

Appendix B: Residence Time Tests using Varying Depth Columns

Optimizing contact time for pollutant removal can be performed in two ways. First, flow-through columns can be used as they would be in field applications and either outlet constrictions or media depth can be used to control the contact time (Appendix B). Second, batch kinetic testing can be used (Appendix C1). Because of outlet clogging concerns and because of the desire to minimize media costs with shallower beds if possible, the flow-through column tests used varying media depths to control contact time. Columns were approximately 1/3, 2/3 and full-depth of the media columns planned for field deployment. Tests were performed for three of the component media (GAC, Peat Moss [PM], and Surface Modified Zeolite [SMZ]) and three of the media mixtures (Rhyolite Sand [R] – SMZ, R-SMZ-GAC, R-SMZ-GAC-PM). These media were selected based on their performance in both the long-column and batch kinetics testing and based on literature performance values.

The graphs in this appendix show the results of the varying column depth tests. The lines on the graphs represent the spiked stormwater (labeled spiked influent), the 3 varying-depth columns that received spiked stormwater, the unspiked stormwater, and the 14-inch column that received the unspiked stormwater (labeled 14" Control). The control column was run to determine if any of the media released pollutants when the stormwater concentration was low. Each constituent has two pages of multiple miniature plots, with the exception of mercury, oil and grease, and perchlorate. The first page of the pair shows the results for the component media, while the second page shows the results for the media mixtures.

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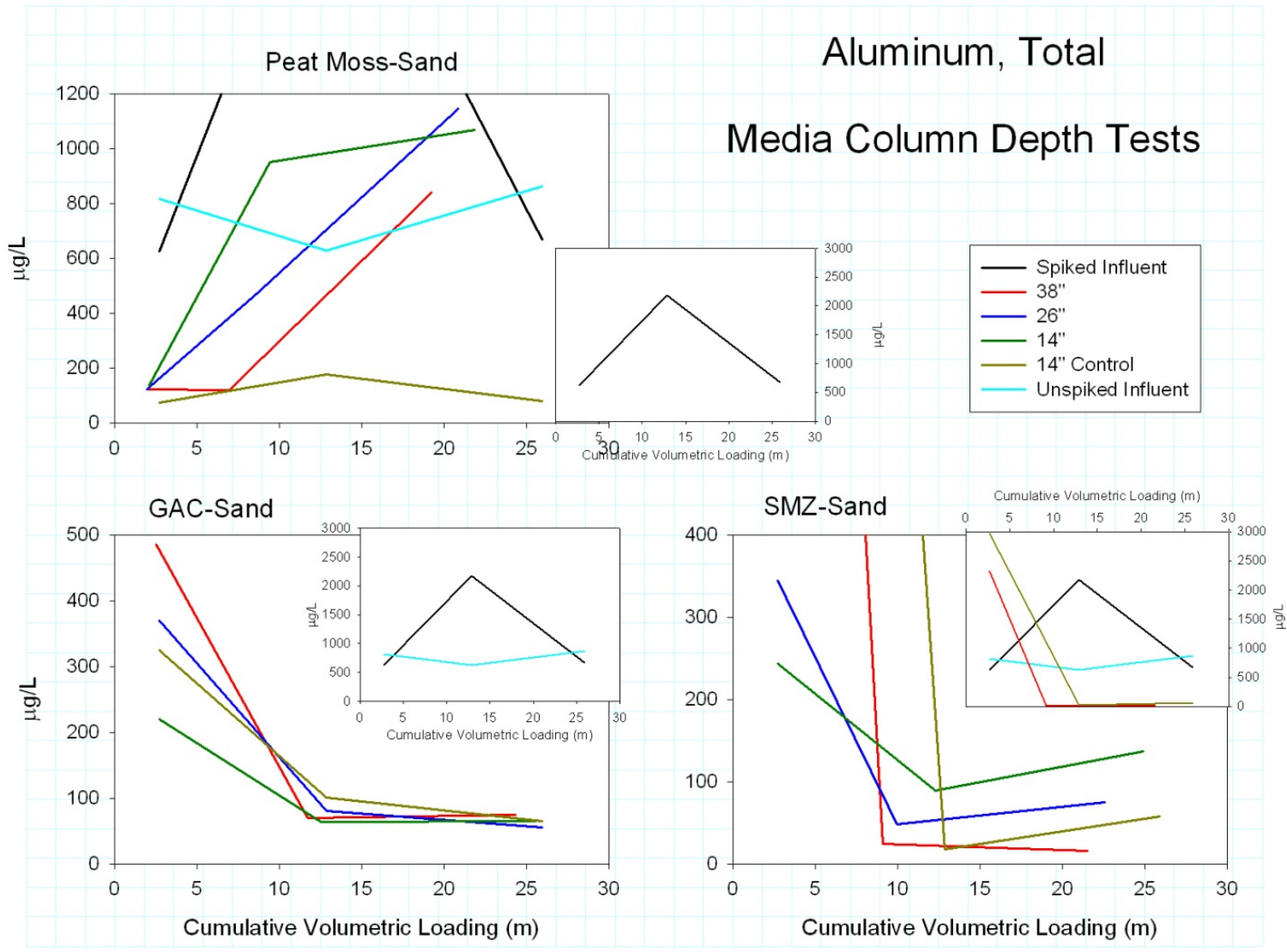
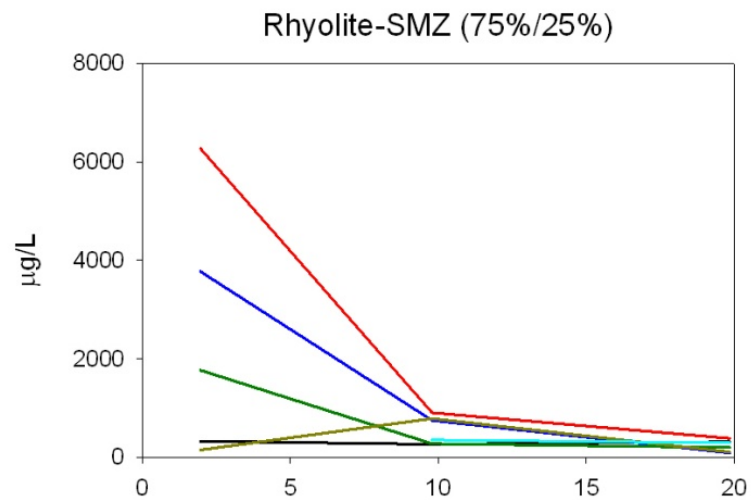


Figure B-1. Aluminum (Total) Removal for Component Media



Aluminum, Total Media Column Depth Tests

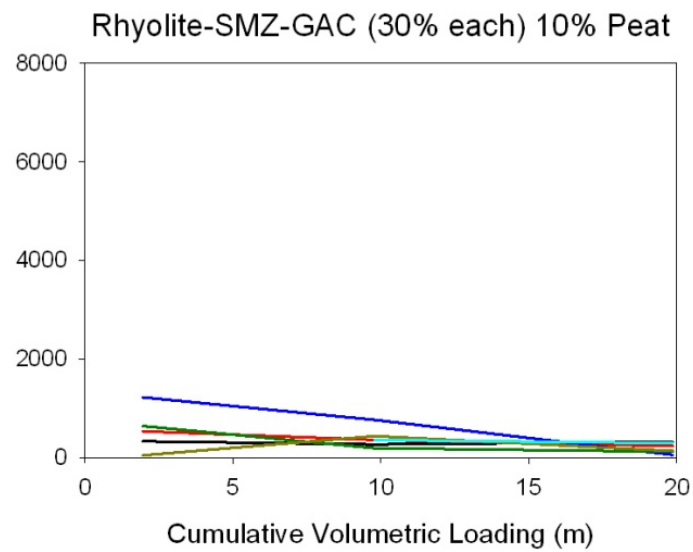
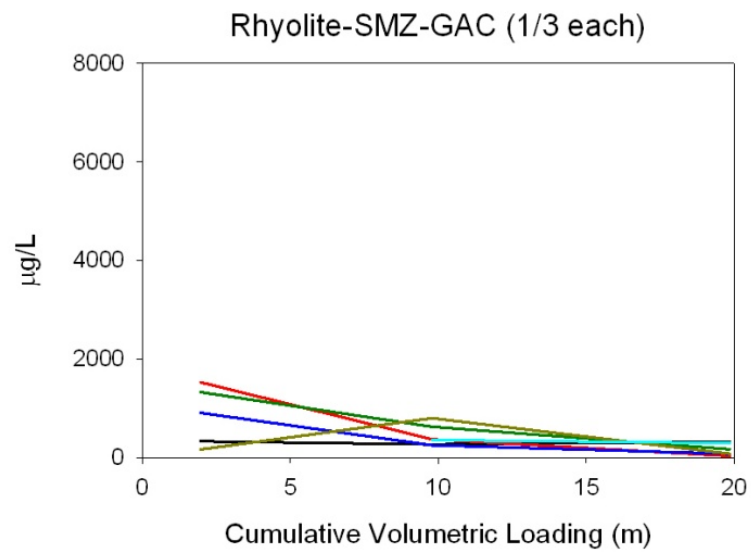
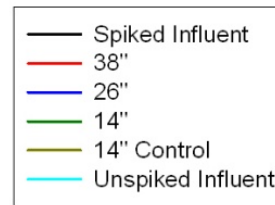


