	$ 3,817	$ 3,955	$ 4,097	$ 4,246	$ 4,399	$ 4,558
Warren WWTP	$ 36,293	$ 37,605	$ 38,965	$ 40,374	$ 41,833	$ 43,346	$ 44,913	$ 46,537	$ 48,219	$ 49,963	$ 51,769	$ 53,641
Wayland WWTP	$ 173	$ 180	$ 186	$ 193	$ 200	$ 207	$ 215	$ 222	$ 230	$ 239	$ 247	$ 256
Webster WWTF	$ 3,724	$ 3,859	$ 3,998	$ 4,143	$ 4,293	$ 4,448	$ 4,609	$ 4,775	$ 4,948	$ 5,127	$ 5,312	$ 5,504
West Stockbridge	$ 16,293	$ 16,882	$ 17,493	$ 18,125	$ 18,780	$ 19,459	$ 20,163	$ 20,892	$ 21,647	$ 22,430	$ 23,241	$ 24,081
Westborough WWTF	$ 5,543	$ 5,743	$ 5,951	$ 6,166	$ 6,389	$ 6,620	$ 6,860	$ 7,108	$ 7,364	$ 7,631	$ 7,907	$ 8,192
Westborough WWTF	$ 2,044,914	$ 2,118,848	$ 2,195,454	$ 2,274,831	$ 2,357,078	$ 2,442,298	$ 2,530,599	$ 2,622,093	$ 2,716,895	$ 2,815,124	$ 2,916,905	$ 3,022,365
Westfield WPCP	$ 5,450,762	$ 5,647,835	$ 5,852,032	$ 6,063,612	$ 6,282,842	$ 6,509,998	$ 6,745,367	$ 6,989,246	$ 7,241,942	$ 7,503,775	$ 7,775,074	$ 8,056,181
Winchendon WPCF	$ 79,404	$ 82,275	$ 85,250	$ 88,332	$ 91,526	$ 94,835	$ 98,263	$ 101,816	$ 105,497	$ 109,312	$ 113,264	$ 117,359

Table H-7F: Annual Solids Hauling Cost per year, per plant (3.1% escalation)

POTW name	2036	2037	2038	2039	2040	2041	2042	2043	2044
Royalston WWTF	$ 115	$ 119	$ 124	$ 128	$ 133	$ 137	$ 142	$ 148	$ 153
Russell Village WWTF	$ 3,362	$ 3,483	$ 3,609	$ 3,740	$ 3,875	$ 4,015	$ 4,160	$ 4,311	$ 4,467
Salisbury WWTF	$ 3,837	$ 3,976	$ 4,120	$ 4,269	$ 4,423	$ 4,583	$ 4,749	$ 4,921	$ 5,098
Scituate WWTF	$ 3,535	$ 3,662	$ 3,795	$ 3,932	$ 4,074	$ 4,222	$ 4,374	$ 4,532	$ 4,696
Shelburne Falls WWTP	$ 20,606	$ 21,351	$ 22,123	$ 22,923	$ 23,751	$ 24,610	$ 25,500	$ 26,422	$ 27,377
Somerset WWTF	$ 5,170	$ 5,357	$ 5,550	$ 5,751	$ 5,959	$ 6,174	$ 6,398	$ 6,629	$ 6,869
South Deerfield	$ 50,295	$ 52,114	$ 53,998	$ 55,950	$ 57,973	$ 60,069	$ 62,241	$ 64,491	$ 66,823
South Essex Sewerage District	$ 72,740	$ 75,370	$ 78,095	$ 80,919	$ 83,845	$ 86,876	$ 90,017	$ 93,271	$ 96,644
South Essex Sewerage District	$ 1,602,564	$ 1,660,505	$ 1,720,540	$ 1,782,746	$ 1,847,201	$ 1,913,987	$ 1,983,187	$ 2,054,889	$ 2,129,184
South Essex Sewerage District	$ 11,747,551	$ 12,172,284	$ 12,612,373	$ 13,068,373	$ 13,540,860	$ 14,030,430	$ 14,537,700	$ 15,063,311	$ 15,607,925
South Essex Sewerage District	$ 1,217,580	$ 1,261,601	$ 1,307,215	$ 1,354,477	$ 1,403,448	$ 1,454,190	$ 1,506,766	$ 1,561,243	$ 1,617,690
South Essex Sewerage District	$ 543,935	$ 563,600	$ 583,977	$ 605,091	$ 626,968	$ 649,636	$ 673,124	$ 697,461	$ 722,677
South Hadley WWTP	$ 825,642	$ 855,493	$ 886,423	$ 918,472	$ 951,679	$ 986,087	$ 1,021,739	$ 1,058,680	$ 1,096,957
Southbridge WWTP	$ 234,419	$ 242,894	$ 251,676	$ 260,776	$ 270,204	$ 279,973	$ 290,096	$ 300,584	$ 311,452
Spencer WWTP	$ 61,984	$ 64,225	$ 66,547	$ 68,953	$ 71,446	$ 74,029	$ 76,706	$ 79,479	$ 82,353
Springfield WWTP - Bondi's Islan	$ 1,355,578	$ 1,404,589	$ 1,455,372	$ 1,507,991	$ 1,562,513	$ 1,619,005	$ 1,677,540	$ 1,738,192	$ 1,801,036
Springfield WWTP - Bondi's Islan	$ 404,604	$ 419,233	$ 434,390	$ 450,096	$ 466,369	$ 483,230	$ 500,702	$ 518,804	$ 537,562
Springfield WWTP - Bondi's Islan	$ 3,980,936	$ 4,124,867	$ 4,274,001	$ 4,428,528	$ 4,588,641	$ 4,754,543	$ 4,926,444	$ 5,104,559	$ 5,289,115
Springfield WWTP - Bondi's Islan	$ 3,969,609	$ 4,113,130	$ 4,261,840	$ 4,415,927	$ 4,575,585	$ 4,741,015	$ 4,912,427	$ 5,090,036	$ 5,274,066
Springfield WWTP - Bondi's Islan	$ 575,695	$ 596,510	$ 618,076	$ 640,423	$ 663,577	$ 687,569	$ 712,428	$ 738,186	$ 764,875
Springfield WWTP - Bondi's Islan	$ 368,037	$ 381,343	$ 395,131	$ 409,417	$ 424,219	$ 439,557	$ 455,449	$ 471,916	$ 488,978
Springfield WWTP - Bondi's Islan	$ 1,447,118	$ 1,499,439	$ 1,553,651	$ 1,609,823	$ 1,668,026	$ 1,728,334	$ 1,790,822	$ 1,855,569	$ 1,922,657
Stockbridge WWTP	$ 4,196	$ 4,348	$ 4,505	$ 4,668	$ 4,837	$ 5,012	$ 5,193	$ 5,381	$ 5,575
Sturbridge WPCF	$ 59,856	$ 62,020	$ 64,263	$ 66,586	$ 68,994	$ 71,488	$ 74,073	$ 76,751	$ 79,526
Sunderland WWTP	$ 1,795	$ 1,860	$ 1,927	$ 1,997	$ 2,069	$ 2,144	$ 2,221	$ 2,301	$ 2,385
Sunderland WWTP	$ 86,346	$ 89,467	$ 92,702	$ 96,054	$ 99,527	$ 103,125	$ 106,853	$ 110,717	$ 114,720
Taunton WWTP	$ 9,145,522	$ 9,476,178	$ 9,818,789	$ 10,173,788	$ 10,541,621	$ 10,922,753	$ 11,317,665	$ 11,726,855	$ 12,150,840
Templeton WWTP	$ 297,161	$ 307,905	$ 319,037	$ 330,572	$ 342,524	$ 354,908	$ 367,739	$ 381,035	$ 394,811
Tisbury Public Works	$ 410	$ 425	$ 441	$ 456	$ 473	$ 490	$ 508	$ 526	$ 545
Upper Blackstone WPAD (Worce	$ 21,203,733	$ 21,970,354	$ 22,764,693	$ 23,587,750	$ 24,440,565	$ 25,324,214	$ 26,239,811	$ 27,188,511	$ 28,171,512
Upton WWTP	$ 10,532	$ 10,913	$ 11,308	$ 11,717	$ 12,140	$ 12,579	$ 13,034	$ 13,505	$ 13,993
Uxbridge WWTF	$ 6,574	$ 6,812	$ 7,058	$ 7,313	$ 7,577	$ 7,851	$ 8,135	$ 8,429	$ 8,734
Ware WWTP	$ 24,073	$ 24,943	$ 25,845	$ 26,780	$ 27,748	$ 28,751	$ 29,791	$ 30,868	$ 31,984
Wareham WPCF	$ 4,723	$ 4,894	$ 5,071	$ 5,254	$ 5,444	$ 5,641	$ 5,845	$ 6,056	$ 6,275
Warren WWTP	$ 55,580	$ 57,590	$ 59,672	$ 61,829	$ 64,065	$ 66,381	$ 68,781	$ 71,268	$ 73,845
Wayland WWTP	$ 266	$ 275	$ 285	$ 296	$ 306	$ 317	$ 329	$ 341	$ 353
Webster WWTF	$ 5,703	$ 5,910	$ 6,123	$ 6,345	$ 6,574	$ 6,812	$ 7,058	$ 7,313	$ 7,578
West Stockbridge	$ 24,952	$ 25,854	$ 26,789	$ 27,757	$ 28,761	$ 29,801	$ 30,878	$ 31,995	$ 33,151
Westborough WWTF	$ 8,489	$ 8,796	$ 9,114	$ 9,443	$ 9,785	$ 10,138	$ 10,505	$ 10,885	$ 11,278
Westborough WWTF	$ 3,131,639	$ 3,244,863	$ 3,362,182	$ 3,483,741	$ 3,609,696	$ 3,740,204	$ 3,875,431	$ 4,015,548	$ 4,160,730
Westfield WPCP	$ 8,347,453	$ 8,649,255	$ 8,961,969	$ 9,285,988	$ 9,621,723	$ 9,969,597	$ 10,330,048	$ 10,703,530	$ 11,090,517
Winchendon WPCF	$ 121,602	$ 125,998	$ 130,554	$ 135,274	$ 140,165	$ 145,232	$ 150,483	$ 155,924	$ 161,561

Table H-7F: Annual Solids Hauling Cost per year, per plant (3.1% escalation)

POTW name	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Sum	$ 121,735,921	$ 126,102,064	$ 130,624,973	$ 135,310,281	$ 140,163,827	$ 145,191,656	$ 150,400,032	$ 155,795,445	$ 161,384,619	$ 167,174,517	$ 173,172,354	$ 179,385,607
Discounted at 2.2%	$ 119,115,383	$ 120,731,446	$ 122,369,596	$ 124,030,134	$ 125,713,369	$ 127,419,613	$ 129,149,182	$ 130,902,395	$ 132,679,577	$ 134,481,058	$ 136,307,172	$ 138,158,257
	GRAND TOTAL	**$ 2,872,074,000**										

Table H-7F: Annual Solids Hauling Cost per year, per plant (3.1% escalation)

POTW name	2036	2037	2038	2039	2040	2041	2042	2043	2044
Sum	$ 185,822,018	$ 192,489,610	$ 199,396,694	$ 206,551,880	$ 213,964,087	$ 221,642,557	$ 229,596,863	$ 237,836,922	$ 246,373,009
Discounted at 2.2%	$ 140,034,655	$ 141,936,716	$ 143,864,790	$ 145,819,236	$ 147,800,416	$ 149,808,698	$ 151,844,452	$ 153,908,058	$ 155,999,898

Table H-7G: Summary of Scenario 7 Calculations - Additional sludge disposal capacity becomes available

For scenario 7, the estimated cost of rehabilitating 5 incinerators ($650M) was converted to an annual equivalent rate, assuming a 20 year usable life, and 4.7% interest rate. O&M costs were calculated for each year, starting with $7M/yr in the first year, and incorporating an escalation of 4.7%. $7M was selected as a representative proportion of the total O&M budget for UBCW ($21M).

Rehabilitation of incinerators was assumed to have an impact of reducing price escalation for solids management from 6.2%/yr to 3.1%/yr. Solids management costs were determined by projecting sludge quantity growth (concurrent with population growth) through 2044, as well as price increases, using 6.2%/yr. Costs for each plant were calculated by multiplying quantities and unit prices and summing to a net present cost. This was then converted to an annual equivalent rate.

Next, these calculations were repeated but using price increases of 3.1%/yr. The difference between these was taken as the savings that would be experienced by POTWs in Massachusetts as a result of decreasing pressure on the biosolids market. For scenarios 7, 8, and 9, this took the form of new solids handling capacity, and for Scenario 10 this took the form of industrial pretreatment reducing PFAS concentrations in biosolids.

Assumptions	
Costs for hauling are assumed to increase at 3.1%/yr instead of 6.2%/yr	
Population increases 0.5% per year	
Calculated costs at both rate increases and found difference	
Estimated price to rehabilitate all 5 incinerators	$ 650,000,000
Annual equivalent rate for amortized capital	$ 50,839,000
Estimated annual O&M cost	$ 14,798,000
Amount for sludge hauling paid at 6.2% escalation, including population growth	$ 4,095,145,000
Annual basis	$ 320,298,000
Amount for sludge hauling paid at 3.1% escalation, including population growth	$ 2,872,074,000
Annual basis	$ 224,637,000
Net Decrease in hauling costs	$ 1,223,071,000

Savings in hauling costs, converted to annual basis	**$ 95,661,000**

Net Savings for Scenario 7	**$ 30,024,000**

Table H-7H: Incinerator Rehabilitation and Operation Costs Calculations

For Scenario 7, the cost of rehabilitating five separate incinerators was estimated from the cost of rehabilitating Upper Blackstone ($650M). O&M costs were calculated for each year, starting with $7M/yr in the first year, and incorporating an escalation of 4.7%. $7M was selected as a representative proportion of the total O&M budget for UBCW ($21M). The total cost for each year was calculated, then discounted back to present dollars using 2.2%. The discounted costs for each year were summed to provide a net present cost for rehabilitating incinerators, and converted to an equivalent rate. Subtracting the savings resulting from a decrease in sludge management price escalation provided the net annual savings for this scenario.

Cost for 35,000 dtpy	$ 650,000,000	Estimated cost to rehabilitate Upper Blackstone, assume same cost for rehabilitating five incinerators					
	2024	2025	2026	2027	2028	2029	2030
Capital	$ 650,000,000						
O&M	$ 7,000,000	$ 7,329,000	$ 7,673,463	$ 8,034,116	$ 8,411,719	$ 8,807,070	$ 9,221,002
Total	$ 657,000,000	$ 7,329,000	$ 7,673,463	$ 8,034,116	$ 8,411,719	$ 8,807,070	$ 9,221,002
Discounted	$ 657,000,000	$ 7,171,233	$ 7,346,654	$ 7,526,367	$ 7,710,476	$ 7,899,088	$ 8,092,315

	2031	2032	2033	2034	2035	2036	2037
O&M	$ 9,654,389	$ 10,108,146	$ 10,583,229	$ 11,080,640	$ 11,601,430	$ 12,146,698	$ 12,717,592
Total	$ 9,654,389	$ 10,108,146	$ 10,583,229	$ 11,080,640	$ 11,601,430	$ 12,146,698	$ 12,717,592
Discounted	$ 8,290,267	$ 8,493,063	$ 8,700,819	$ 8,913,657	$ 9,131,701	$ 9,355,079	$ 9,583,922
	2038	2039	2040	2041	2042	2043	2044
O&M	$ 13,315,319	$ 13,941,139	$ 14,596,373	$ 15,282,402	$ 16,000,675	$ 16,752,707	$ 17,540,084
Total	$ 13,315,319	$ 13,941,139	$ 14,596,373	$ 15,282,402	$ 16,000,675	$ 16,752,707	$ 17,540,084
Discounted	$ 9,818,362	$ 10,058,537	$ 10,304,588	$ 10,556,657	$ 10,814,892	$ 11,079,444	$ 11,350,468
Net Present Cost for rehabilitated incinerators	**$ 839,197,588**						
Annual equivalent cost	**$ 65,637,144**						
Net annual savings from decreased price escalation	**$ 95,661,000**						
Net annual savings for this Scenario	**$ 30,024,000**						

Table H-8A: Summary of Scenario 8 Calculations - Additional sludge reduction capacity becomes available

For Scenario 8, the cost of a 3600 dtpy drying facility was calculated using the cost curves developed in Part 2. Then this price was scaled based on capacity to a 35,000 dtpy facility. O&M costs fo 35,000 dtpy were calculated for each year, again based on cost curves and incorporating an escalation of 4.7%. The total cost for each year was calculated, then discounted back to present dollars using 2.2%. The discounted costs for each year were summed to provide a net present cost for a regional drying facility, and converted to an equivalent rate. Subtracting the savings resulting from a decrease in sludge management price escalation provided the net annual cost for this scenario.