Figure B-2. Aluminum (Total) Removal for Media Mixtures

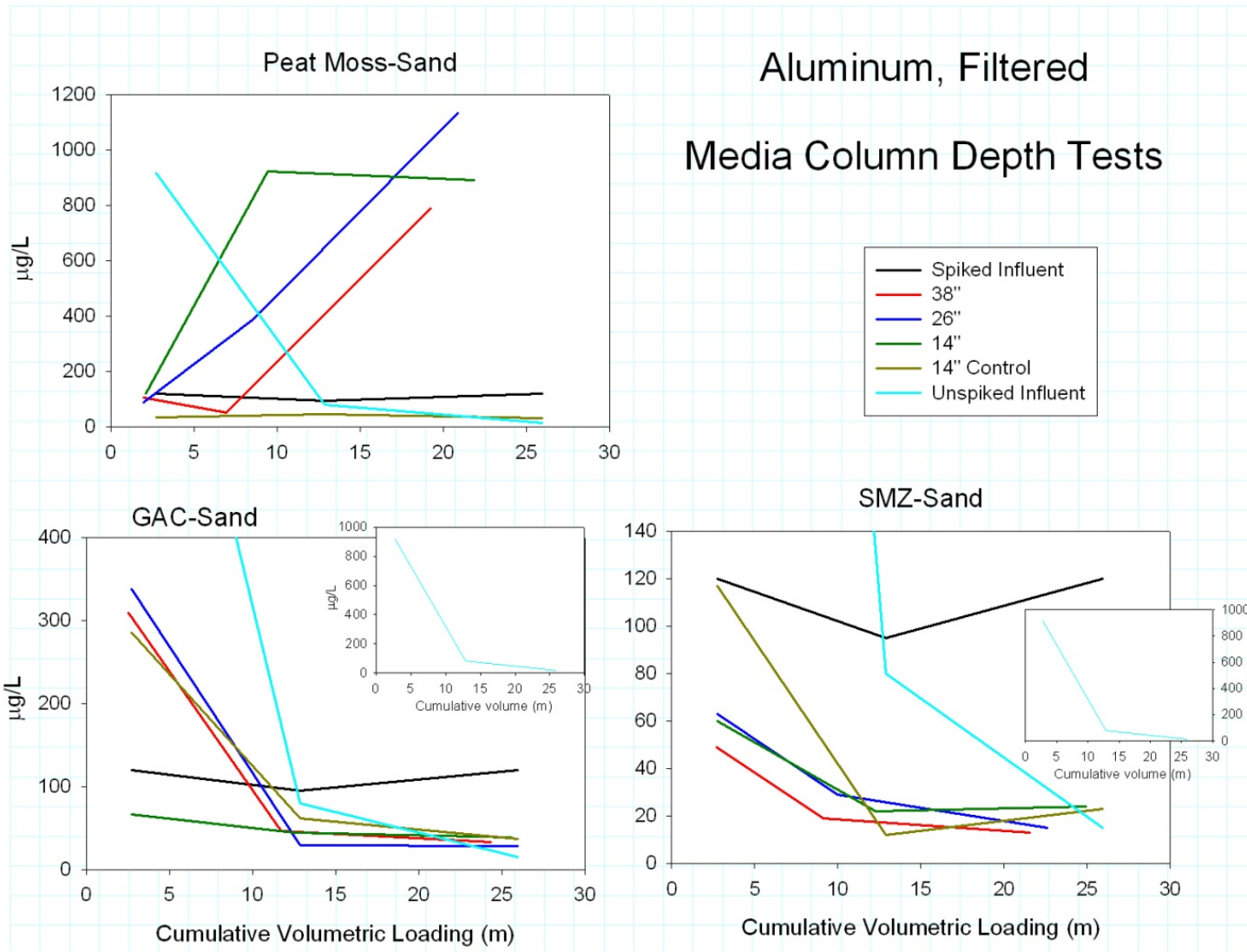


Figure B-3. Aluminum (Filtered) Removal for Component Media

Aluminum, Filtered Media Column Depth Tests

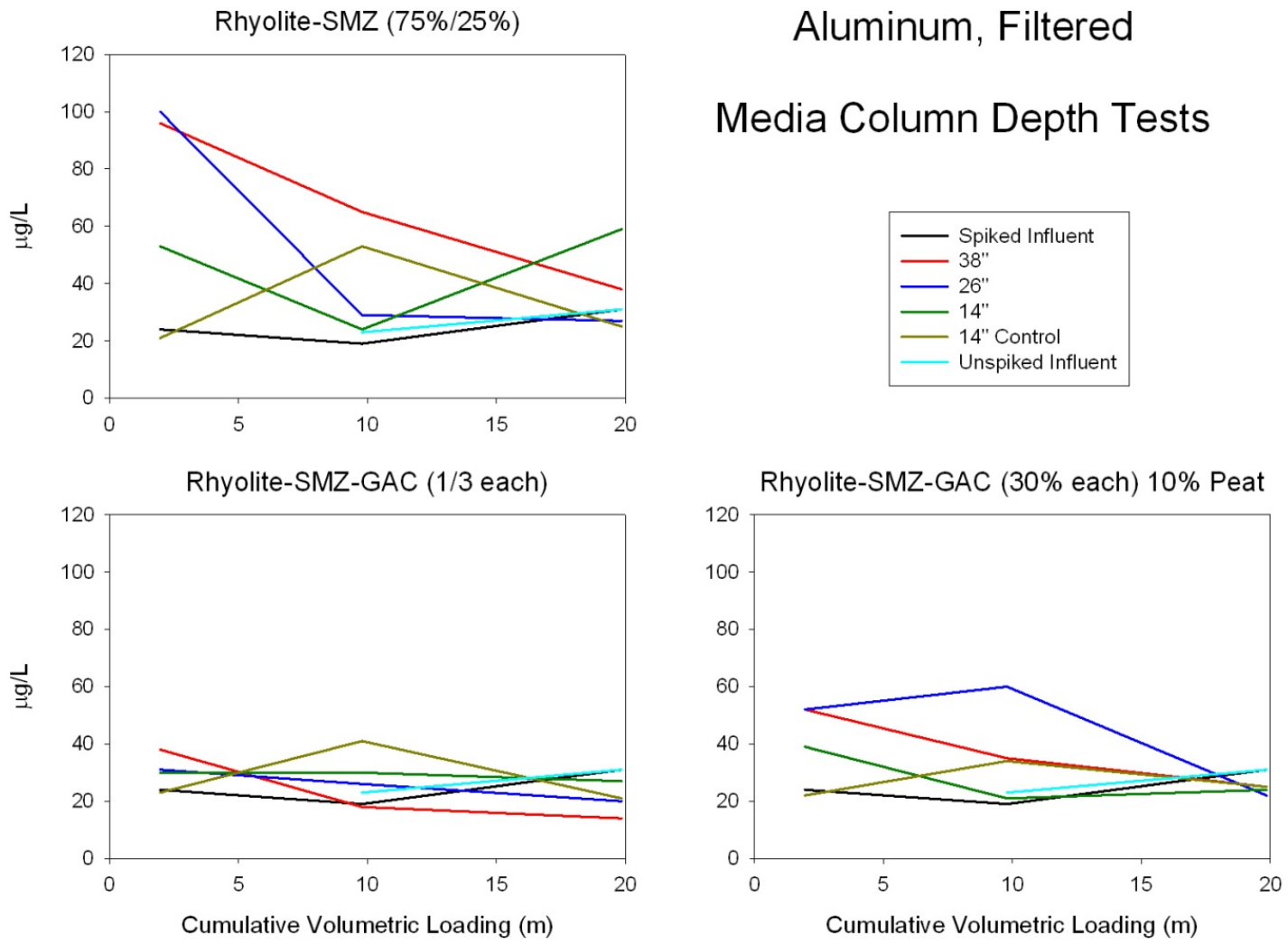


Figure B-4. Aluminum (Filtered) Removal for Media Mixtures

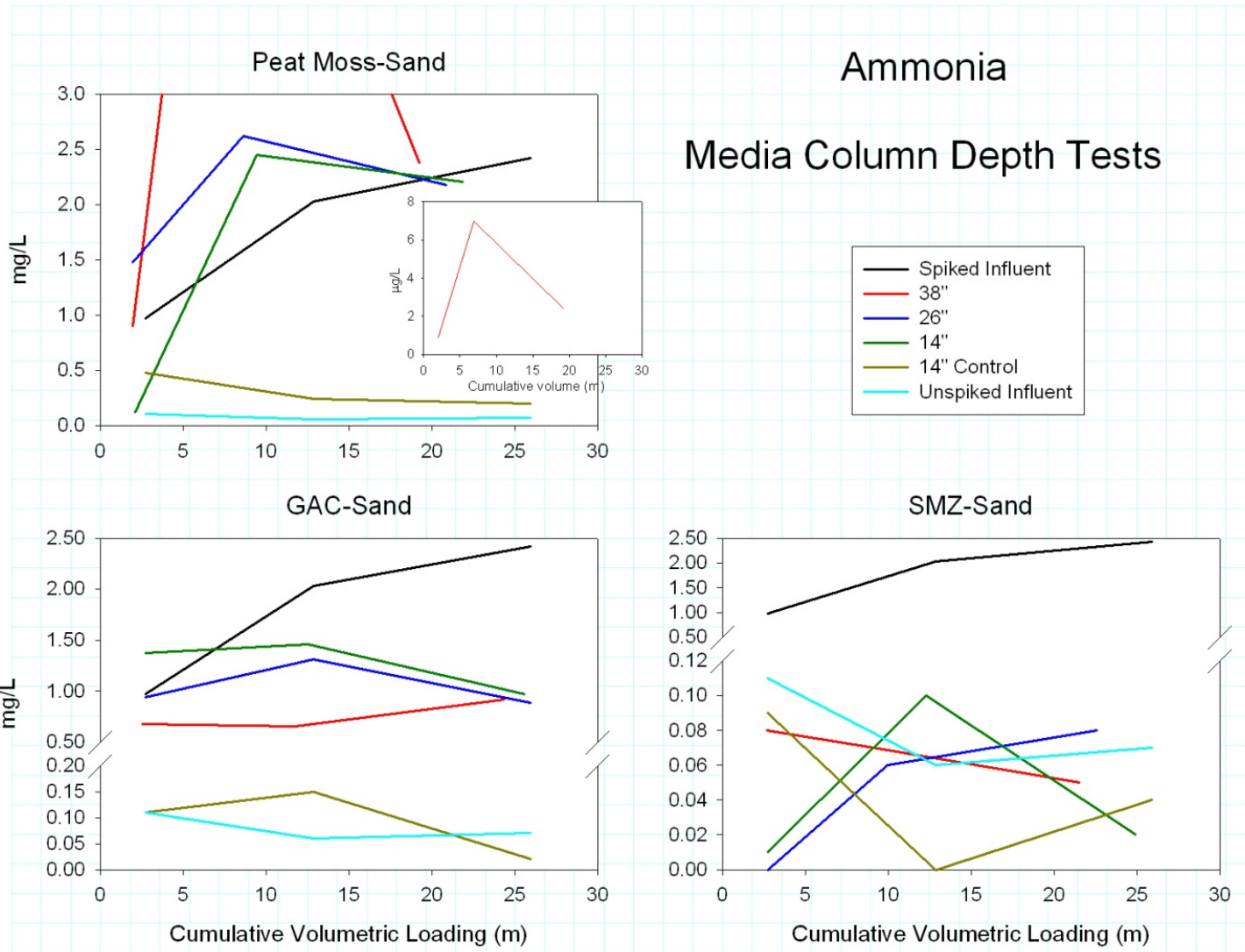
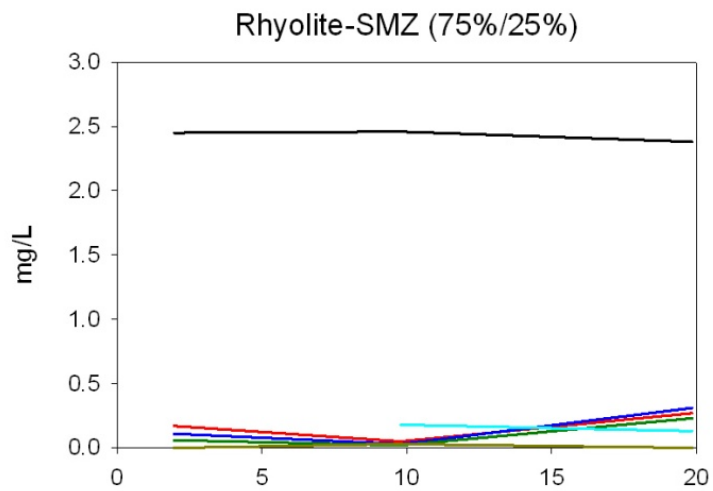


Figure B-5. Ammonia Removal for Component Media



Ammonia Media Column Depth Tests

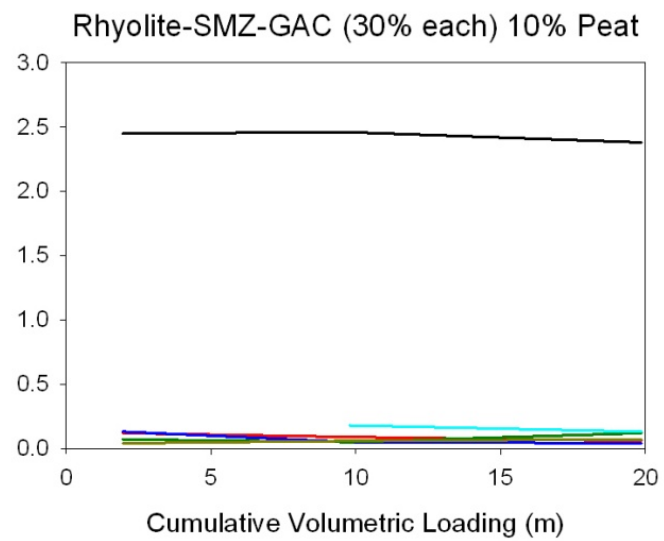
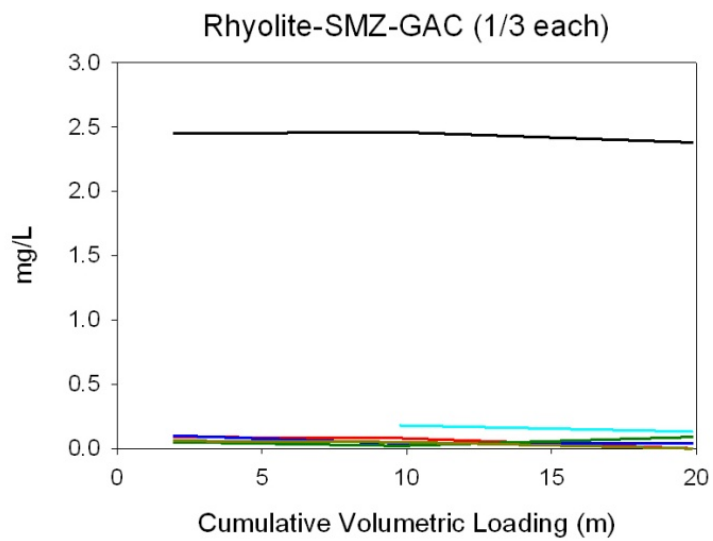
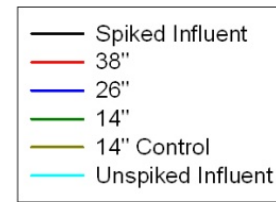


Figure B-6. Ammonia Removal for Media Mixtures

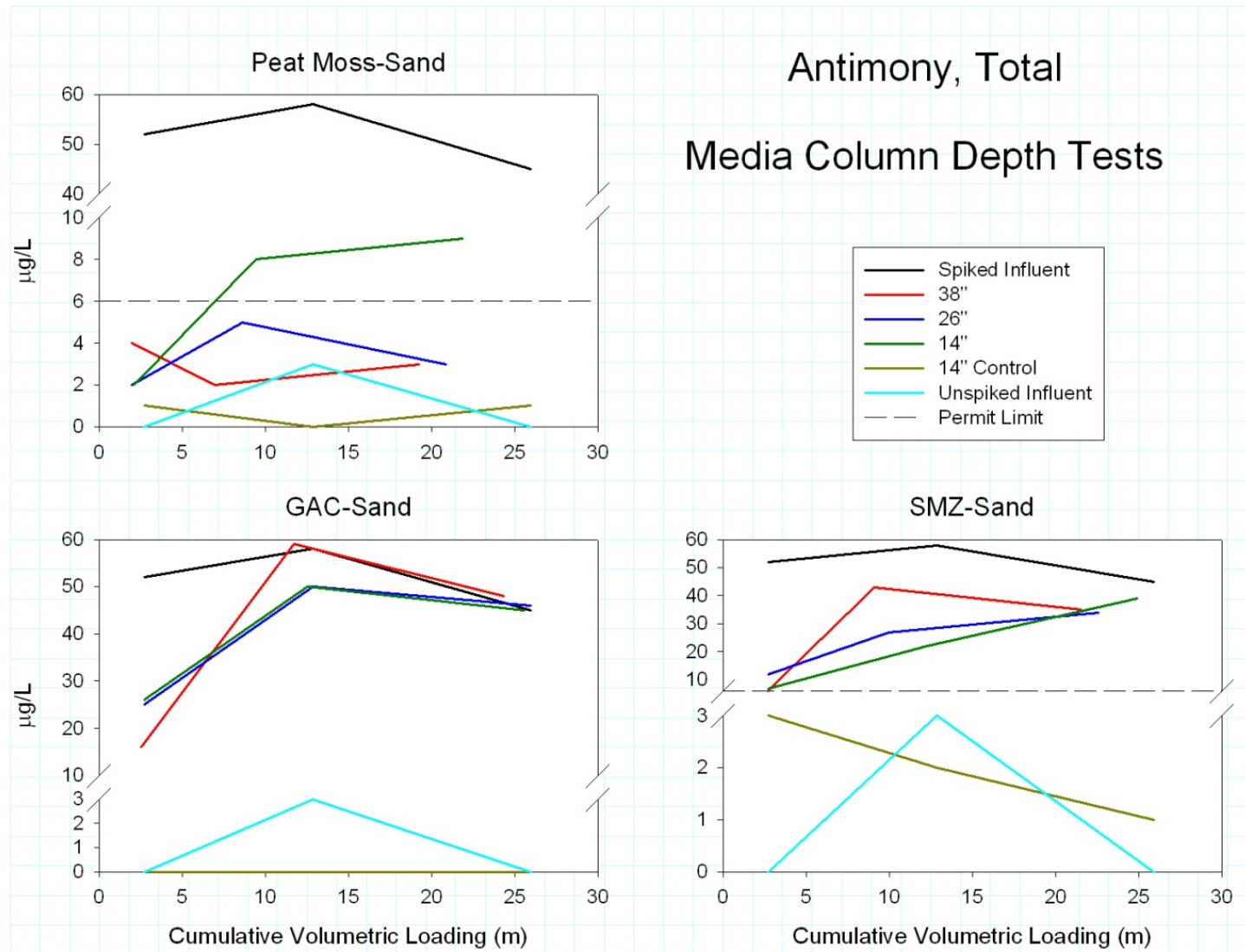


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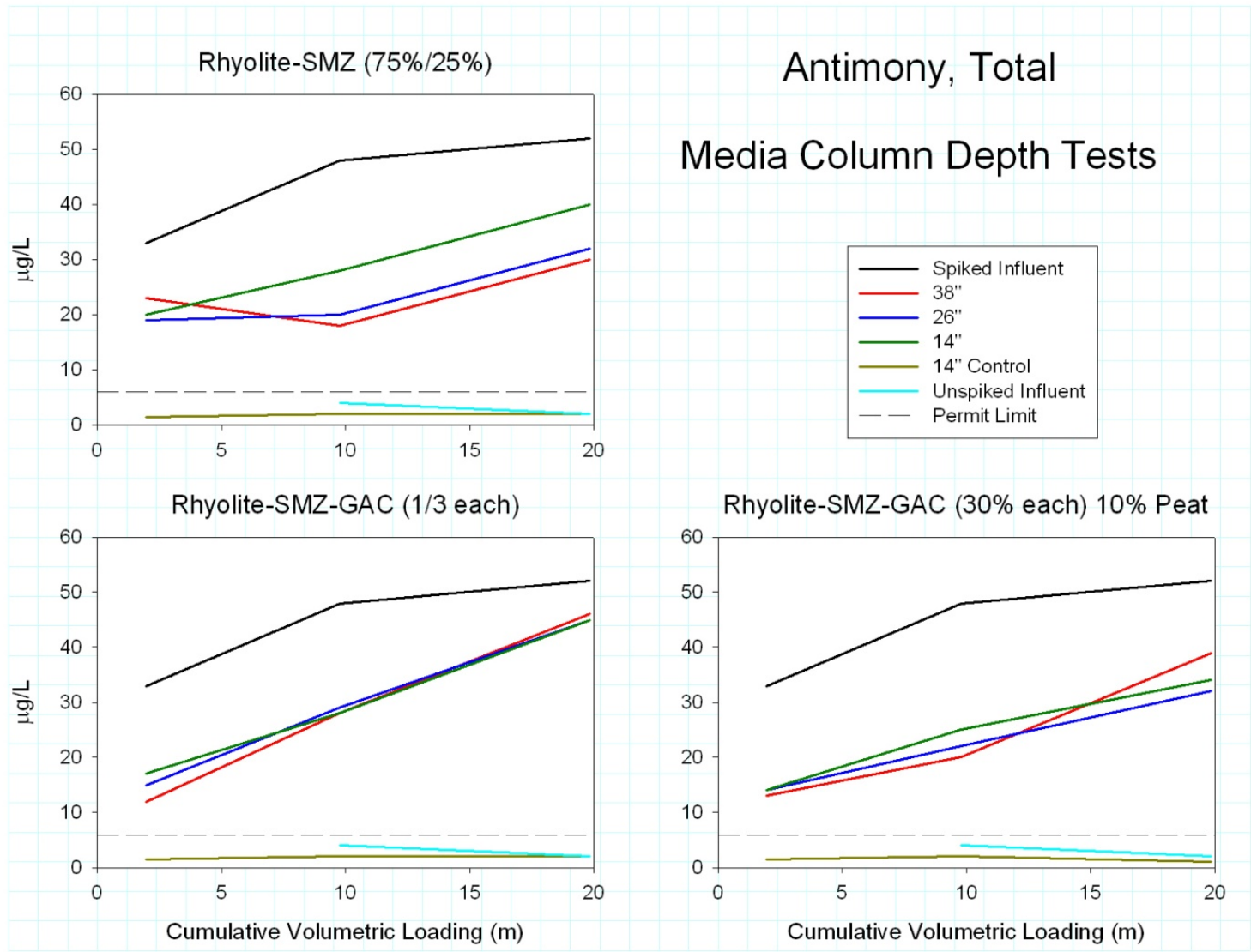