Cost of 3600 dtpy	$ 139,713,036	Determined from cost curves					
Cost for 35,000 dtpy	$ 1,358,321,185	Scaled based on dry tonnage					
	2024	2025	2026	2027	2028	2029	2030
Capital	$ 1,358,321,185						
O&M	$ 34,206,851	$ 35,814,573	$ 37,497,858	$ 39,260,257	$ 41,105,489	$ 43,037,447	$ 45,060,207
Total	$ 1,392,528,036	$ 35,814,573	$ 37,497,858	$ 39,260,257	$ 41,105,489	$ 43,037,447	$ 45,060,207
Discounted	$ 1,392,528,036	$ 35,043,613	$ 35,900,845	$ 36,779,045	$ 37,678,729	$ 38,600,420	$ 39,544,657

	2031	2032	2033	2034	2035	2036	2037
O&M	$ 47,178,037	$ 49,395,405	$ 51,716,989	$ 54,147,687	$ 56,692,629	$ 59,357,182	$ 62,146,970
Total	$ 47,178,037	$ 49,395,405	$ 51,716,989	$ 54,147,687	$ 56,692,629	$ 59,357,182	$ 62,146,970
Discounted	$ 40,511,992	$ 41,502,990	$ 42,518,229	$ 43,558,303	$ 44,623,820	$ 45,715,400	$ 46,833,683
	2038	2039	2040	2041	2042	2043	2044
O&M	$ 65,067,877	$ 68,126,068	$ 71,327,993	$ 74,680,408	$ 78,190,388	$ 81,865,336	$ 85,713,007
Total	$ 65,067,877	$ 68,126,068	$ 71,327,993	$ 74,680,408	$ 78,190,388	$ 81,865,336	$ 85,713,007
Discounted	$ 47,979,321	$ 49,152,984	$ 50,355,356	$ 51,587,141	$ 52,849,057	$ 54,141,842	$ 55,466,251
Net Present Cost for regional dryer facility	**$ 2,282,871,713**						
Annual equivalent cost	**$ 178,552,921**						
Net annual savings from decreased price escalation	**$ 95,661,000**						
Net annual cost for this Scenario	**$ 82,892,000**						

Table H-9A: Summary of Scenario 9 Calculations - New sludge PFAS treatment capacity becomes available

For Scenario 9, the approach was identical to that in Scenario 8, with the exception of the captial and O&M costs reflecting pyrolysis instead of drying. The cost of a 3600 dtpy pyrolysis facility wa calculated using the cost curves developed in Part 2. Then this price was scaled based on capacity to a 35,000 dtpy facility. O&M costs for 35,000 dtpy were calculated for each year, again based on cost curves and incorporating an escalation of 4.7%. The total cost for each year was calculated, then discounted back to present dollars using 2.2%. The discounted costs for each year were summed to provide a net present cost for a regional pyrolysis facility, and converted to an equivalent rate. Subtracting the savings resulting from a decrease in sludge management price escalation provided the

Cost of 3600 dtpy	$ 129,298,882	Determined from cost curves					
Cost for 35,000 dtpy	$ 1,257,072,465	Scaled based on dry tonnage					
	2024	2025	2026	2027	2028	2029	2030
Capital	$ 1,257,072,465						
O&M	$ 13,504,000	$ 14,138,688	$ 14,803,206	$ 15,498,957	$ 16,227,408	$ 16,990,096	$ 17,788,631
Total	$ 1,270,576,465	$ 14,138,688	$ 14,803,206	$ 15,498,957	$ 16,227,408	$ 16,990,096	$ 17,788,631
Discounted	$ 1,270,576,465	$ 13,834,333	$ 14,172,746	$ 14,519,437	$ 14,874,609	$ 15,238,470	$ 15,611,231

	2031	2032	2033	2034	2035	2036	2037
O&M	$ 18,624,696	$ 19,500,057	$ 20,416,560	$ 21,376,138	$ 22,380,817	$ 23,432,715	$ 24,534,053
Total	$ 18,624,696	$ 19,500,057	$ 20,416,560	$ 21,376,138	$ 22,380,817	$ 23,432,715	$ 24,534,053
Discounted	$ 15,993,110	$ 16,384,331	$ 16,785,122	$ 17,195,717	$ 17,616,356	$ 18,047,284	$ 18,488,754
	2038	2039	2040	2041	2042	2043	2044
O&M	$ 25,687,153	$ 26,894,449	$ 28,158,488	$ 29,481,937	$ 30,867,588	$ 32,318,365	$ 33,837,328
Total	$ 25,687,153	$ 26,894,449	$ 28,158,488	$ 29,481,937	$ 30,867,588	$ 32,318,365	$ 33,837,328
Discounted	$ 18,941,023	$ 19,404,355	$ 19,879,021	$ 20,365,299	$ 20,863,472	$ 21,373,831	$ 21,896,674
Net Present Cost for regional dryer facility	**$ 1,622,061,640**						
Annual equivalent cost	**$ 126,868,208**						
Net annual savings from decreased price escalation	**$ 95,661,000**						
Net annual cost for this Scenario	**$ 31,207,000**						

Appendix I: Capital Cost Calculations

Alternative
GAC

Total Treatment Flow Rate			Units
Low	Middle	High	
0.5	5	20	MGD

		Low Flow Rate			Medium Flow Rate			Large Flow Rate			
Item Description	Unit	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Notes
Main Equipment	$	1	$692,009	$692,009	1	$4,439,303	$4,439,303	1	$17,001,281	$17,001,281	
Ancillary Equipment	$	1	$1,307,791	$1,307,791	1	$3,923,373	$3,923,373	1	$7,846,745	$7,846,745	
Equipment Installation	20%			$399,960	20%		$1,672,535	20%		$4,969,605	
Treatment Building		1,200	$564	$676,800	6,000	$564	$3,384,000	18,000	$564	$10,152,000	
Subtotal A				$3,076,560			$13,419,211			$39,969,632	
Misc. Demolition	5%			$153,828			$670,961			$1,998,482	
Electrical, Instrumentation, & Controls (minus bldg.)	50%			$1,199,880			$5,017,605			$14,908,816	
Site Work	10%			$307,656			$1,341,921			$3,996,963	
Misc. Piping	15%			$461,484			$2,012,882			$5,995,445	
Excavation and soil disposal	9%			$276,890			$1,207,729			$3,597,267	Not deep or special excavation
Subtotal B				$5,476,298			$23,670,308			$70,466,604	
Startup and Construction Sequencing	2%			$109,526			$473,406			$1,409,332	
General Conditions	15%			$821,445			$3,550,546			$10,569,991	
Contractor Overhead and Profit	20%			$1,095,260			$4,734,062			$14,093,321	
Sales Tax	6%			$342,269			$1,479,394			$4,404,163	
Bonds and Insurance	3%			$136,907			$591,758			$1,761,665	
Subtotal C				$7,981,704			$34,499,474			$102,705,075	
Engineering	10%			$798,170			$3,449,947			$10,270,508	
Construction Management	10%			$798,170			$3,449,947			$10,270,508	
Subtotal Project Costs				$9,578,045			$41,399,369			$123,246,090	
Estimating Contingency	30%			$2,873,414			$12,419,811			$36,973,827	
Total Project Cost				**$12,451,459**			**$53,819,179**			**$160,219,917**	
Estimated Accuracy Range	-50%			$6,225,729			$26,909,590			$80,109,959	
	100%			$24,902,918			$107,638,359			$320,439,834	

Alternative
IX

Total Treatment Flow Rate			Units
Low	Middle	High	
0.5	5	20	MGD

		Low Flow Rate			Medium Flow Rate			Large Flow Rate			
Item Description	Unit	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Notes
Main Equipment	$	1	$587,555	$587,555	1	$3,917,032	$3,917,032	1	$10,462,327	$10,462,327	
Ancillary Equipment	$	1	$1,438,570	$1,438,570	1	$4,577,268	$4,577,268	1	$9,154,536	$9,154,536	
Equipment Installation	20%		IX	$405,225	20%		$1,698,860	20%		$3,923,373	
Treatment Building		1200	$564	$676,800	6000	$564	$3,384,000	20,000	$564	$11,280,000	
Subtotal A				$3,108,150			$13,577,160			$34,820,236	
Misc. Demolition	5%			$155,407			$678,858			$1,741,012	
Electrical, Instrumentation, & Controls (minus bldg.)	50%			$1,215,675			$5,096,580			$11,770,118	
Site Work	10%			$310,815			$1,357,716			$3,482,024	
Misc. Piping	15%			$466,222			$2,036,574			$5,223,035	
Excavation and soil disposal	9%			$279,733			$1,221,944			$3,133,821	Not deep or special excavation
Subtotal B				$5,536,003			$23,968,832			$60,170,245	
Startup and Construction Sequencing	2%			$110,720			$479,377			$1,203,405	
General Conditions	15%			$830,400			$3,595,325			$9,025,537	
Contractor Overhead and Profit	20%			$1,107,201			$4,793,766			$12,034,049	
Sales Tax	6%			$346,000			$1,498,052			$3,760,640	
Bonds and Insurance	3%			$138,400			$599,221			$1,504,256	
Subtotal C				$8,068,724			$34,934,573			$87,698,132	
Engineering	10%			$806,872			$3,493,457			$8,769,813	
Construction Management	10%			$806,872			$3,493,457			$8,769,813	
Subtotal Project Costs				$9,682,469			$41,921,488			$105,237,759	
Estimating Contingency	30%			$2,904,741			$12,576,446			$31,571,328	
Total Project Cost				**$12,587,210**			**$54,497,934**			**$136,809,086**	
Estimated Accuracy Range	-50%			$6,293,605			$27,248,967			$68,404,543	
	100%			$25,174,420			$108,995,868			$273,618,173	

Alternative
GAC & IX

Total Treatment Flow Rate			Units
Low	Middle	High	
0.5	5	20	MGD

		Low Flow Rate			Medium Flow Rate			Large Flow Rate			
Item Description	Unit	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Notes
Main Equipment	$	1	$1,279,564	$1,279,564	1	$8,356,335	$8,356,335	1	$28,160,333	$28,160,333	
Ancillary Equipment	$	1	$2,746,361	$2,746,361	1	$8,500,641	$8,500,641	1	$17,432,587	$17,432,587	
Equipment Installation	20%			$805,185	20%		$3,371,395	20%		$9,118,584	
Treatment Building		1200	$564	$676,800	6000	$564	$3,384,000	18,000	$564	$10,152,000	
Subtotal A				$5,507,910			$23,612,371			$64,863,505	
Misc. Demolition	5%			$275,395			$1,180,619			$3,243,175	
Electrical, Instrumentation, & Controls (minus bldg.)	50%			$2,415,555			$10,114,185			$27,355,752	
Site Work	10%			$550,791			$2,361,237			$6,486,350	
Misc. Piping	15%			$826,186			$3,541,856			$9,729,526	
Excavation and soil disposal	9%			$495,712			$2,125,113			$5,837,715	Not deep or special excavation
Subtotal B				$10,071,549			$42,935,380			$117,516,024	
Startup and Construction Sequencing	2%			$201,431			$858,708			$2,350,320	
General Conditions	15%			$1,510,732			$6,440,307			$17,627,404	
Contractor Overhead and Profit	20%			$2,014,310			$8,587,076			$23,503,205	
Sales Tax	6%			$629,472			$2,683,461			$7,344,751	
Bonds and Insurance	3%			$251,789			$1,073,385			$2,937,901	
Subtotal C				$14,679,283			$62,578,317			$171,279,605	
Engineering	10%			$1,467,928			$6,257,832			$17,127,960	
Construction Management	10%			$1,467,928			$6,257,832			$17,127,960	
Subtotal Project Costs				$17,615,139			$75,093,980			$205,535,526	
Estimating Contingency	30%			$5,284,542			$22,528,194			$61,660,658	
Total Project Cost				**$22,899,681**			**$97,622,174**			**$267,196,184**	
Estimated Accuracy Range	-50%			$11,449,840			$48,811,087			$133,598,092	
	100%			$45,799,362			$195,244,349			$534,392,367	

Alternative
Screw Press

Total Treatment Flow Rate			Units
Small	Medium	Medium - Large	
0.5	5	10	MGD
90	900	1800	dtyp
0.25	2.47	4.93	dtpd

		Small Flow Rate			Medium Flow Rate			Medium - Large Flow Rate			
Item Description	Unit	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Notes
Main Equipment	$	1	$935,000	$935,000	1	$2,244,990	$2,244,990	1	$3,053,477	$3,053,477	All costs in MA & 2024 $
Ancillary Equipment	$	1	$159,093	$159,093	1	$530,310	$530,310	1	$1,060,619	$1,060,619	All costs in MA & 2024 $
Equipment Installation	20%			$218,819			$555,060			$822,819	
Treatment Building		1893	$564	$1,067,652	2781.1875	$564	$1,568,590	3463.75	$564	$1,953,555	
Subtotal A				$2,380,563			$4,898,949			$6,890,471	
Misc. Demolition	5%			$119,028			$244,947			$344,524	
Electrical, Instrumentation, & Controls (minus bldg.)	50%			$656,456			$1,665,180			$2,468,458	
Site Work	10%			$238,056			$489,895			$689,047	
Misc. Piping	15%			$357,085			$734,842			$1,033,571	
Excavation and soil disposal	9%			$214,251			$440,905			$620,142	Not deep or special excavation
Subtotal B				$3,965,439			$8,474,719			$12,046,213	
Startup and Construction Sequencing	2%			$79,309			$169,494			$240,924	
General Conditions	15%			$594,816			$1,271,208			$1,806,932	
Contractor Overhead and Profit	20%			$793,088			$1,694,944			$2,409,243	
Sales Tax	6.3%			$247,840			$529,670			$752,888	
Bonds and Insurance	3%			$99,136			$211,868			$301,155	
Subtotal C				$5,779,627			$12,351,903			$17,557,356	
Engineering	10%			$577,963			$1,235,190			$1,755,736	
Construction Management	10%			$577,963			$1,235,190			$1,755,736	
Subtotal Project Costs				$6,935,553			$14,822,284			$21,068,827	
Estimating Contingency	30%			$2,080,666			$4,446,685			$6,320,648	
Total Project Cost				**$9,016,219**			**$19,268,969**			**$27,389,475**	
Estimated Accuracy Range	-50%			$4,508,109			$9,634,484			$13,694,737	
	100%			$18,032,437			$38,537,937			$54,778,949	

Alternative
Centrifuge

Total Treatment Flow Rate			Units
Small	Medium	Medium - Large	
0.5	5	10	MGD
90	900	1800	dtyp
0.25	2.47	4.93	dtpd