Figure B-8. Antimony (Total) Removal for Media Mixtures

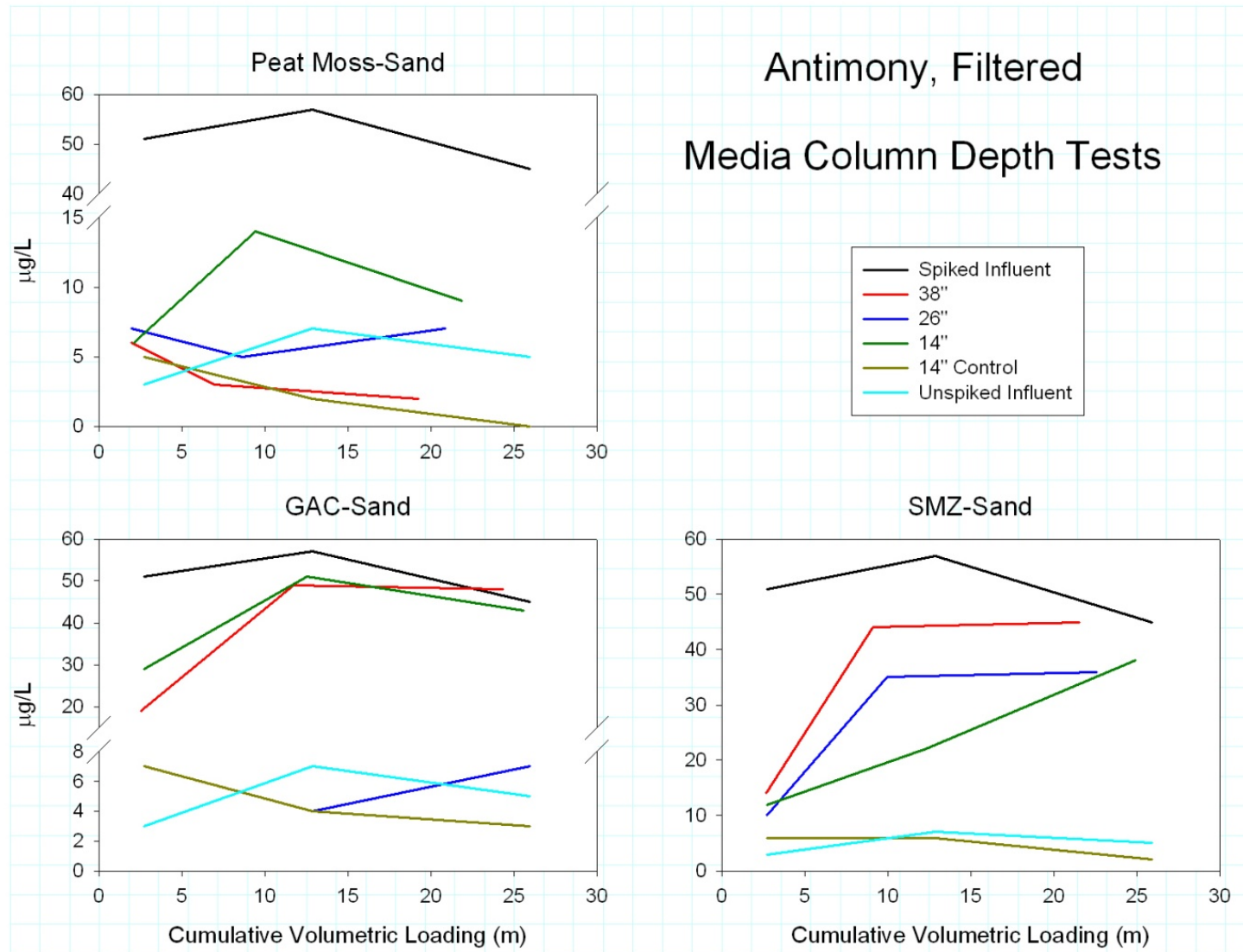


Figure B-9. Antimony (Filtered) Removal for Component Media

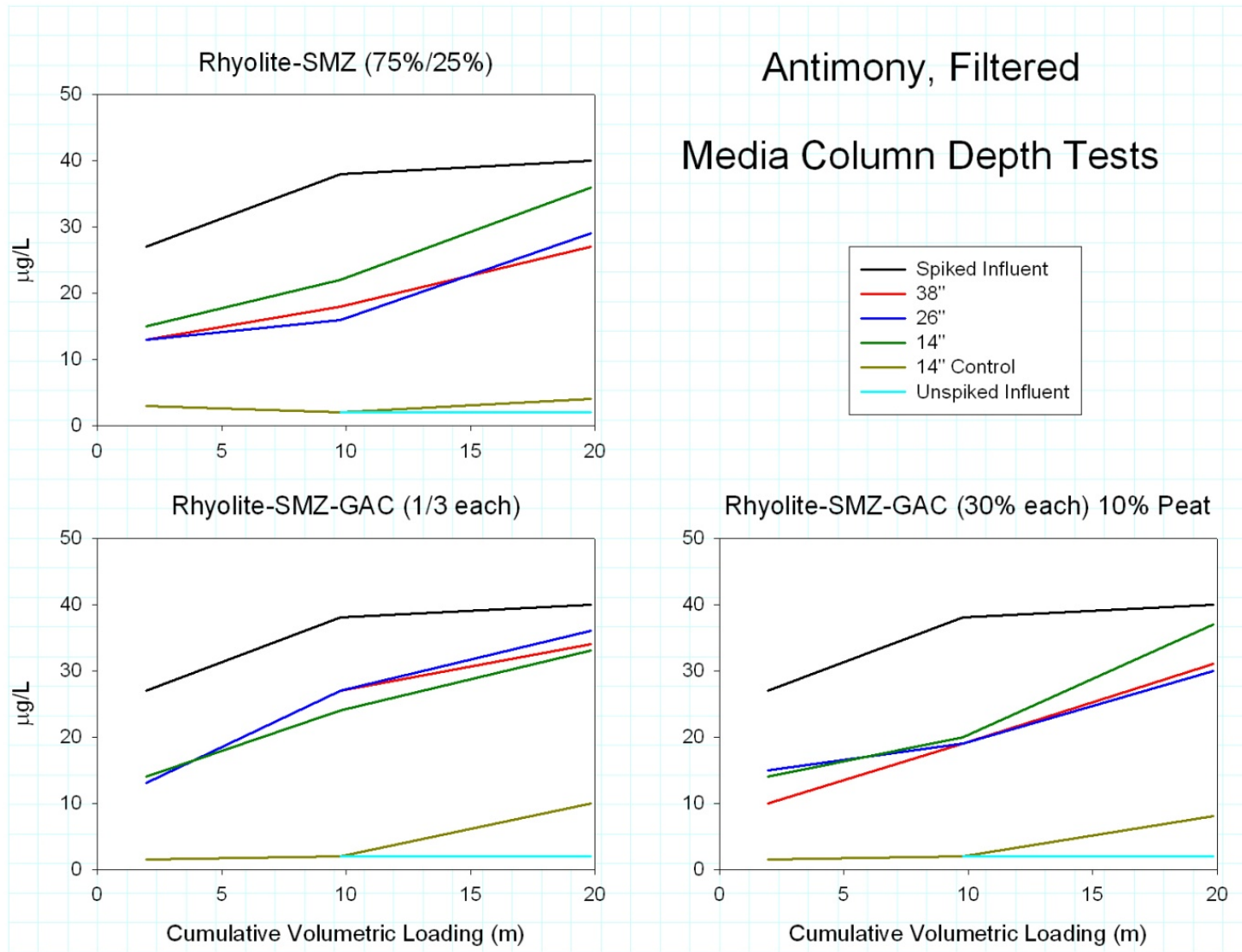


Figure B-10. Antimony (Filtered) Removal for Media Mixtures

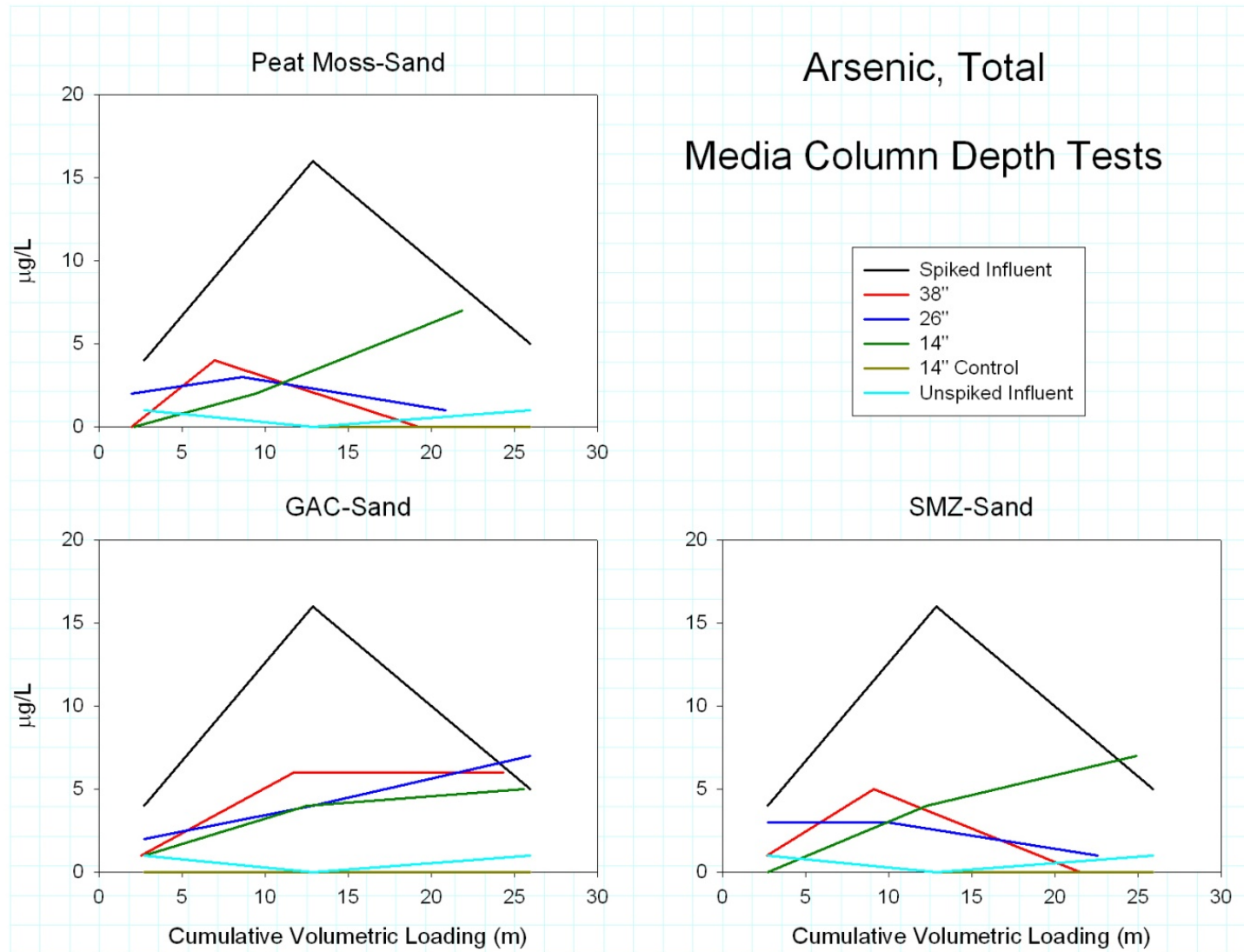


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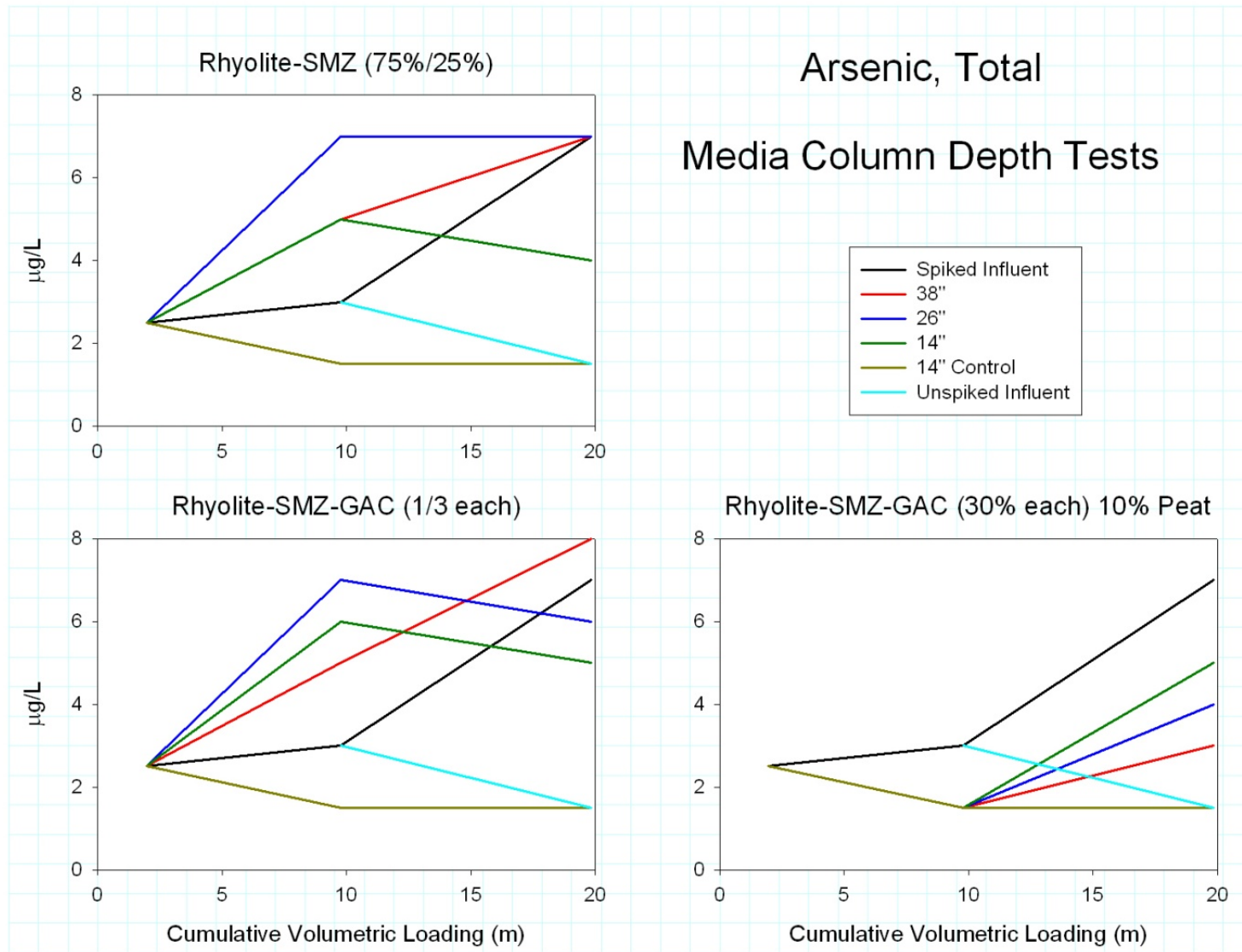