		Small Flow Rate			Medium Flow Rate			Medium - Large Flow Rate			
Item Description	Unit	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Notes
Main Equipment	$	1	$1,033,079	$1,033,079	1	$1,453,061	$1,453,061	1	$1,524,416	$1,524,416	All costs in MA & 2024 $
Ancillary Equipment	$	1	$159,093	$159,093	1	$530,310	$530,310	1	$1,060,619	$1,060,619	All costs in MA & 2024 $
Equipment Installation	20%			$238,434			$396,674			$517,007	
Treatment Building		1333	$564	$751,812	2151.041667	$564	$1,213,188	2326.041667	$564	$1,311,888	
Subtotal A				$2,182,418			$3,593,233			$4,413,930	
Misc. Demolition	5%			$109,121			$179,662			$220,697	
Electrical, Instrumentation, & Controls (minus bldg.)	50%			$715,303			$1,190,023			$1,551,021	
Site Work	10%			$218,242			$359,323			$441,393	
Misc. Piping	20%			$436,484			$718,647			$882,786	
Excavation and soil disposal	9%			$196,418			$323,391			$397,254	Not deep or special excavation
Subtotal B				$3,857,986			$6,364,277			$7,907,081	
Startup and Construction Sequencing	2%			$77,160			$127,286			$158,142	
General Conditions	15%			$578,698			$954,642			$1,186,062	
Contractor Overhead and Profit	20%			$771,597			$1,272,855			$1,581,416	
Sales Tax	6.3%			$241,124			$397,767			$494,193	
Bonds and Insurance	3%			$96,450			$159,107			$197,677	
Subtotal C				$5,623,014			$9,275,934			$11,524,570	
Engineering	10%			$562,301			$927,593			$1,152,457	
Construction Management	10%			$562,301			$927,593			$1,152,457	
Subtotal Project Costs				$6,747,617			$11,131,121			$13,829,484	
Estimating Contingency	30%			$2,024,285			$3,339,336			$4,148,845	
Total Project Cost				**$8,771,902**			**$14,470,458**			**$17,978,329**	
Estimated Accuracy Range	-50%			$4,385,951			$7,235,229			$8,989,165	
	100%			$17,543,804			$28,940,915			$35,956,658	

Alternative
Mesophilic Anaerobic Digestion

Total Treatment Flow Rate			Units
Medium	Medium - Large	Large	
5	10	20	MGD
900	1800	3600	dtyp
2.47	4.93	9.86	dtpd

		Medium Flow Rate			Medium Large Flow Rate			Large Flow Rate			
Item Description	Unit	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Notes
Digesters & Dig Storage	$	1	$5,422,727	$5,422,727	1	$8,324,553	$8,324,553	1	$16,649,107	$16,649,107	Includes all ancillary equipment & control building
Dewatering		1	$1,350,754	$1,350,754	1	$2,017,676	$2,017,676	1	$2,424,412	$2,424,412	
Equipment Installation	20%			$270,151			$403,535			$484,882	This installation is not included as part of the dig & storage tanks as it is already included
Dewatering Building		1801	$564	$1,015,764	2151	$564	$1,213,164	2802	$564	$1,580,328	
Subtotal A				$8,059,396			$11,958,928			$21,138,729	
Misc. Demolition	5%			$402,970			$597,946			$1,056,936	
Electrical, Instrumentation, & Controls (minus bldg.)	50%			$3,521,816			$5,372,882			$9,779,200	
Site Work	10%			$805,940			$1,195,893			$2,113,873	
Misc. Piping	15%			$1,208,909			$1,793,839			$3,170,809	
Excavation and soil disposal	9%			$725,346			$1,076,304			$1,902,486	Not deep or special excavation
Subtotal B				$14,724,377			$21,995,792			$39,162,034	
Startup and Construction Sequencing	2%			$294,488			$439,916			$783,241	
General Conditions	15%			$2,208,656			$3,299,369			$5,874,305	
Contractor Overhead and Profit	20%			$2,944,875			$4,399,158			$7,832,407	
Sales Tax	6.3%			$920,274			$1,374,737			$2,447,627	
Bonds and Insurance	3%			$368,109			$549,895			$979,051	
Subtotal C				$21,460,779			$32,058,867			$57,078,664	
Engineering	10%			$2,146,078			$3,205,887			$5,707,866	
Construction Management	10%			$2,146,078			$3,205,887			$5,707,866	
Subtotal Project Costs				$25,752,935			$38,470,641			$68,494,397	
Estimating Contingency	30%			$7,725,880			$11,541,192			$20,548,319	
Total Project Cost				**$33,478,815**			**$50,011,833**			**$89,042,716**	
Estimated Accuracy Range	-50%			$16,739,407			$25,005,917			$44,521,358	
	100%			$66,957,630			$100,023,666			$178,085,432	

Alternative
Belt Dryer

Total Treatment Flow Rate				Units
Small	Medium	Medium-Large	Large	
0.5	5	10	20	MGD
90	900	1800	3600	dtyp
0.25	2.47	4.93	9.86	dtpd

		Small Flow Rate			Medium Flow Rate			Medium-Large Flow Rate			Large Flow Rate			
Item Description	Unit	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Notes
Main Equipment	$	1	$2,346,938	$2,346,938	1	$4,159,672	$4,159,672	1	$4,650,000	$4,650,000	1	$8,951,673	$8,951,673	
Ancillary Equipment	$	1	$391,156	$391,156	1	$469,640	$469,640	1	$613,623	$613,623	1	$721,909	$721,909	
Equipment Installation	20%			$547,619			$925,863			$1,052,725			$1,934,716	
Treatment Building		2800	$564	$1,579,200	3200	$564	$1,804,800	4,400	$564	$2,481,600	5,600	$564	$3,158,400	
Subtotal A				$4,864,913			$7,359,975			$8,797,947			$14,766,699	
Misc. Demolition	5%			$243,246			$367,999			$439,897			$738,335	
Electrical, Instrumentation, & Controls (minus bldg.)	50%			$1,642,857			$2,777,588			$3,158,174			$7,383,349	
Site Work	10%			$486,491			$735,998			$879,795			$1,476,670	
Misc. Piping	15%			$729,737			$1,103,996			$1,319,692			$2,215,005	
Excavation and soil disposal	9%			$437,842			$662,398			$791,815			$1,329,003	Not deep or special excavation
Subtotal B				$8,405,086			$13,007,953			$15,387,320			$27,909,060	
Startup and Construction Sequencing	2%			$168,102			$260,159			$307,746			$558,181	
General Conditions	15%			$1,260,763			$1,951,193			$2,308,098			$4,186,359	
Contractor Overhead and Profit	20%			$1,681,017			$2,601,591			$3,077,464			$5,581,812	
Sales Tax	6%			$525,318			$812,997			$961,708			$1,744,316	
Bonds and Insurance	3%			$210,127			$325,199			$384,683			$697,727	
Subtotal C				$12,250,412			$18,959,092			$22,427,019			$40,677,456	
Engineering	10%			$1,225,041			$1,895,909			$2,242,702			$4,067,746	
Construction Management	10%			$1,225,041			$1,895,909			$2,242,702			$4,067,746	
Subtotal Project Costs				$14,700,495			$22,750,910			$26,912,423			$48,812,947	
Estimating Contingency	30%			$4,410,148			$6,825,273			$8,073,727			$14,643,884	
Total Project Cost				**$19,110,643**			**$29,576,184**			**$34,986,150**			**$63,456,831**	
Estimated Accuracy Range	-50%			$9,555,322			$14,788,092			$17,493,075			$31,728,415	
	100%			$38,221,286			$59,152,367			$69,972,301			$126,913,661	

Alternative
Rotary Drum Dryer

Total Treatment Flow Rate			Units
Medium	Medium - Large	Large	
5	10	20	MGD
900	1800	3600	dtyp
2.47	4.93	9.86	dtpd

		Medium Flow Rate			Medium Large Flow Rate			Large Flow Rate			
Item Description	Unit	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Notes
Main Equipment	$	1	$11,472,645	$11,472,645	1	$22,945,289	$22,945,289	1	$22,945,289	$22,945,289	
Ancillary Equipment	$	1		$0	1		$0	1		$0	
Equipment Installation	20%			$2,294,529	20%		$4,589,058	20%		$4,589,058	
Treatment Building		7,000	$564	$3,948,000	12,000	$564	$6,768,000	12,000	$564	$6,768,000	
Subtotal A				$17,715,174			$34,302,347			$34,302,347	
Misc. Demolition	5%			$885,759			$1,715,117			$1,715,117	
Electrical, Instrumentation, & Controls (minus bldg.)	50%			$6,883,587			$13,767,174			$13,767,174	
Site Work	10%			$1,771,517			$3,430,235			$3,430,235	
Misc. Piping	15%			$2,657,276			$5,145,352			$5,145,352	
Excavation and soil disposal	9%			$1,594,366			$3,087,211			$3,087,211	Not deep or special excavation
Subtotal B				$31,507,678			$61,447,436			$61,447,436	
Startup and Construction Sequencing	2%			$630,154			$1,228,949			$1,228,949	
General Conditions	15%			$4,726,152			$9,217,115			$9,217,115	
Contractor Overhead and Profit	20%			$6,301,536			$12,289,487			$12,289,487	
Sales Tax	6%			$1,969,230			$3,840,465			$3,840,465	
Bonds and Insurance	3%			$787,692			$1,536,186			$1,536,186	
Subtotal C				$45,922,441			$89,559,639			$89,559,639	
Engineering	10%			$4,592,244			$8,955,964			$8,955,964	
Construction Management	10%			$4,592,244			$8,955,964			$8,955,964	
Subtotal Project Costs				$55,106,929			$107,471,566			$107,471,566	
Estimating Contingency	30%			$16,532,079			$32,241,470			$32,241,470	
Total Project Cost				**$71,639,008**			**$139,713,036**			**$139,713,036**	
Estimated Accuracy Range	-50%			$35,819,504			$69,856,518			$69,856,518	
	100%			$143,278,016			$279,426,072			$279,426,072	

Alternative
Gasification

Total Treatment Flow Rate			Units
Medium	Medium - Large	Large	
5	10	20	MGD
900	1800	3600	dtyp
2.47	4.93	9.86	dtpd

		Medium Flow Rate			Medium Large Flow Rate			Large Flow Rate			
Item Description	Unit	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Notes
Main Equipment	$	1	$17,443,787	$17,443,787	1	$17,443,787	$17,443,787	1	$30,862,085	$30,862,085	
Ancillary Equipment	$			$0			$0			$0	
Equipment Installation	20%			$3,488,757	20%		$3,488,757	20%		$6,172,417	
Treatment Building		4,400	$564	$2,481,600	4,400	$564	$2,481,600	6,400	$564	$3,609,600	
Subtotal A				$23,414,145			$23,414,145			$40,644,102	
Misc. Demolition	5%			$1,170,707			$1,170,707			$2,032,205	
Electrical, Instrumentation, & Controls (minus bldg.)	50%			$10,466,272			$10,466,272			$18,517,251	
Site Work	10%			$2,341,414			$2,341,414			$4,064,410	
Misc. Piping	15%			$3,512,122			$3,512,122			$6,096,615	
Excavation and soil disposal	9%			$2,107,273			$2,107,273			$3,657,969	Not deep or special excavation
Subtotal B				$43,011,934			$43,011,934			$75,012,553	
Startup and Construction Sequencing	2%			$860,239			$860,239			$1,500,251	
General Conditions	15%			$6,451,790			$6,451,790			$11,251,883	
Contractor Overhead and Profit	20%			$8,602,387			$8,602,387			$15,002,511	
Sales Tax	6%			$2,688,246			$2,688,246			$4,688,285	
Bonds and Insurance	3%			$1,075,298			$1,075,298			$1,875,314	
Subtotal C				$62,689,893			$62,689,893			$109,330,796	
Engineering	10%			$6,268,989			$6,268,989			$10,933,080	
Construction Management	10%			$6,268,989			$6,268,989			$10,933,080	
Subtotal Project Costs				$75,227,872			$75,227,872			$131,196,956	
Estimating Contingency	30%			$22,568,362			$22,568,362			$39,359,087	
Total Project Cost				**$97,796,233**			**$97,796,233**			**$170,556,042**	
Estimated Accuracy Range	-50%			$48,898,117			$48,898,117			$85,278,021	
	100%			$195,592,467			$195,592,467			$341,112,085	

Alternative
Pyrolysis

Total Treatment Flow Rate			Units
Medium	Medium - Large	Large	
5	10	20	MGD
900	1800	3600	dtyp
2.47	4.93	9.86	dtpd

		Medium Flow Rate			Medium Large Flow Rate			Large Flow Rate			
Item Description	Unit	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Notes
Main Equipment	$	1	$4,211,611	$4,211,611	1	$8,423,223	$8,423,223	1	$12,634,834	$12,634,834	
Ancillary Equipment	$	1	$2,738,094	$2,738,094	1	$4,629,313	$4,629,313	1	$9,673,582	$9,673,582	Included cost of belt dryer as ancilllary equipment
Equipment Installation	20%			$1,389,941	20%		$2,610,507	20%		$4,461,683	
Treatment Building		4,400	$564	$2,481,600	5,600	$564	$3,158,400	8,000	$564	$4,512,000	
Subtotal A				$10,821,247			$18,821,443			$31,282,100	
Misc. Demolition	5%			$541,062			$941,072			$1,564,105	
Electrical, Instrumentation, & Controls (minus bldg.)	50%			$4,169,823			$7,831,521			$13,385,050	
Site Work	10%			$1,082,125			$1,882,144			$3,128,210	
Misc. Piping	15%			$1,623,187			$2,823,216			$4,692,315	
Excavation and soil disposal	9%			$973,912			$1,693,930			$2,815,389	Not deep or special excavation
Subtotal B				$19,211,356			$33,993,327			$56,867,169	
Startup and Construction Sequencing	2%			$384,227			$679,867			$1,137,343	
General Conditions	15%			$2,881,703			$5,098,999			$8,530,075	
Contractor Overhead and Profit	20%			$3,842,271			$6,798,665			$11,373,434	
Sales Tax	6%			$1,200,710			$2,124,583			$3,554,198	
Bonds and Insurance	3%			$480,284			$849,833			$1,421,679	
Subtotal C				$28,000,552			$49,545,274			$82,883,899	
Engineering	10%			$2,800,055			$4,954,527			$8,288,390	
Construction Management	10%			$2,800,055			$4,954,527			$8,288,390	
Subtotal Project Costs				$33,600,662			$59,454,329			$99,460,679	
Estimating Contingency	30%			$10,080,199			$17,836,299			$29,838,204	
Total Project Cost				**$43,680,861**			**$77,290,628**			**$129,298,882**	
Estimated Accuracy Range	-50%			$21,840,431			$38,645,314			$64,649,441	
	100%			$87,361,722			$154,581,256			$258,597,764	

Alternative
SWCO

Total Treatment Flow Rate			Units
Medium	Medium - Large	Large	
5	10	20	MGD
900	1800	3600	dtyp
2.47	4.93	9.86	dtpd

		Medium Flow Rate			Medium Large Flow Rate			Large Flow Rate			
Item Description	Unit	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Quantity	Unit Cost	Item Cost	Notes
Main Equipment	$	1	$7,506,000	$7,506,000	1	$7,506,000	$7,506,000	1	$15,012,000	$15,012,000	
Ancillary Equipment	$	1	$1,085,318	$1,085,318	1	$1,149,771	$1,149,771	1	$1,266,959	$1,266,959	
Equipment Installation	20%			$1,718,264	20%		$1,731,154	20%		$3,255,792	
Treatment Building		1,500	$564	$846,000	1,750	$564	$987,000	2,000	$564	$1,128,000	
Subtotal A				$11,155,581			$11,373,926			$20,662,751	
Misc. Demolition	5%			$557,779			$568,696			$1,033,138	
Electrical, Instrumentation, & Controls (minus bldg.)	50%			$5,154,791			$5,193,463			$9,767,375	
Site Work	20%			$2,231,116			$2,274,785			$4,132,550	
Misc. Piping	15%			$1,673,337			$1,706,089			$3,099,413	
Excavation and soil disposal	9%			$1,004,002			$1,023,653			$1,859,648	Not deep or special excavation
Subtotal B				$21,776,606			$22,140,612			$40,554,874	
Startup and Construction Sequencing	2%			$435,532			$442,812			$811,097	
General Conditions	15%			$3,266,491			$3,321,092			$6,083,231	
Contractor Overhead and Profit	20%			$4,355,321			$4,428,122			$8,110,975	
Sales Tax	6%			$1,361,038			$1,383,788			$2,534,680	
Bonds and Insurance	3%			$544,415			$553,515			$1,013,872	
Subtotal C				$31,739,404			$32,269,942			$59,108,728	
Engineering	10%			$3,173,940			$3,226,994			$5,910,873	
Construction Management	10%			$3,173,940			$3,226,994			$5,910,873	
Subtotal Project Costs				$38,087,284			$38,723,930			$70,930,474	
Estimating Contingency	50%			$19,043,642			$19,361,965			$35,465,237	
Total Project Cost				**$57,130,926**			**$58,085,895**			**$106,395,711**	
Estimated Accuracy Range	-50%			$28,565,463			$29,042,947			$53,197,855	
	100%			$114,261,853			$116,171,790			$212,791,422	