Figure B-12. Arsenic (Total) Removal for Media Mixtures

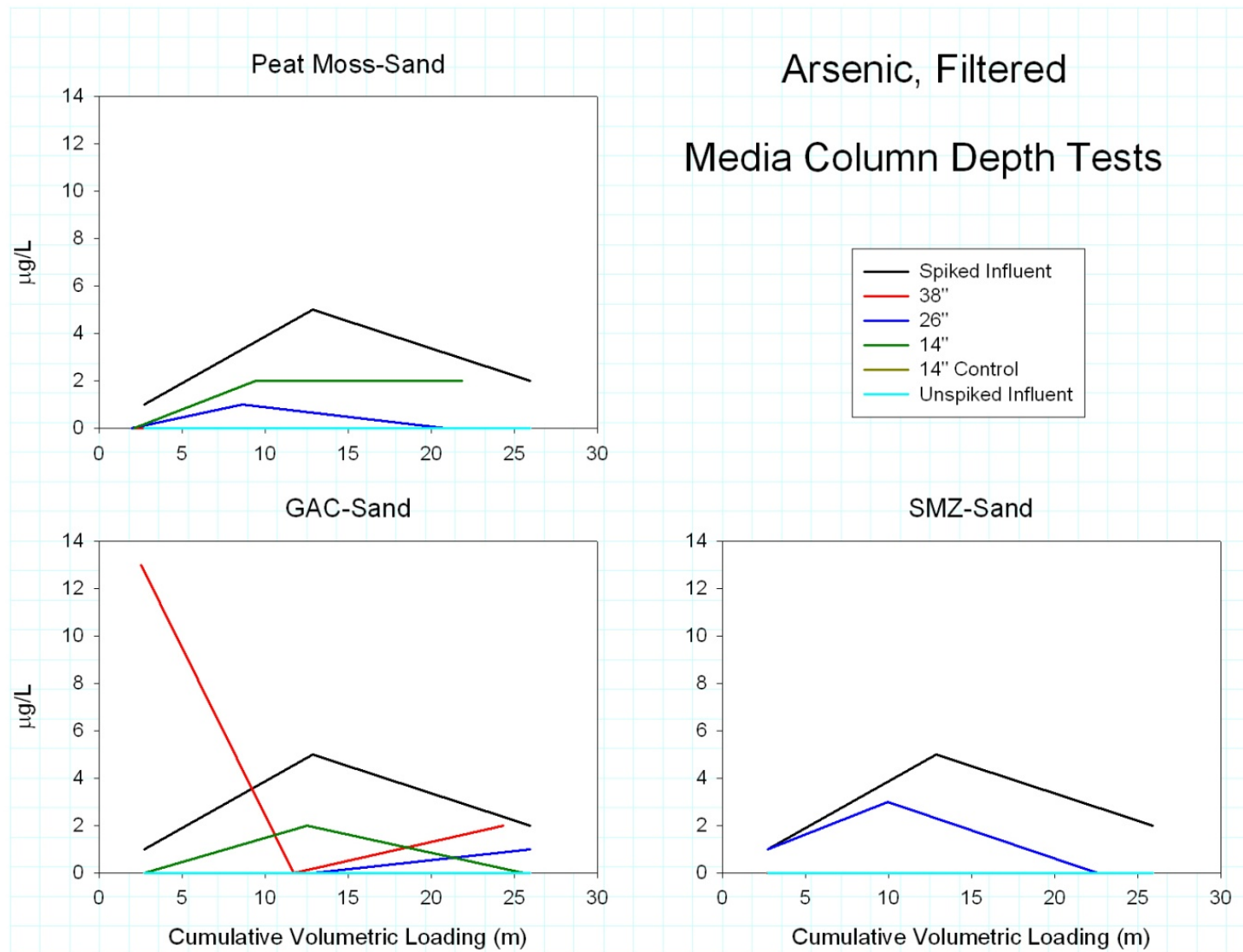


Figure B-13. Arsenic (Filtered) Removal for Component Media

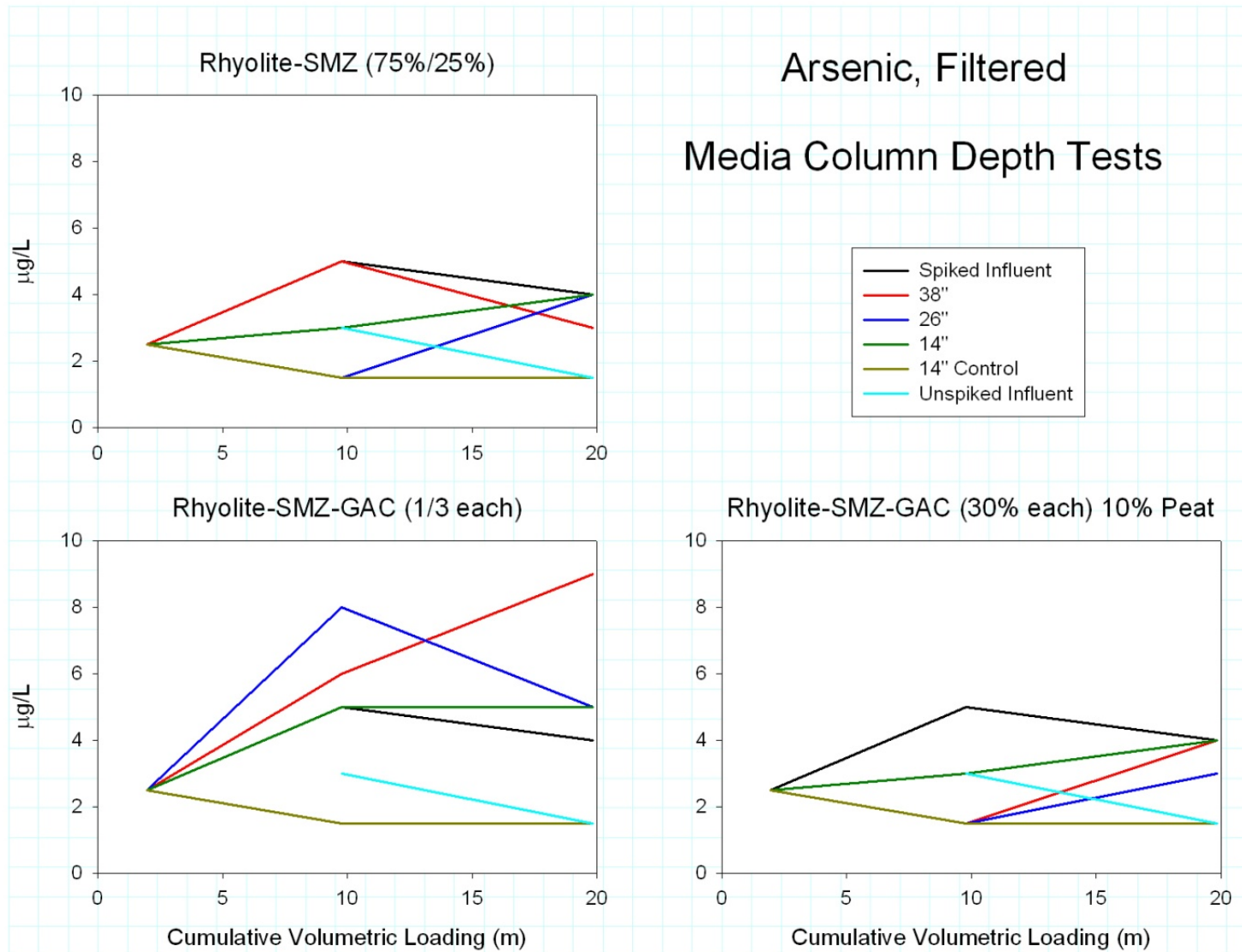


Figure B-14. Arsenic (Filtered) Removal for Media Mixtures

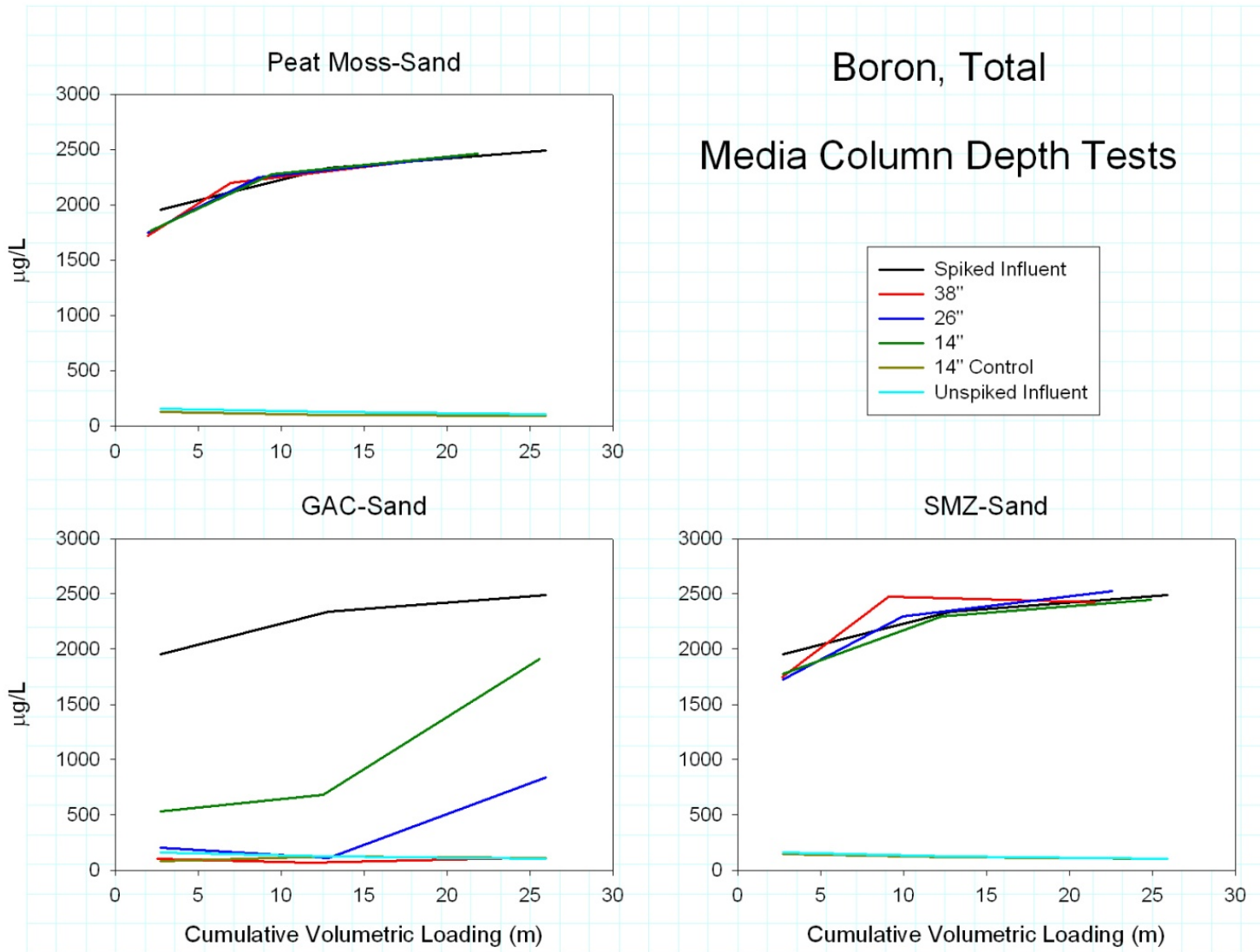


Figure B-15. Boron (Total) Removal for Component Media

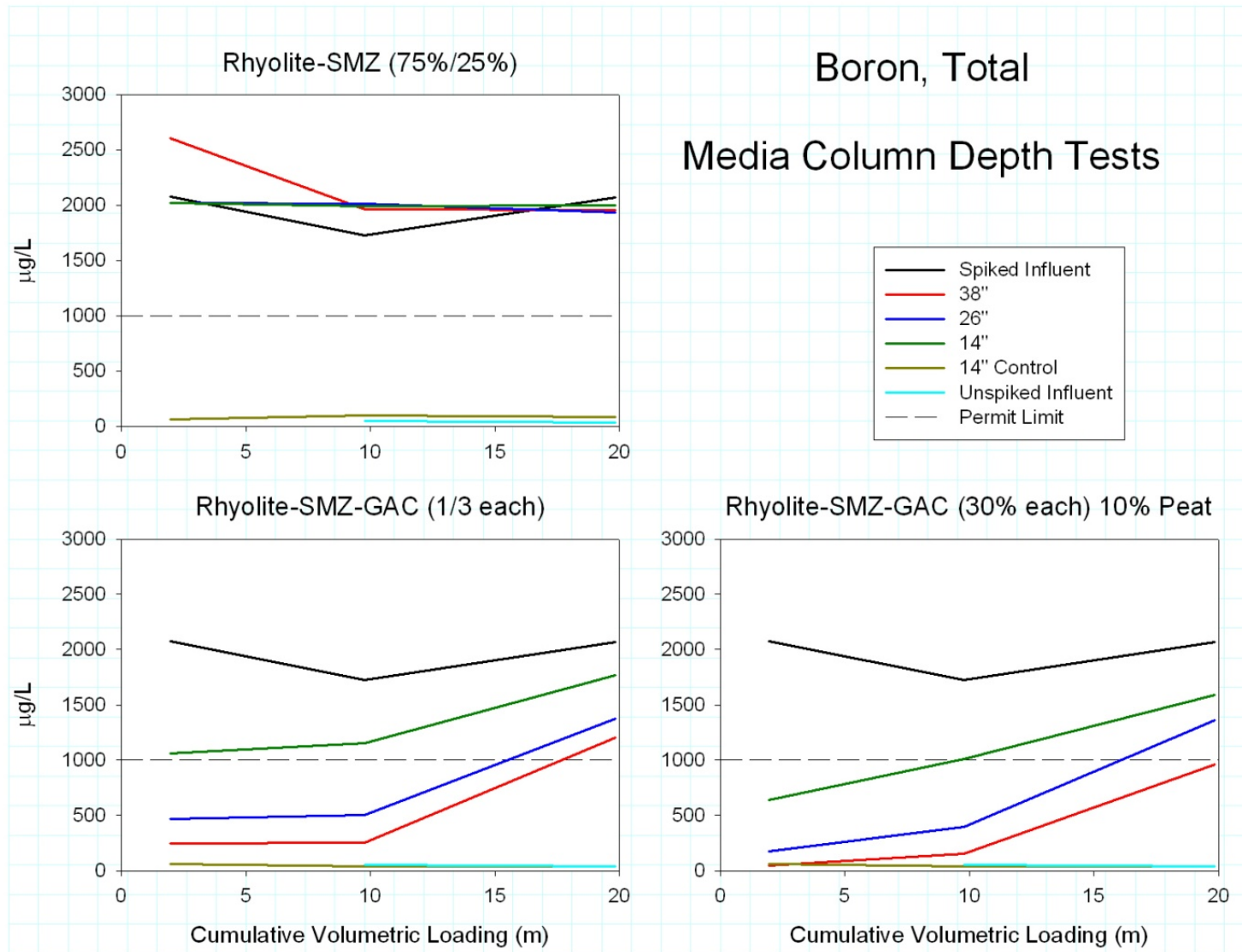


Figure B-16. Boron (Total) Removal for Media Mixtures

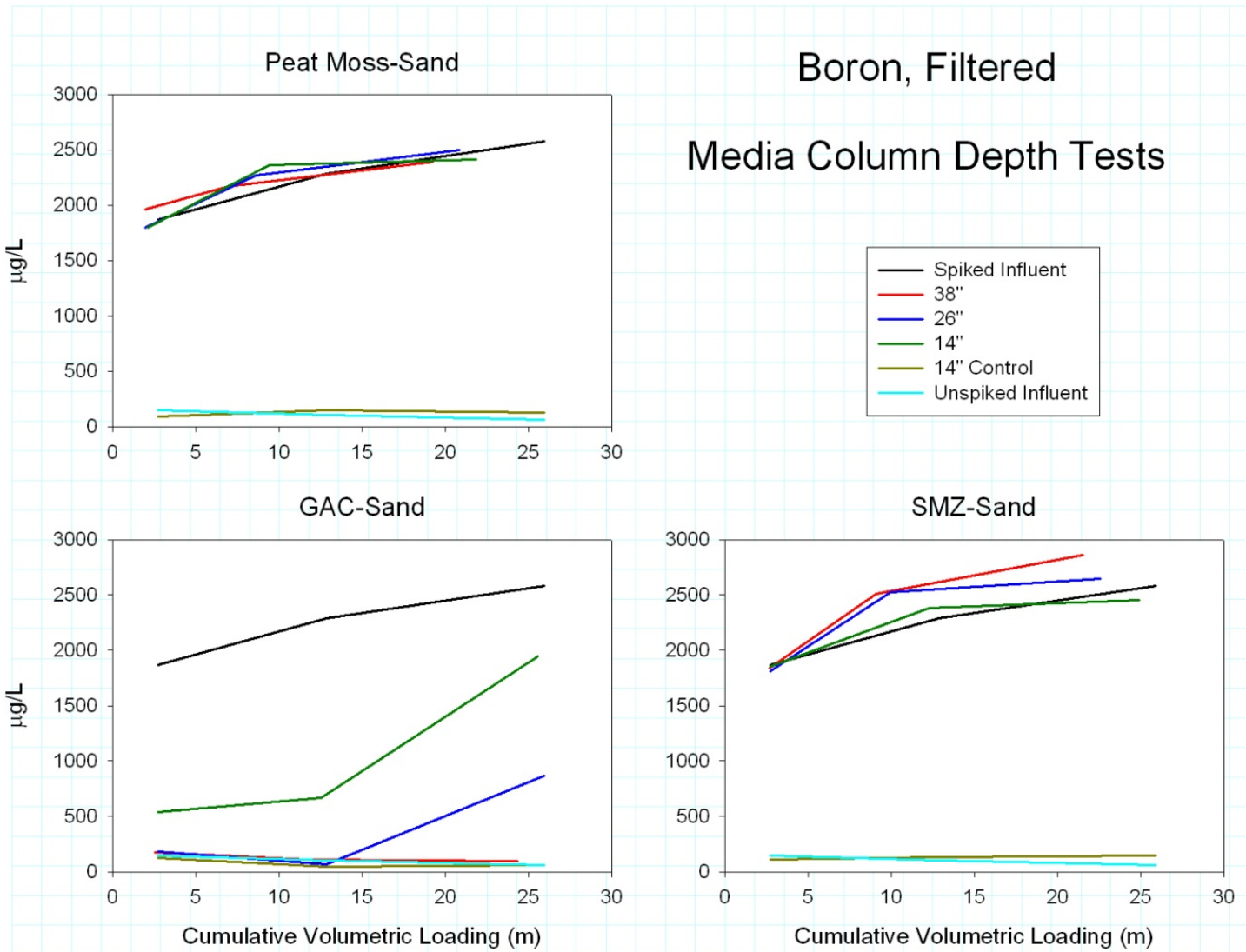


Figure B-17. Boron (Filtered) Removal for Component Media

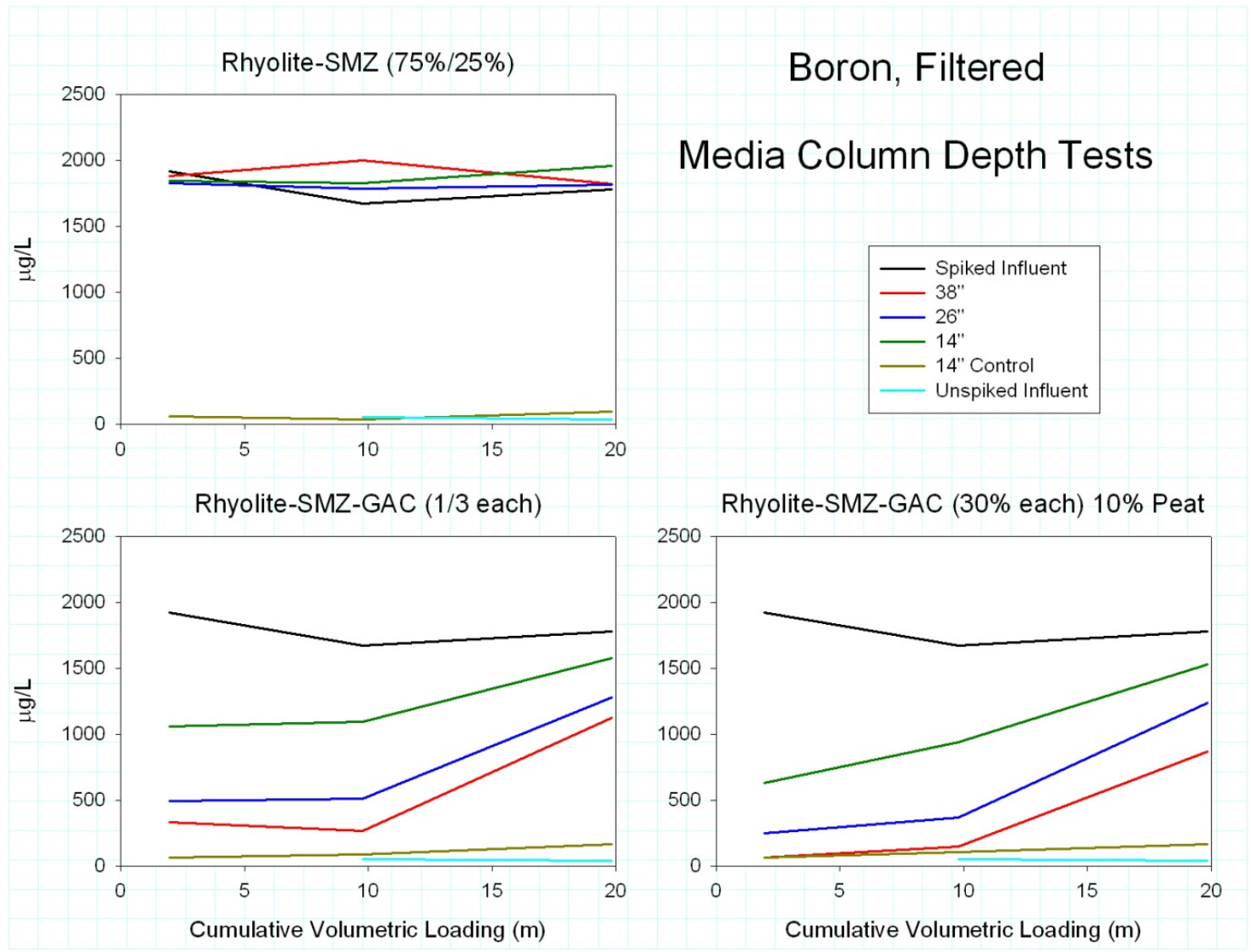


Figure B-18. Boron (Filtered) Removal for Media Mixtures

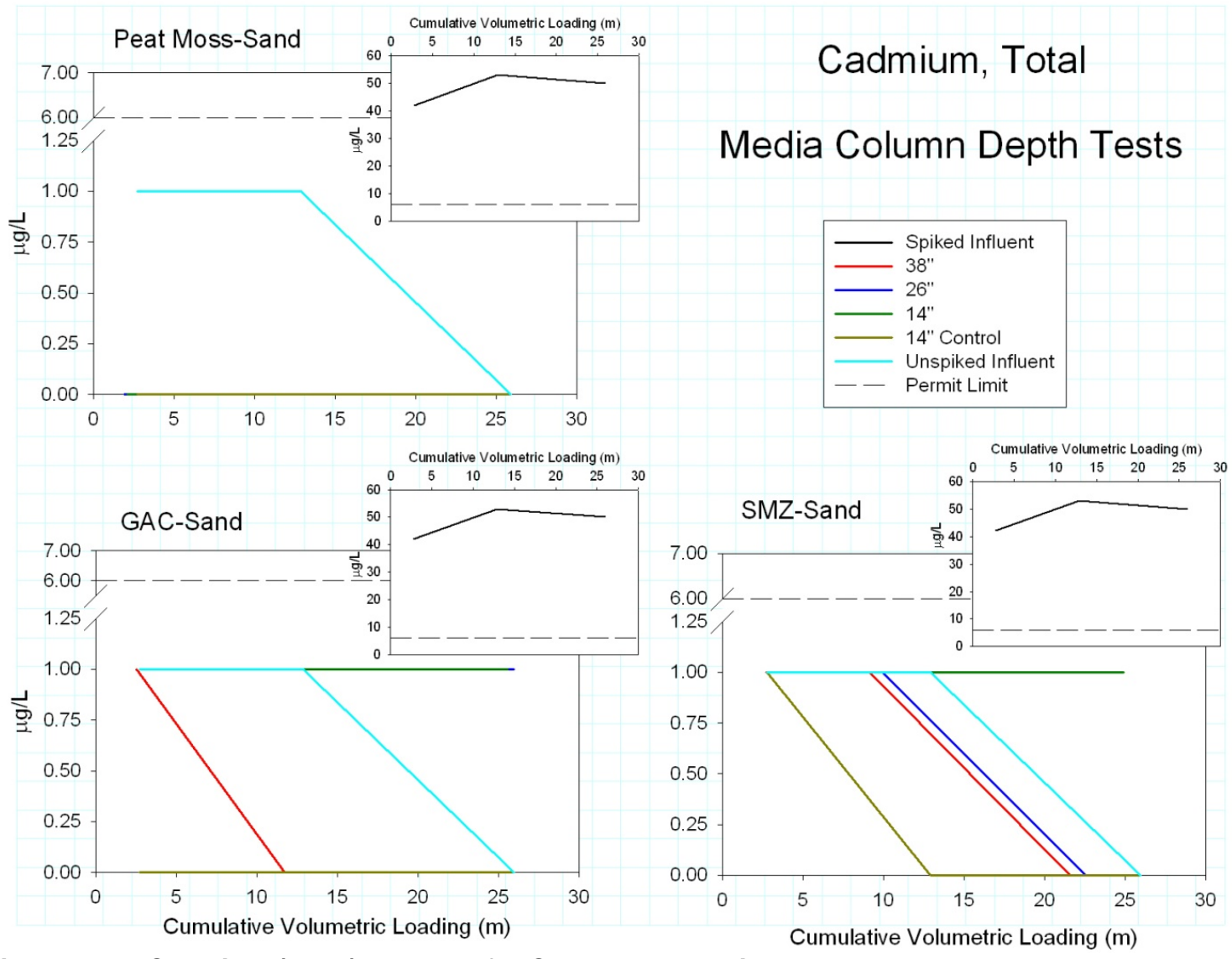


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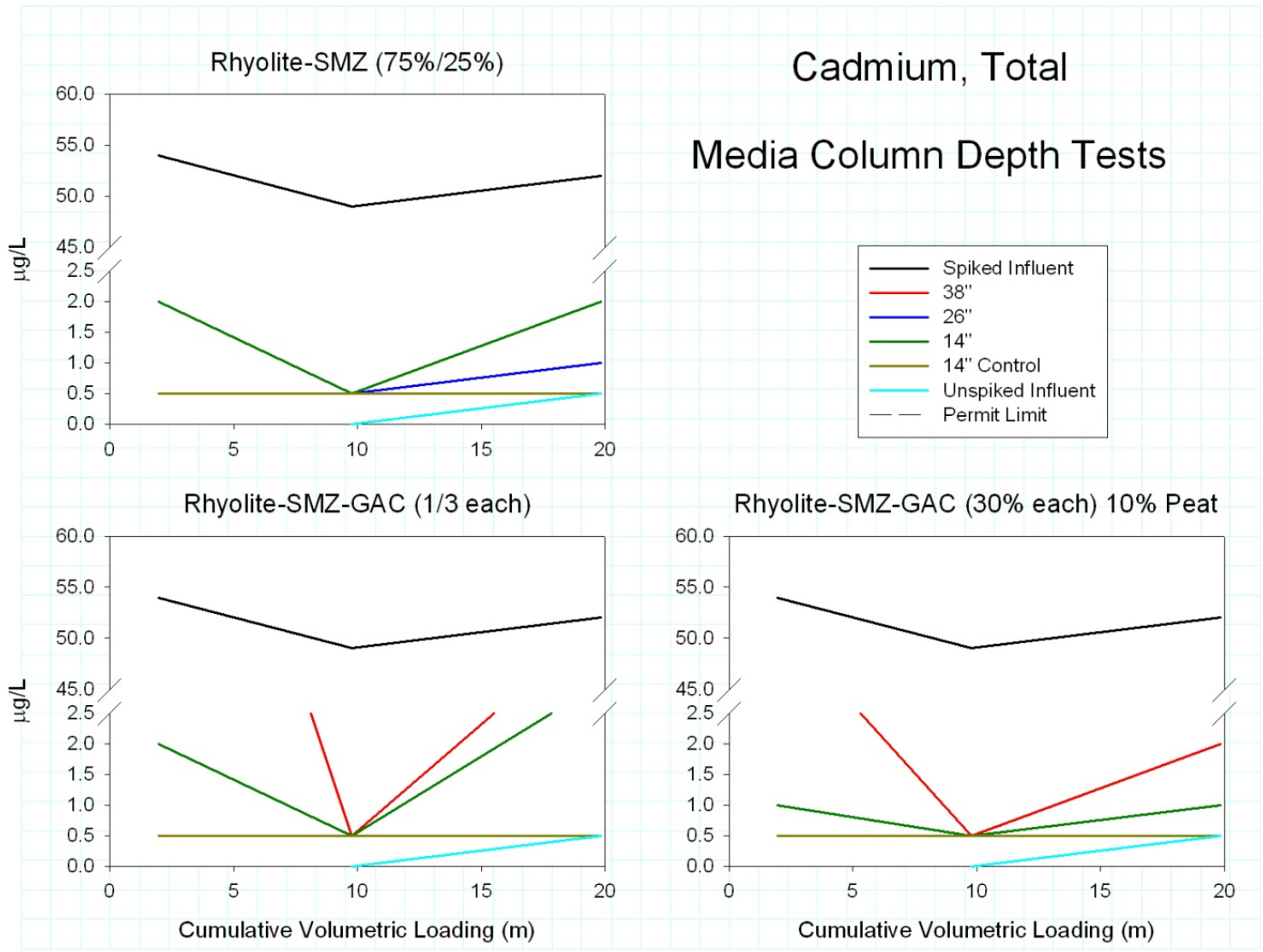


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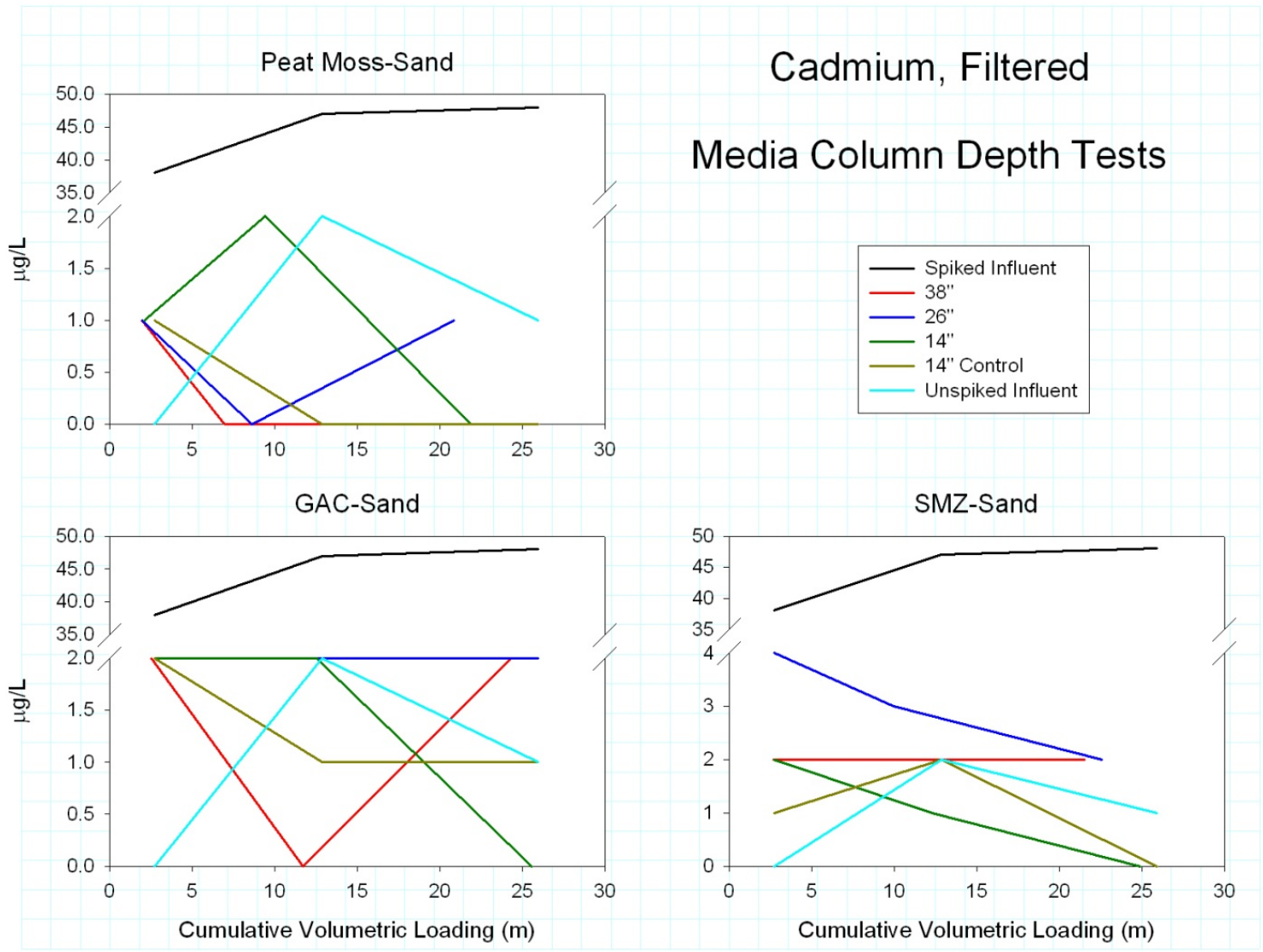


Figure B-21. Cadmium (Filtered) Removal for Component Media

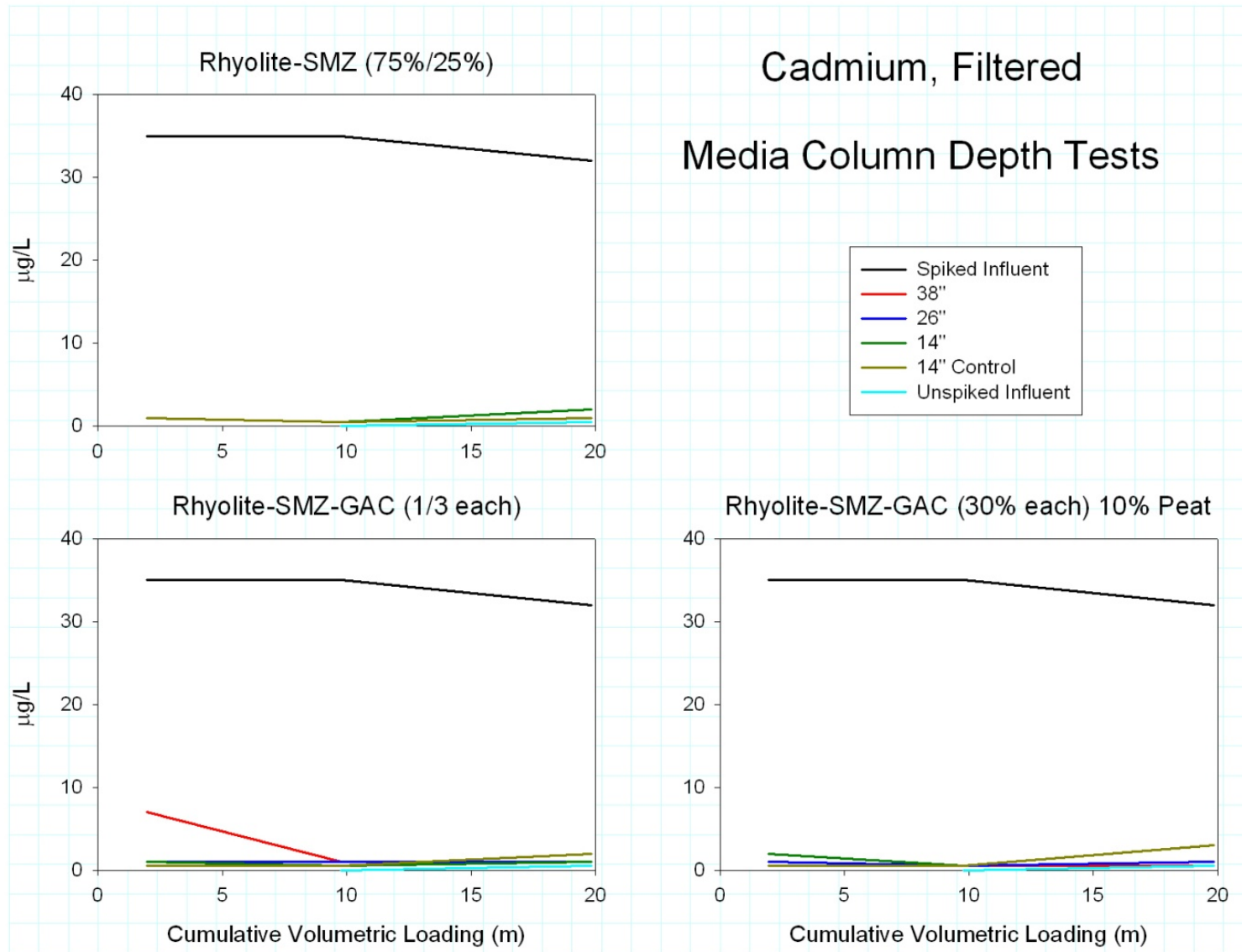


Figure B-22. Cadmium (Filtered) Removal for Media Mixtures

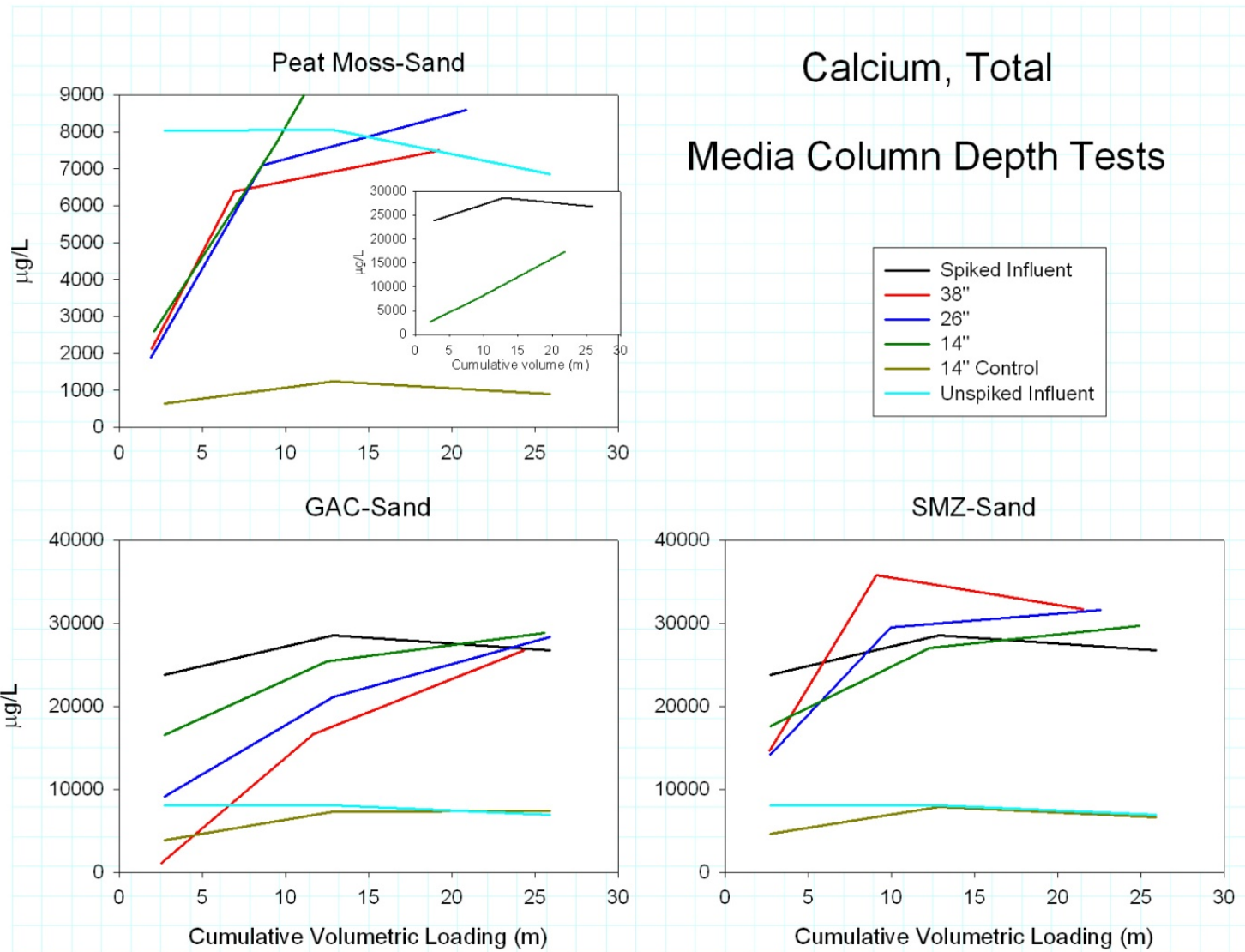


Figure B-23. Calcium (Total) Removal for Component Media

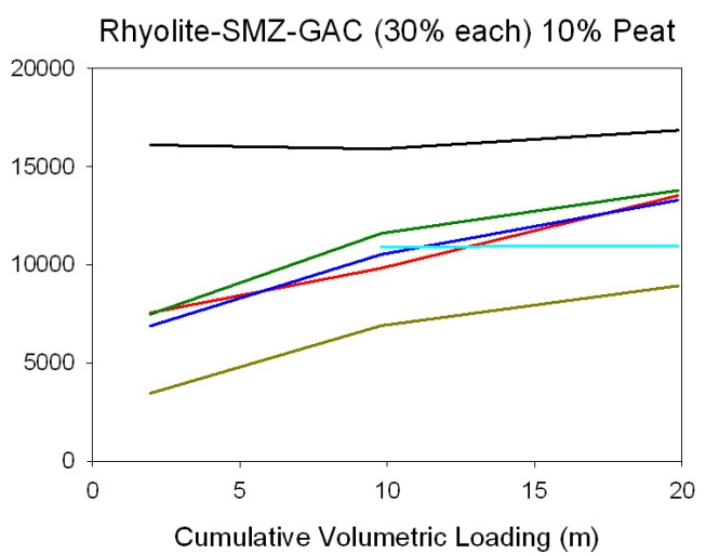
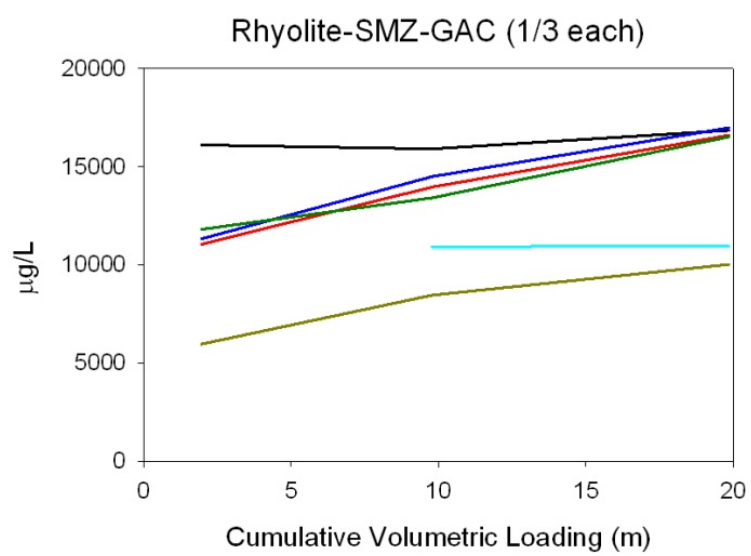
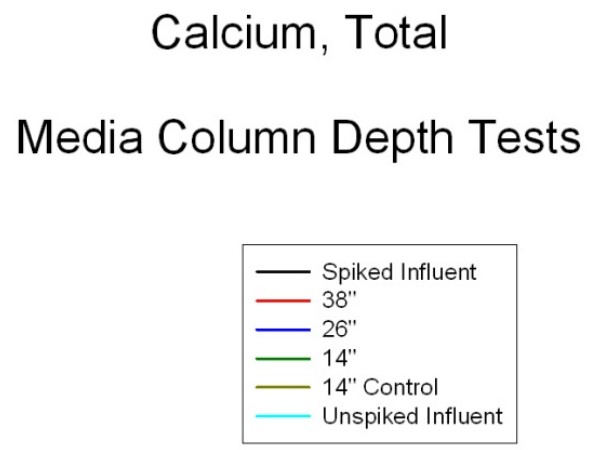
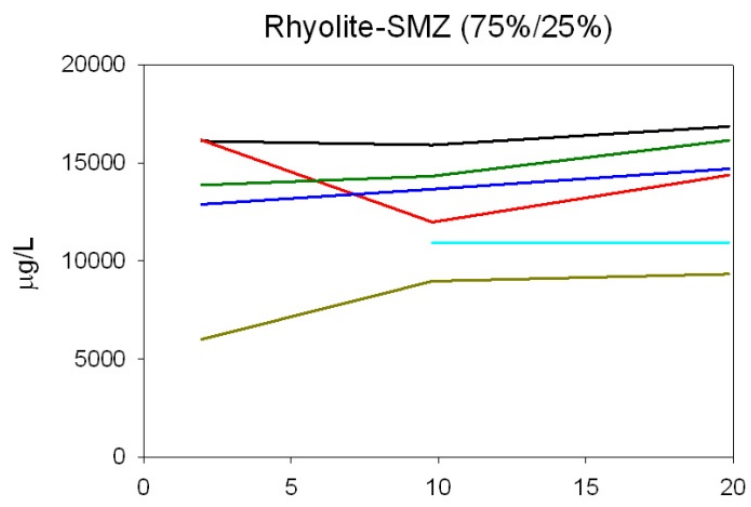