Alternative
Foam Fractionation

Total Treatment Flow Rate			Units
Small	Medium	Large	
25000	100000	250000	gpd

		Small Flow Rate			Medium Flow Rate			Large Flow Rate		
	Stated Range	Selected %	Cost	% of TIC	Selected %	Cost	% of TIC	Selected %	Cost	% of TIC
Direct Costs										
Purchased Equipment Cost (PEC)		--	$ 264,517	3.8%	--	$ 464,443	3.9%	--	$ 813,015	4%
Freight	5% - 10%	10%	$ 26,452	0.38%	10%	$ 46,444	0.39%	10%	$ 81,302	0.4%
Sales Tax	Site Specific		$ -			$ -			$ -	
Purchased Equipment Delivered (PEC-D) Subtotal			**$ 290,968**			**$ 510,888**			**$ 894,317**	
Purchased Equipment Installation	25% - 55%	25%	$ 72,742	1.0%	25%	$ 127,722	1%	25%	$ 223,579	1.0%
Instrumentation and Controls (Installed)	8% - 50%	40%	$ 116,387	1.7%	40%	$ 204,355	1.7%	40%	$ 357,727	1.6%
Piping (Installed)	10% - 80%	35%	$ 101,839	1.5%	35%	$ 178,811	2%	35%	$ 313,011	1.4%
Electrical Systems (Installed)	10% - 40%	40%	$ 116,387	1.7%	40%	$ 204,355	2%	40%	$ 357,727	1.6%
Buildings (incl. services)	10% - 70%	5%	$ 14,548	0.2%	5%	$ 25,544	0%	5%	$ 44,716	0.2%
Yard Improvements	10% - 20%	7%	$ 20,368	0.3%	7%	$ 35,762	0.3%	7%	$ 62,602	0.3%
Service Utilities (Installed)	30% - 80%	30%	$ 87,290	1.3%	30%	$ 153,266	1%	30%	$ 268,295	1.2%
Land	4% - 8%	0%	$ -	0%	0%	$ -	0%	0%	$ -	0%
Raw Cost Subtotal			**$ 529,562**			**$ 929,816**			**$ 1,627,657**	
Lump Sum Packages	N/A	--	$ 2,202,044	32%	--	$ 3,802,943	32%	--	$ 8,030,886	36%
Buildings	N/A	--	$ 166,500	2%	--	$ 166,500	1%	--	$ 166,500	1%
Direct Cost Subtotal			**$ 3,189,074**			**$ 5,410,147**			**$ 10,719,359**	
Indirect Costs										
Contractor's Fee	10% - 15%	15%	$ 478,361	7%	15%	$ 811,522	7%	15%	$ 1,607,904	7%
Legal Expenses - Permits	1% - 3%	2%	$ 63,781.48	1%	2%	$ 108,202.93	1%	2%	$ 214,387.19	1%
Indirect Subtotal			**$ 3,731,217**			**$ 6,329,871**			**$ 12,541,651**	
Construction Expenses - General Conditions	10% - 20%	20%	$ 746,243	11%	20%	$ 1,265,974	11%	20%	$ 2,508,330	11%
Indirect + GC Subtotal			**$ 4,477,460**			**$ 7,595,846**			**$ 15,049,981**	

Alternative
Foam Fractionation

Total Treatment Flow Rate			Units
Small	Medium	Large	
25000	100000	250000	gpd

		Small Flow Rate			Medium Flow Rate			Large Flow Rate		
	Stated Range	Selected %	Cost	% of TIC	Selected %	Cost	% of TIC	Selected %	Cost	% of TIC
Contingency	30% - 50%	35%	$ 1,567,111	23%	35%	$ 2,658,546	23%	35%	$ 5,267,493	24%
Fixed Capital Investment (FCI)			**$ 6,044,571**			**$ 10,254,392**			**$ 20,317,474**	
Estimate Date	[SUBMITTAL DATE]									
Project Start (Construction Starts)	[START DATE]									
Estimated Project Duration	[MONTHS]									
Estimated Project End	[END DATE]	1/0/1900			1/0/1900			1/0/1900		
1/2 Construction Period	[MONTHS]	0			0			0		
Time to Mid-Point	[MONTHS]	0			0			0		
Annual Escaluation	4% - 10%				4%					
Escalation to Mid-Point		0%	$ -	0%	0%	$ -	0%	0%	$ -	0%
Escalation + FCI Subtotal			**$ 6,044,571**			**$ 10,254,392**			**$ 20,317,474**	
Engineering and Services During Contruction	Input from Project Team [1] =		$ 906,685.69	13%		$ 1,538,158.77	13%		$ 2,031,747.39	9%
Total Installed Cost (TIC)			**$ 6,951,257**			**$ 11,792,551**			**$ 22,349,221**	
Class 5 Estimate	-50% - 100%	**$ 3,485,142**	**$ 13,940,568**		**$ 5,890,707**	**$ 23,562,829**		**$ 11,146,642**	**$ 44,586,567**	

Alternative
Reverse Osmosis

Total Treatment Flow Rate			Units
Small	Medium	Large	
25000	100000	250000	MGD

		Small Flow Rate			Medium Flow Rate			Large Flow Rate		
	Stated Range	Selected %	Cost	% of TIC	Selected %	Cost	% of TIC	Selected %	Cost	% of TIC
Direct Costs										
Purchased Equipment Cost (PEC)		--	$ 337,002	2.8%	--	$ 482,582	2.2%	--	$ 954,613	3%
Freight	5% - 10%	10%	$ 33,700	0.28%	10%	$ 48,258	0.22%	10%	$ 95,461	0.3%
Sales Tax	Site Specific		$ -			$ -			$ -	
Purchased Equipment Delivered (PEC-D) Subtotal			**$ 370,703**			**$ 530,841**			**$ 1,050,075**	
Purchased Equipment Installation	25% - 55%	25%	$ 92,676	0.8%	25%	$ 132,710	1%	25%	$ 262,519	0.8%
Instrumentation and Controls (Installed)	8% - 50%	40%	$ 148,281	1.2%	40%	$ 212,336	1.0%	40%	$ 420,030	1.2%
Piping (Installed)	10% - 80%	35%	$ 129,746	1.1%	35%	$ 185,794	1%	35%	$ 367,526	1.1%
Electrical Systems (Installed)	10% - 40%	40%	$ 148,281	1.2%	40%	$ 212,336	1%	40%	$ 420,030	1.2%
Buildings (incl. services)	10% - 70%	5%	$ 18,535	0.2%	5%	$ 26,542	0%	5%	$ 52,504	0.2%
Yard Improvements	10% - 20%	7%	$ 25,949	0.2%	7%	$ 37,159	0.2%	7%	$ 73,505	0.2%
Service Utilities (Installed)	30% - 80%	30%	$ 111,211	0.9%	30%	$ 159,252	1%	30%	$ 315,022	0.9%
Land	4% - 8%	0%	$ -	0%	0%	$ -	0%	0%	$ -	0%
Raw Cost Subtotal			**$ 674,679**			**$ 966,130**			**$ 1,911,136**	
Lump Sum Packages	N/A	--	$ 4,304,029	36%	--	$ 8,223,061	38%	--	$ 13,499,783	39%
Buildings	N/A	--	$ 166,500	1%	--	$ 166,500	1%	--	$ 166,500	0%
Direct Cost Subtotal			**$ 5,515,910**			**$ 9,886,531**			**$ 16,627,494**	
Indirect Costs										
Contractor's Fee	10% - 15%	15%	$ 827,387	7%	15%	$ 1,482,980	7%	15%	$ 2,494,124	7%
Legal Expenses - Permits	1% - 3%	2%	$ 110,318.20	1%	2%	$ 197,730.63	1%	2%	$ 332,549.88	1%
Indirect Subtotal			**$ 6,453,615**			**$ 11,567,242**			**$ 19,454,168**	
Construction Expenses - General Conditions	10% - 20%	20%	$ 1,290,723	11%	20%	$ 2,313,448	11%	20%	$ 3,890,834	11%
Indirect + GC Subtotal			**$ 7,744,338**			**$ 13,880,690**			**$ 23,345,002**	