Figure B-24. Calcium (Total) Removal for Media Mixtures

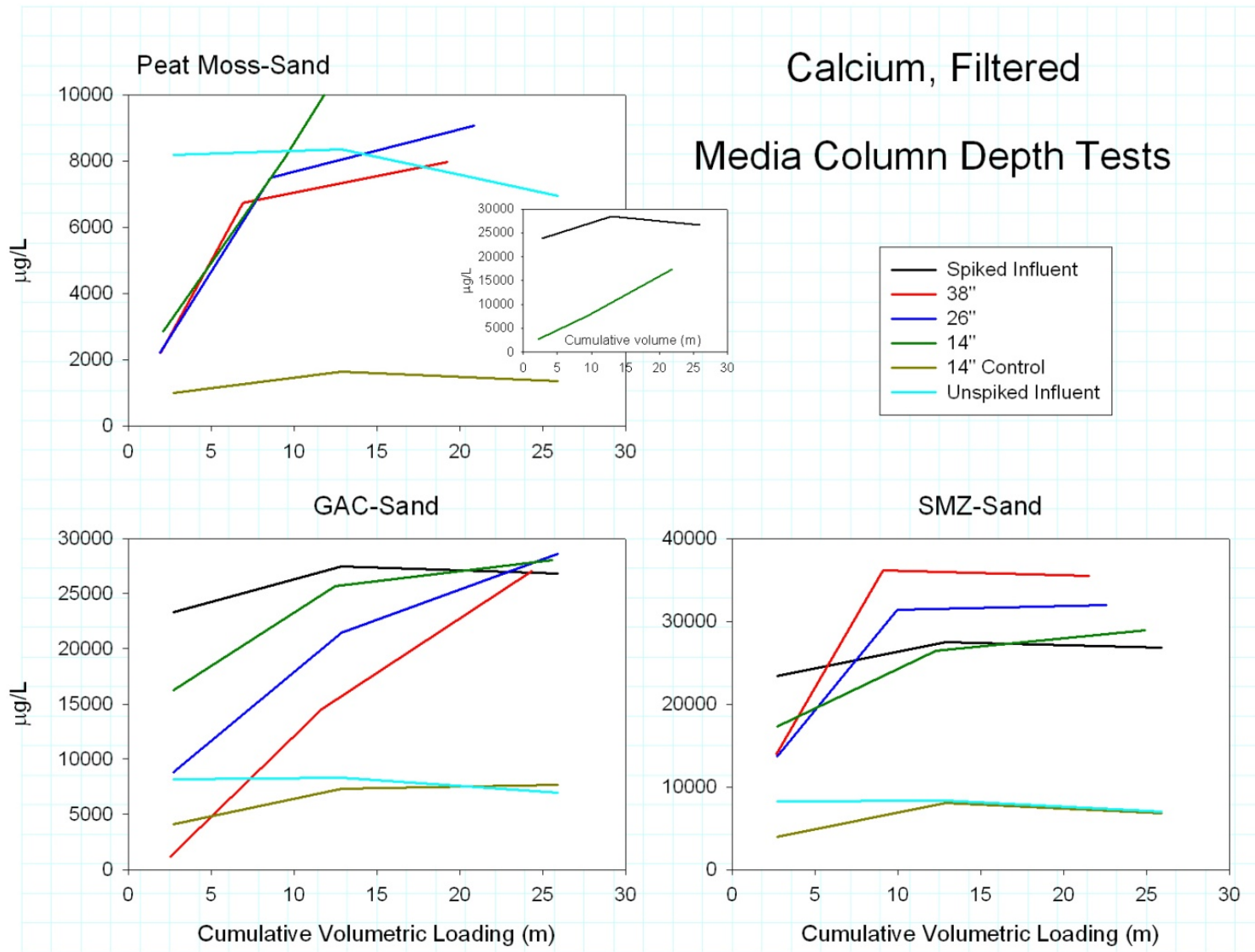


Figure B-25. Calcium (Filtered) Removal

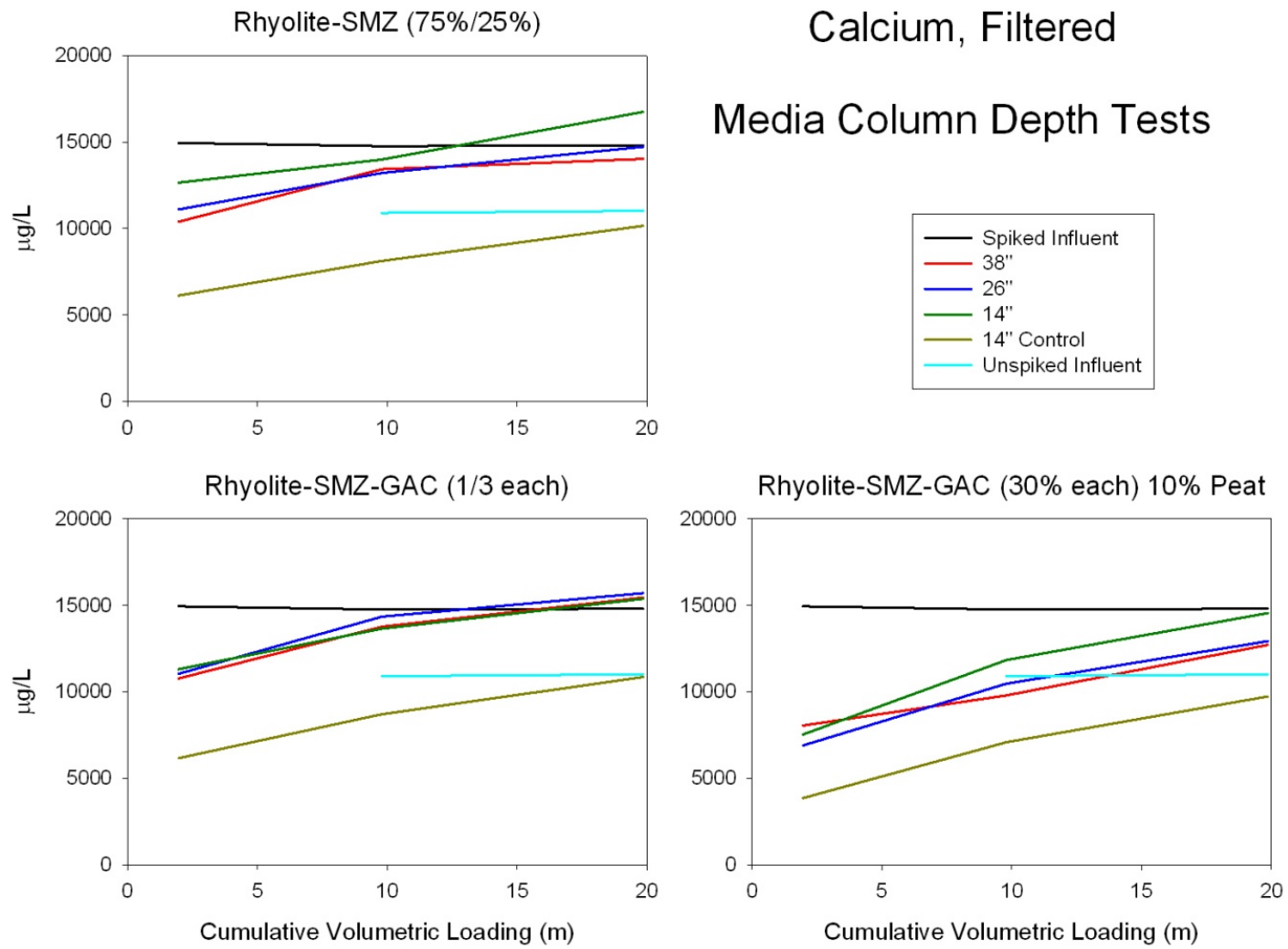
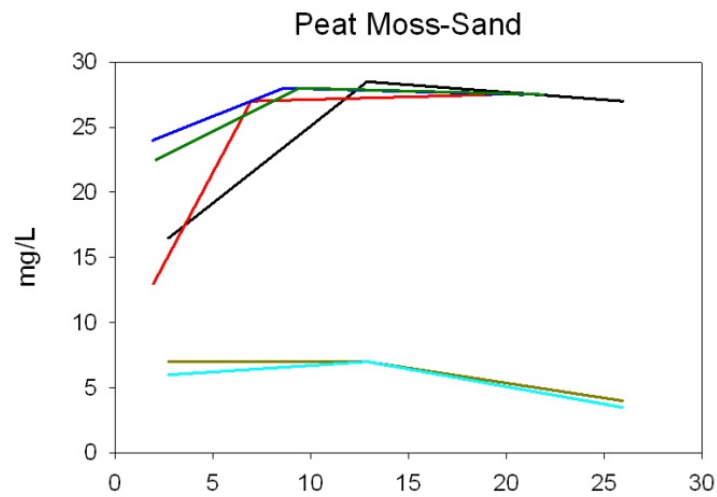


Figure B-26. Calcium (Filtered) Removal for Media Mixtures



Chloride Media Column Depth Tests

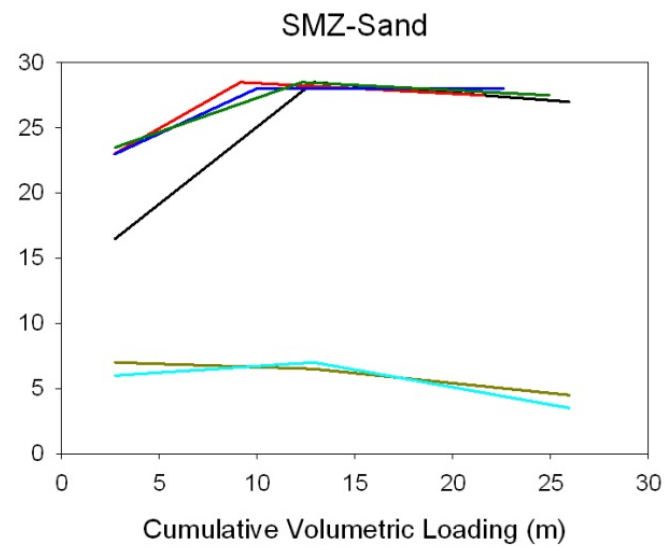
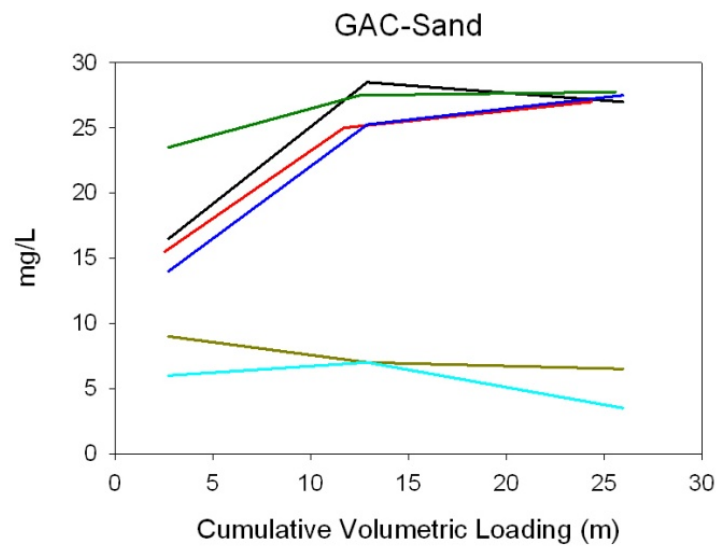
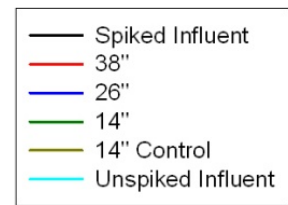


Figure B-27. Chloride Removal for Component Media

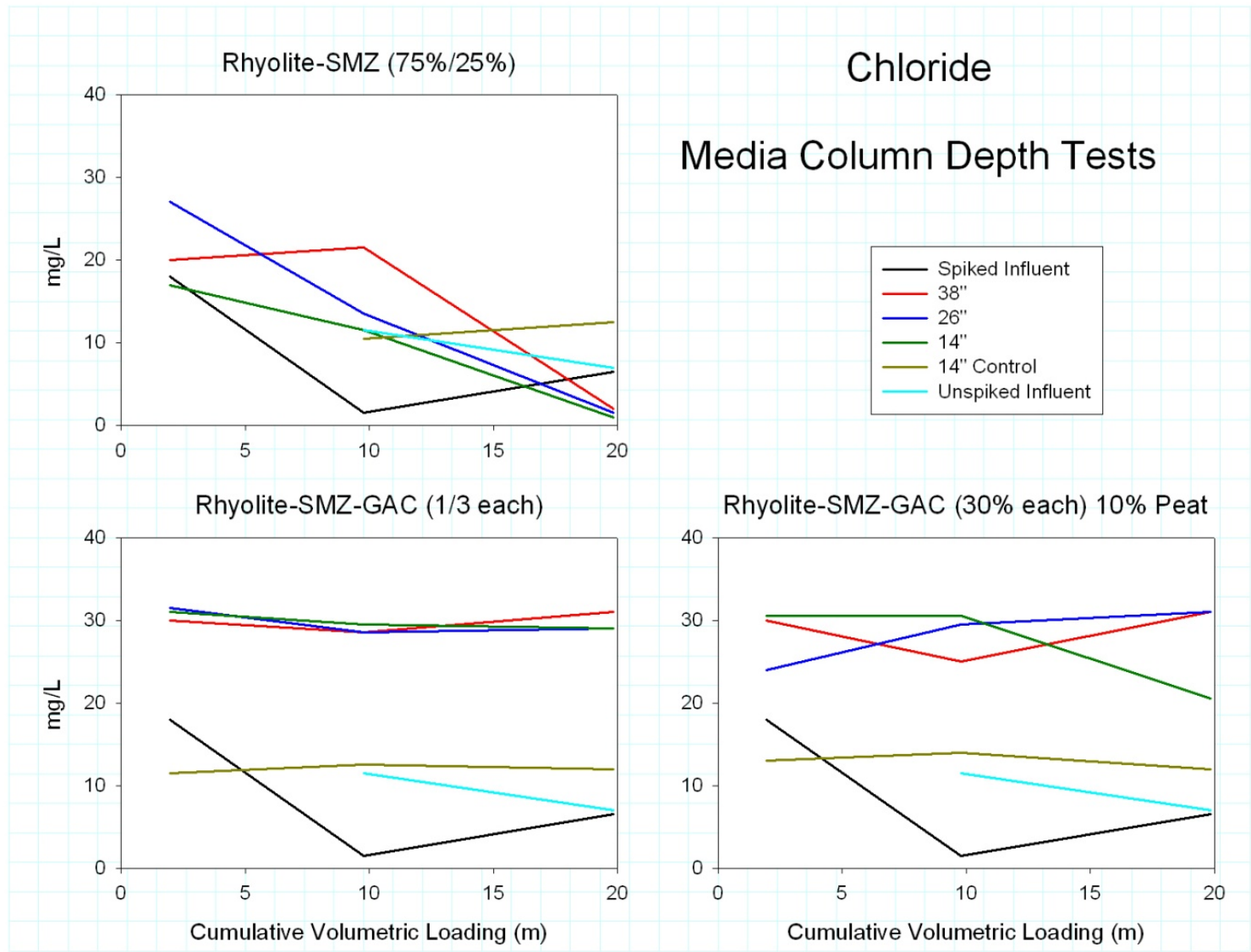


Figure B-28. Chloride Removal for Media Mixtures

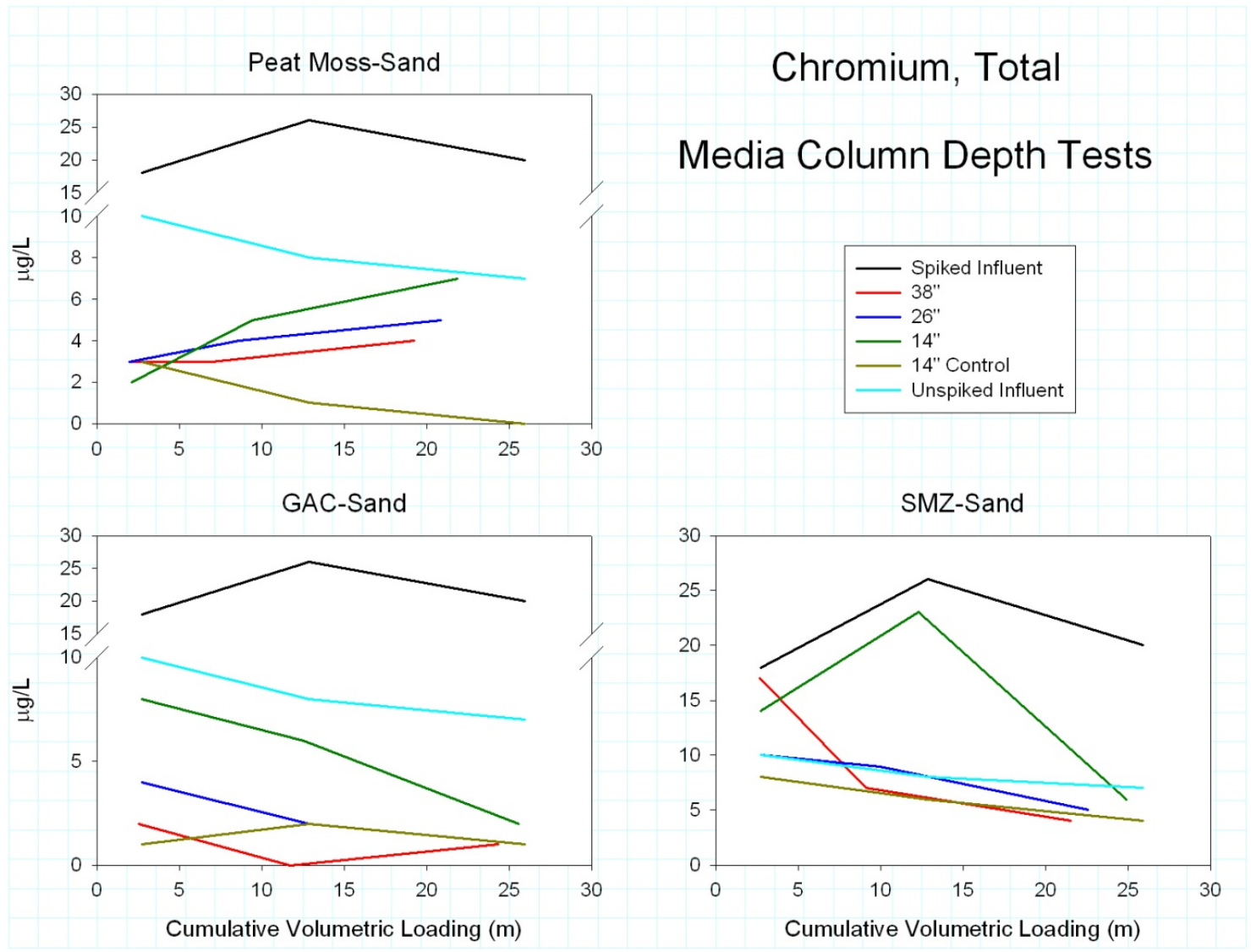


Figure B-29. Chromium (Total) Removal

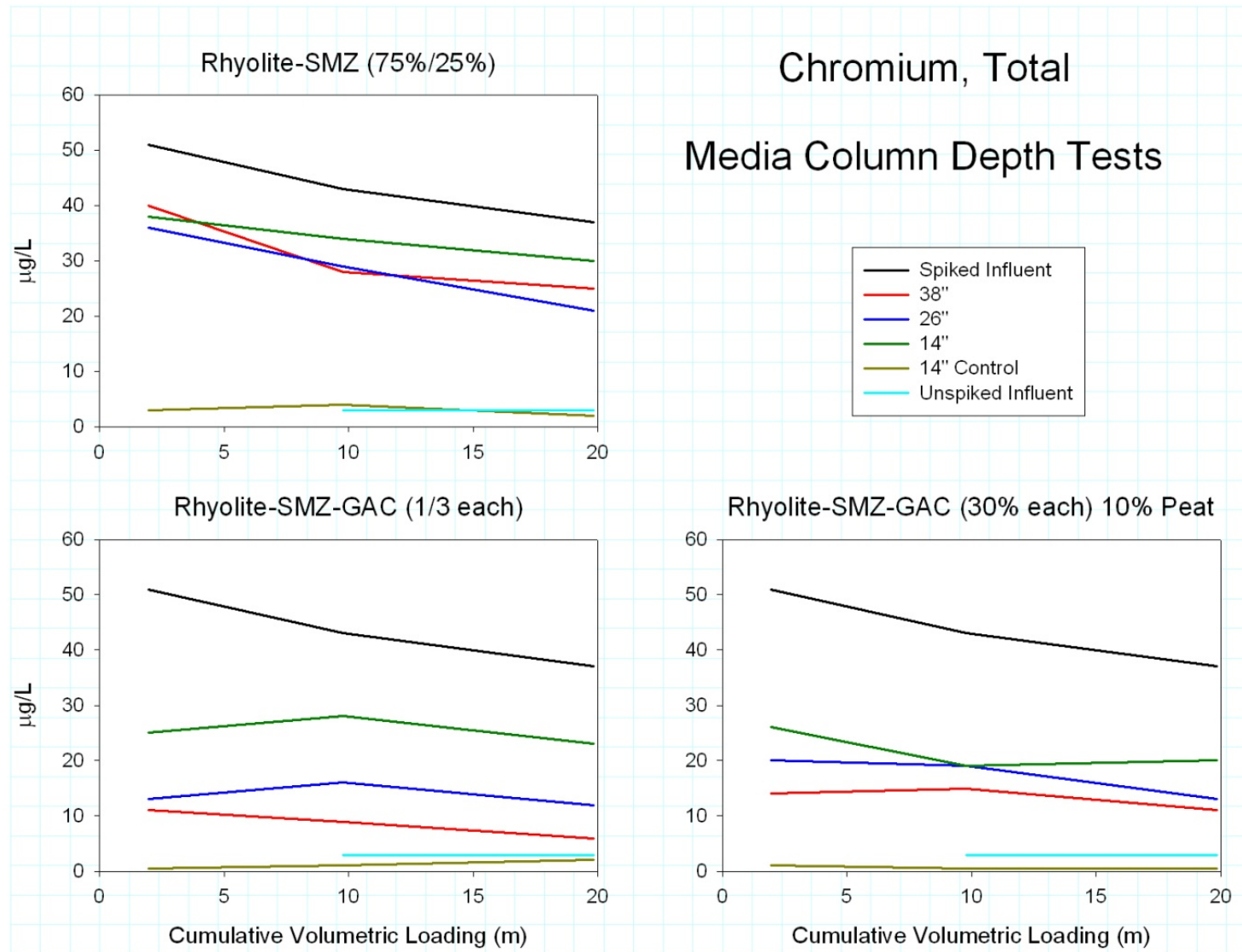


Figure B-30. Chromium (Total) Removal for Media Mixtures

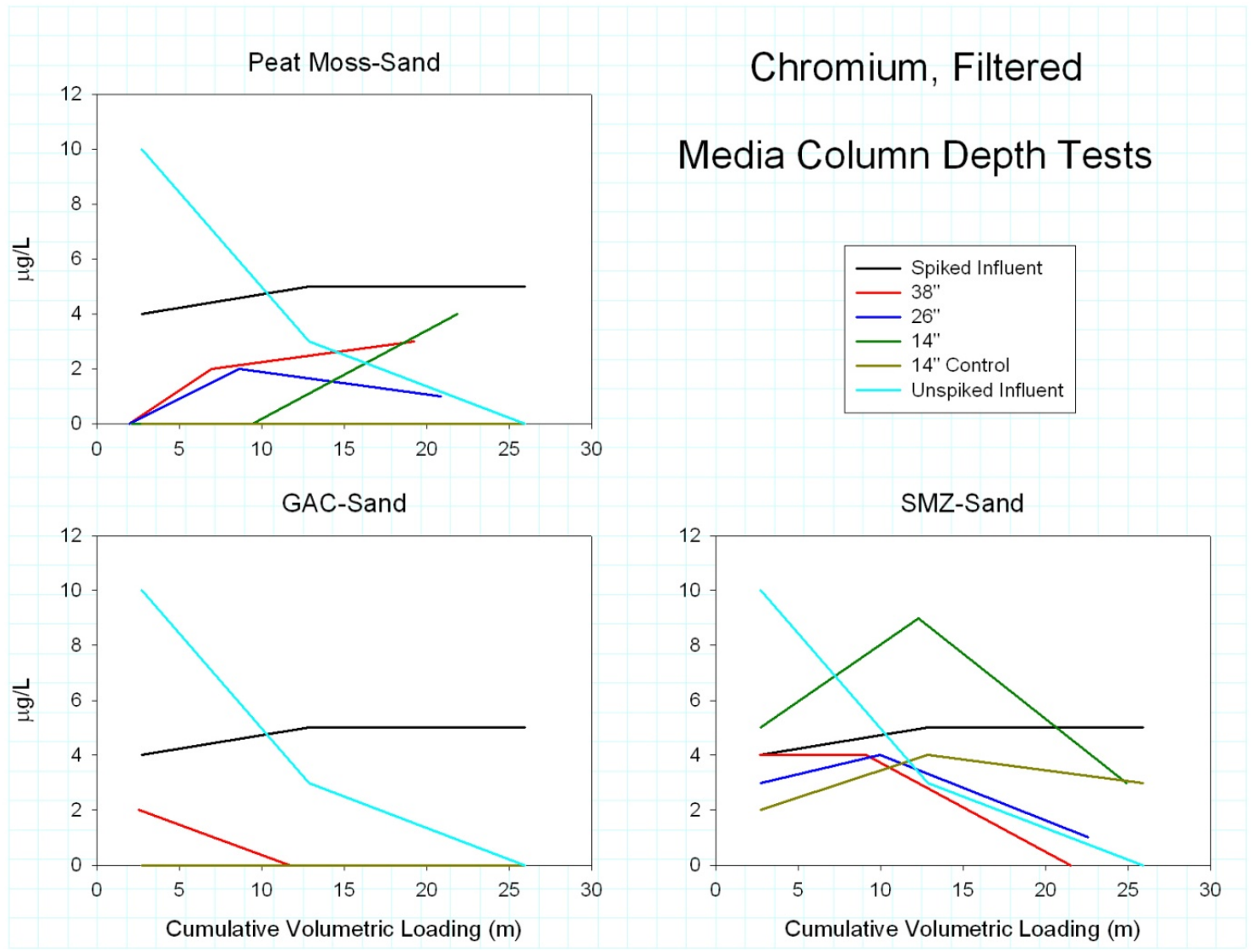


Figure B-31. Chromium (Filtered) Removal for Component Media

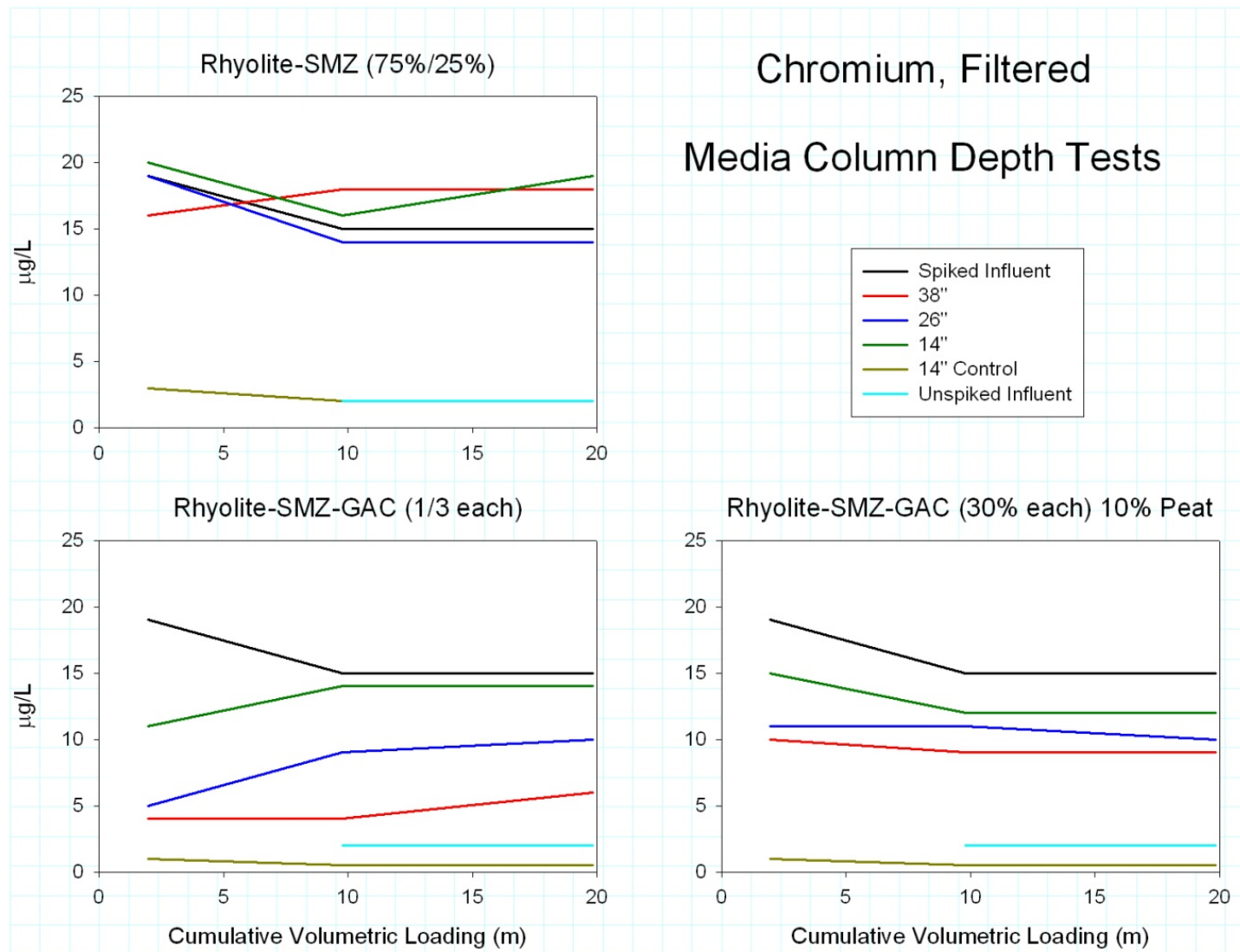


Figure B-32. Chromium (Filtered) Removal for Media Mixtures

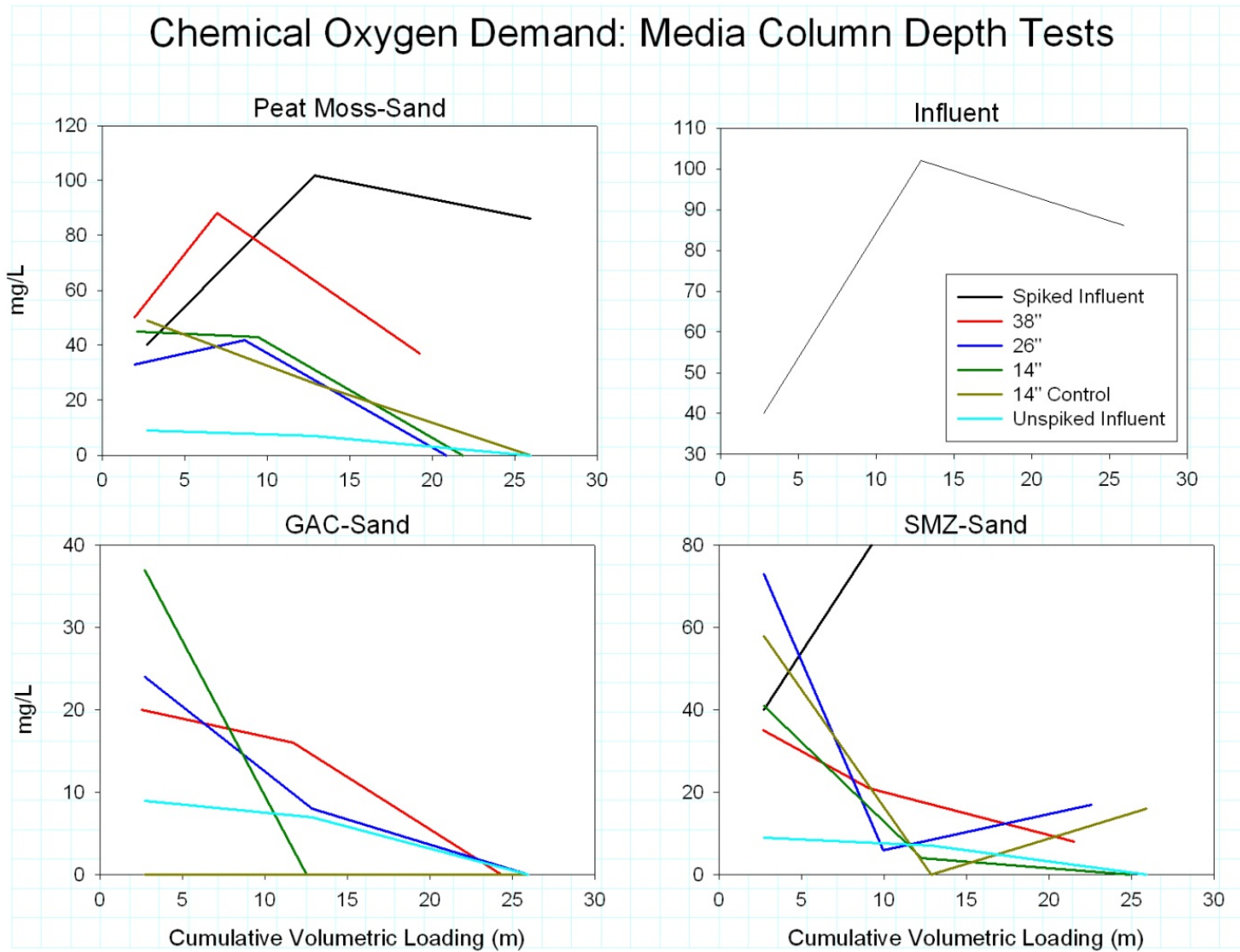


Figure B-33. Chemical Oxygen Demand Removal for Component Media

Chemical Oxygen Demand Media Column Depth Tests

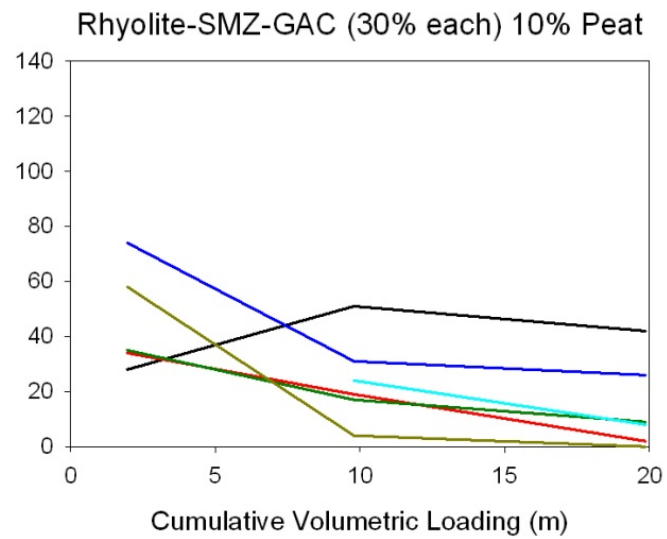
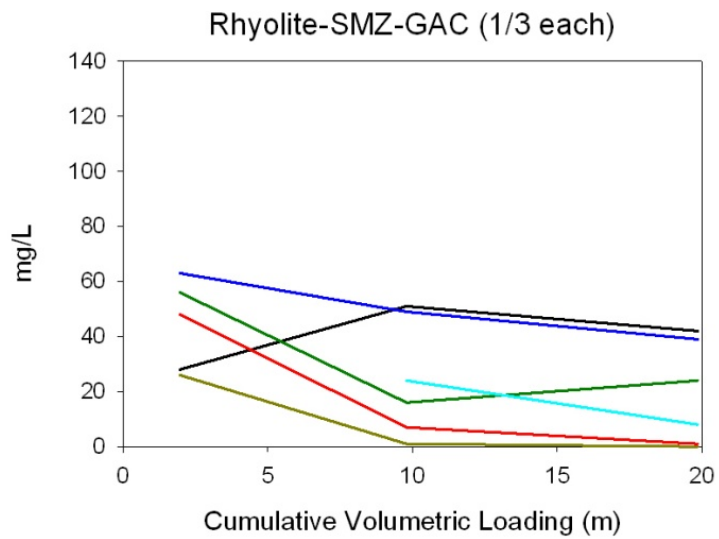
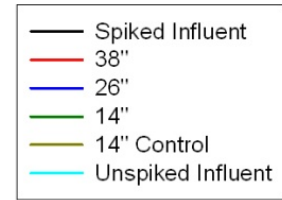
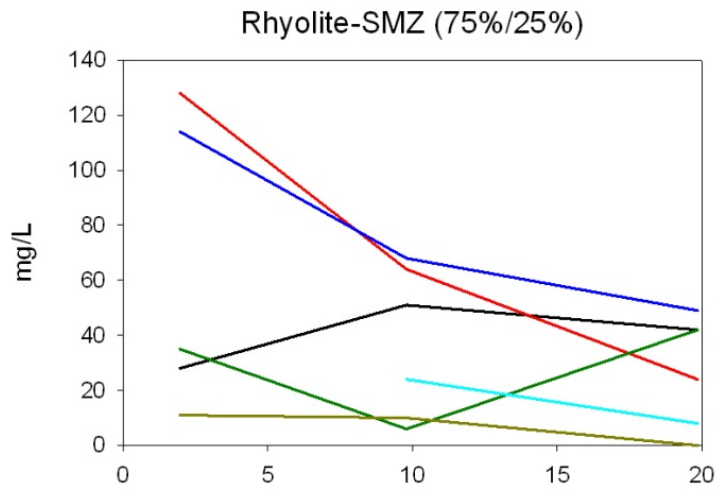
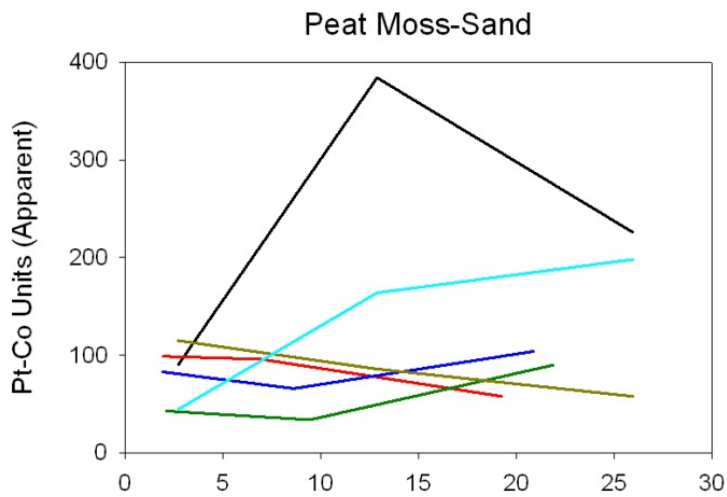


Figure B-34. Chemical Oxygen Demand Removal for Media Mixtures