Alternative
Reverse Osmosis

Total Treatment Flow Rate			Units
Small	Medium	Large	
25000	100000	250000	MGD

		Small Flow Rate			Medium Flow Rate			Large Flow Rate		
	Stated Range	Selected %	Cost	% of TIC	Selected %	Cost	% of TIC	Selected %	Cost	% of TIC
Contingency	30% 50%	35%	$ 2,710,518	23%	35%	$ 4,858,242	23%	35%	$ 8,170,751	24%
Fixed Capital Investment (FCI)			**$ 10,454,856**			**$ 18,738,932**			**$ 31,515,752**	
Estimate Date	[SUBMITTAL DATE]									
Project Start (Construction Starts)	[START DATE]									
Estimated Project Duration	[MONTHS]									
Estimated Project End	[END DATE]	1/0/1900			1/0/1900			1/0/1900		
1/2 Construction Period	[MONTHS]	0			0			0		
Time to Mid-Point	[MONTHS]	0			0			0		
Annual Escaluation	4% - 10%	4%			4%			4%		
Escalation to Mid-Point		0%	$ -	0%	0%	$ -	0%	0%	$ -	0%
Escalation + FCI Subtotal			**$ 10,454,856**			**$ 18,738,932**			**$ 31,515,752**	
Engineering and Services During Contruction	Input from Project Team [1] =		$ 1,568,228.40	13%		$ 2,810,839.73	13%		$ 3,151,575.24	9%
Total Installed Cost (TIC)			**$ 12,023,084**			**$ 21,549,771**			**$ 34,667,328**	
Class 5 Estimate	-50% - 100%	**$ 3,485,142**	**$ 13,940,568**		**$ 5,890,707**	**$ 23,562,829**		**$ 11,146,642**	**$ 44,586,567**	

Appendix J: Recommendations for Future Scientific Research

In our review of previous studies, it became clear that PFAS mass concentrations were used in some instances in which the use of molar concentrations would have been beneficial. Commonly, studies have assessed PFAS fate and transport by summing the mass concentrations of individual species or have presented a 'PFAS profile' using stacked bar charts based on mass concentrations. Whether intentional or not, this practice biases results by over-representing larger molecules. Biasing results toward larger compounds may be justifiable in some cases based on their environmental or health risk level; in fact, long-chain PFAS have been found to bioaccumulate more readily than short-chain PFAS (Tavasoli et al., 2021). However, care should be taken to deliberately consider such analytical decisions, their benefits and limitations, and their implications for interpretation of results.

Figure H-1 illustrates the difference in PFAS profiles developed using a mass basis (left) and using a molar basis (right). Using data compiled in Section 4, percent PFAS mass compositions were calculated for POTW influent, effluent, and sludge and industrial wastewater effluent by dividing the mass concentration of each species by the sum of mass concentrations for all species and multiplying by 100 percent. This process was repeated using molar concentrations. For simplicity, PFAS that were not at least 2% of total PFAS were grouped as "Other." Figure 6-2 shows that 3:3 FTCA and PFPeA together comprise at least 30% of the average influent PFAS composition on a molar basis; however, these species make up less than 2% of the average influent PFAS composition on a mass basis because they are among the smallest PFAS measured by EPA Method 1633.

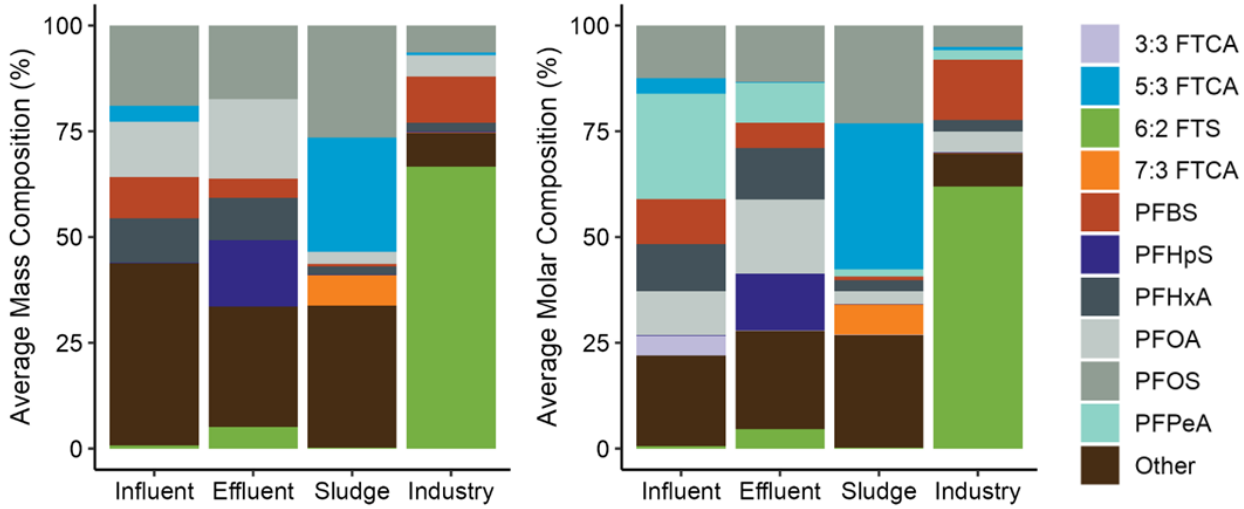


Figure H-1. Average PFAS Profiles for POTW Influent, Effluent, Sludge, and Industrial Effluent

Note: Average percent PFAS compositions were calculated on a mass basis (left) and on a molar basis (right). PFAS that comprised <2% of total PFAS were grouped as "Other" for clarity.

In the absence of explicit justification for the use of a mass basis, we recommend future analyses analyze fate and transport of PFAS on a molar basis. In addition to normalizing the concentration data by molecular weight, this procedure allows for comprehensive mass and energy balances to identify and understand PFAS transport and transformation phenomena within the treatment plant itself and among solid and liquid phases. Unbiased analyses are especially important given the rapidly evolving scientific and regulatory landscape with respect to PFAS. An alternative approach might be representing PFAS mass concentrations in terms of a structural element common to all PFAS. This method of standardization is widely used in wastewater nutrient removal applications: Concentrations of ammonia, nitrite, and nitrate are commonly reported in mass concentrations "as nitrogen," disregarding the specific molecular structures and sizes of the individual compounds to

emphasize the nutrient itself. Representing PFAS quantities in terms of the carbon-fluorine bond, for example, offers an opportunity to standardize mass concentrations. This practice would both facilitate comparison among different species and emphasize the structural component of PFAS that is particularly environmentally persistent. However, there is not yet consensus for expressing the quantity of PFAS in terms of a structural equivalent.

In Section 4 of this study, we present analyses based on both mass and molar concentrations. Data were analyzed on a mass basis for descriptive summaries, such as for the case studies included in Section 4.1.2, primarily to facilitate comparison with previous studies. However, more complex, nonparametric statistical analyses such as NMDS and PERMANOVA require frequency or "count" data and cannot account for the concept of size. Consider the fact that these statistical methods originate from ecology; when assessing ecosystem diversity, one typically compares the total number of species and the number of unique members of each species, where different species tend to be present in different abundances in different ecosystems, forming a "profile." In our case, different PFAS represent different species, moles are the "unique members" of each species, and wastewater media represent different possible "ecosystems." Therefore, these methods based on molarity compare samples' PFAS profiles using the number of moles observed and their frequency of observation to elucidate underlying characteristics of the data.

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