Color Media Column Depth Tests

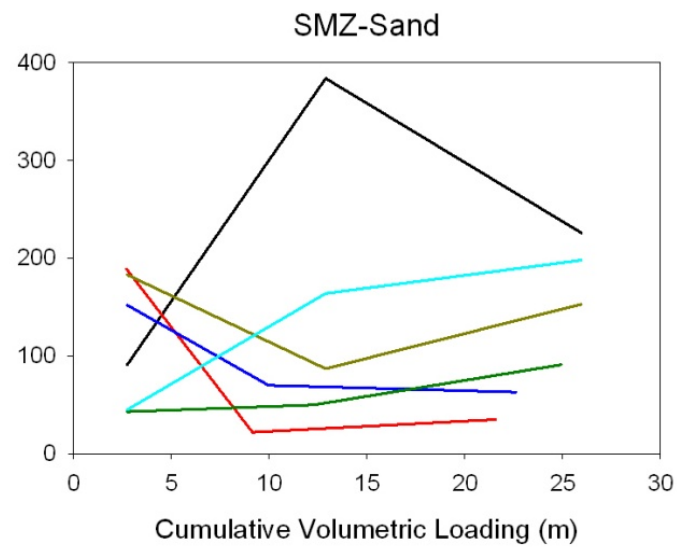
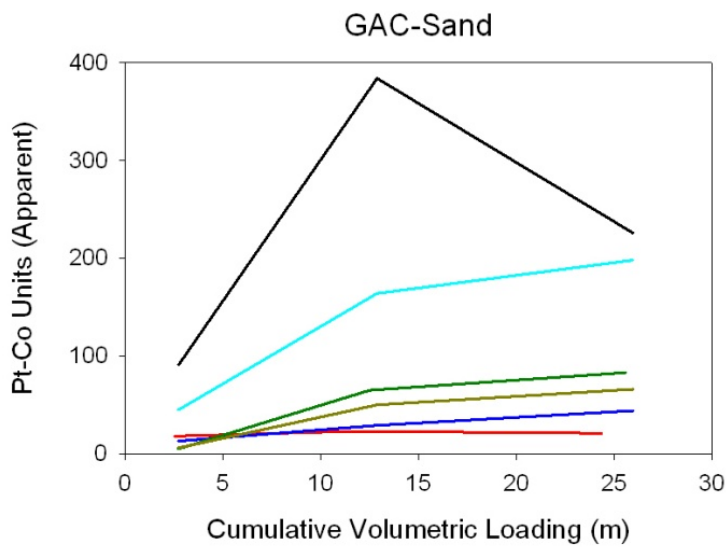
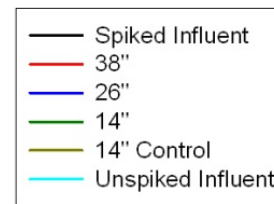
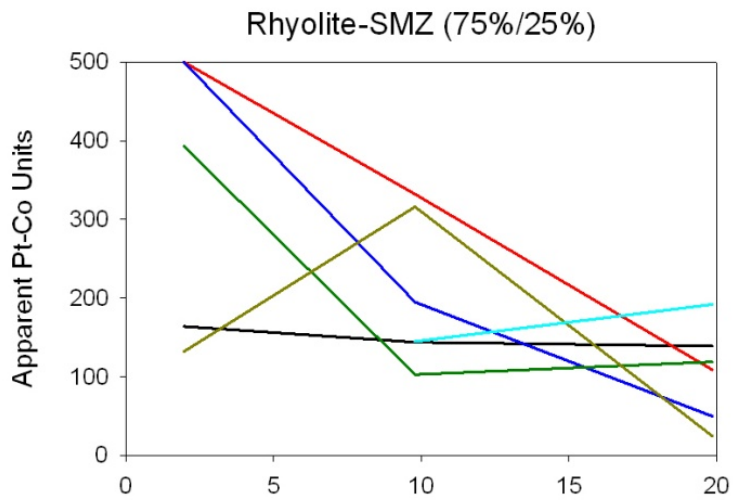


Figure B-35. Color (Apparent) Removal for Component Media



Color Media Column Depth Tests

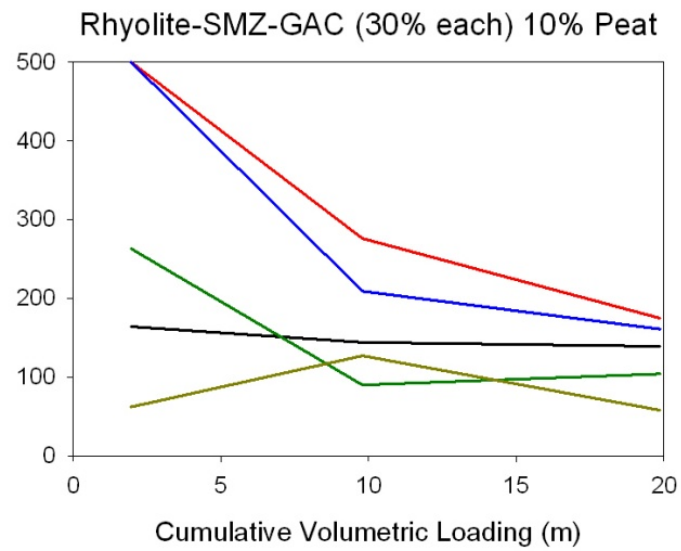
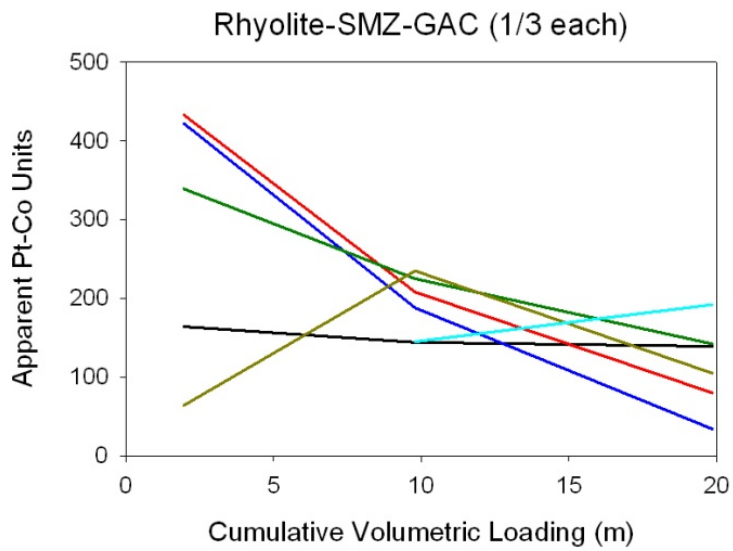
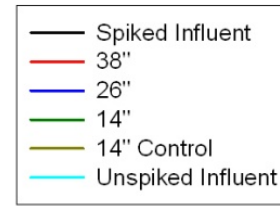


Figure B-36. Color (Apparent) Removal for Media Mixtures

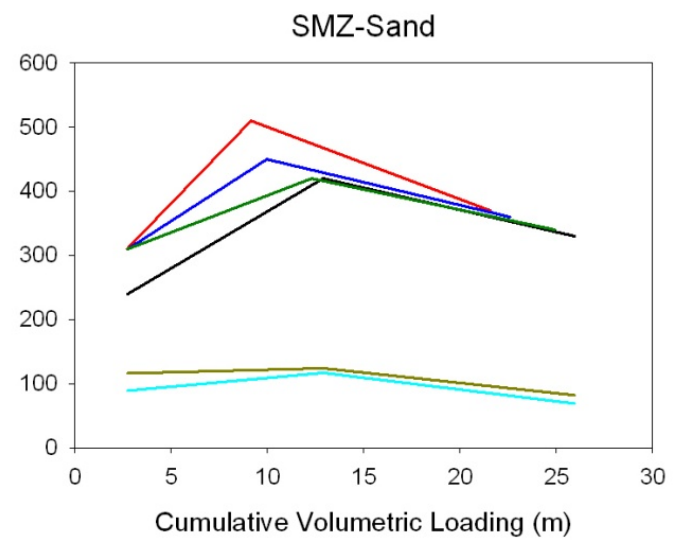
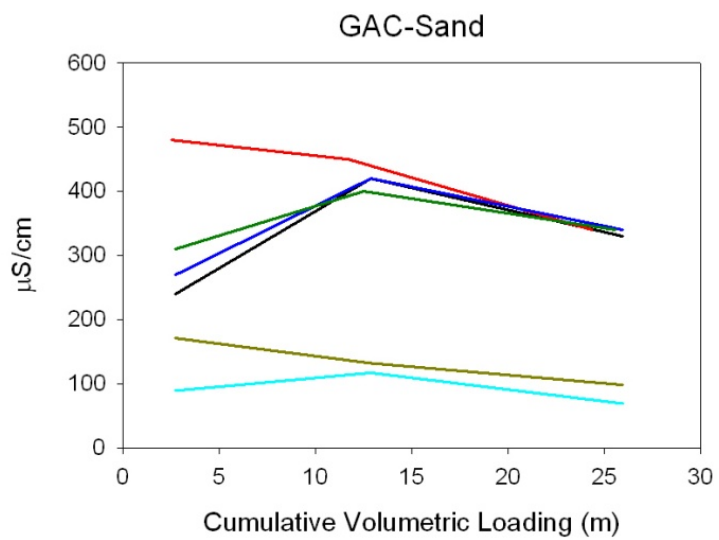
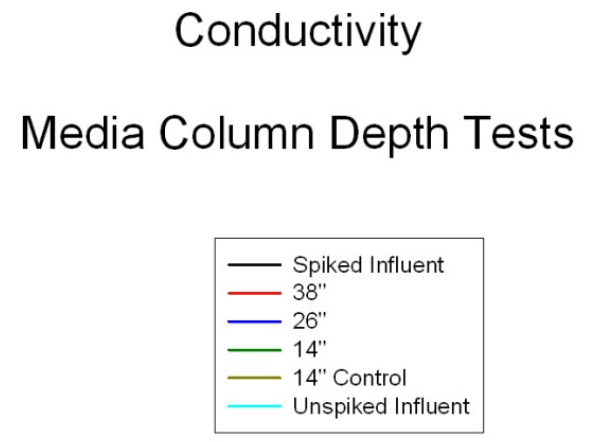
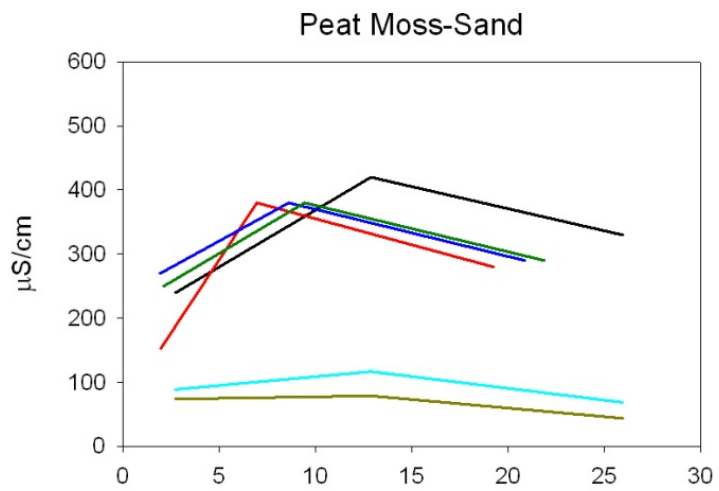


Figure B-37. Conductivity Removal for Component Media

Conductivity

Media Column Depth Tests

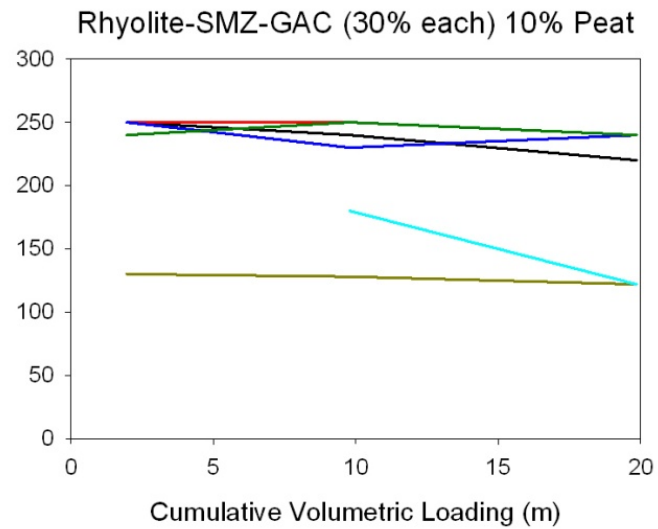
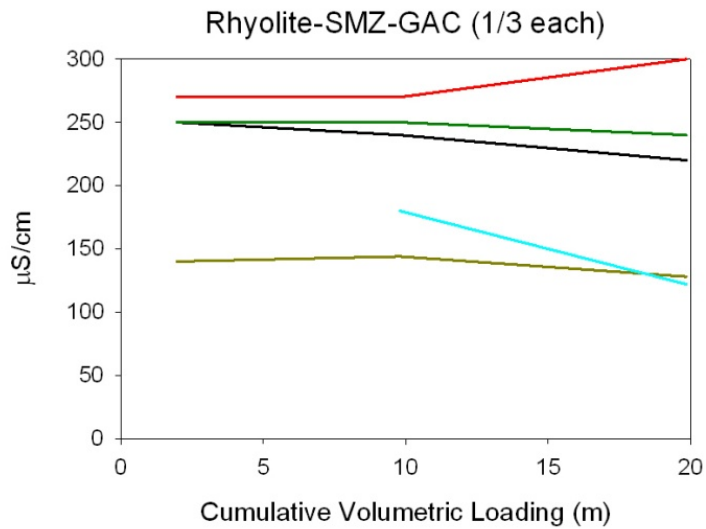
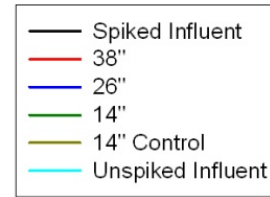
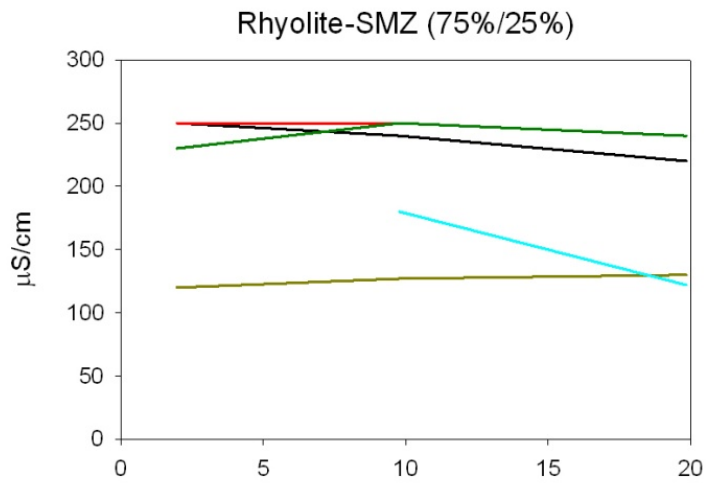


Figure B-38. Conductivity Removal

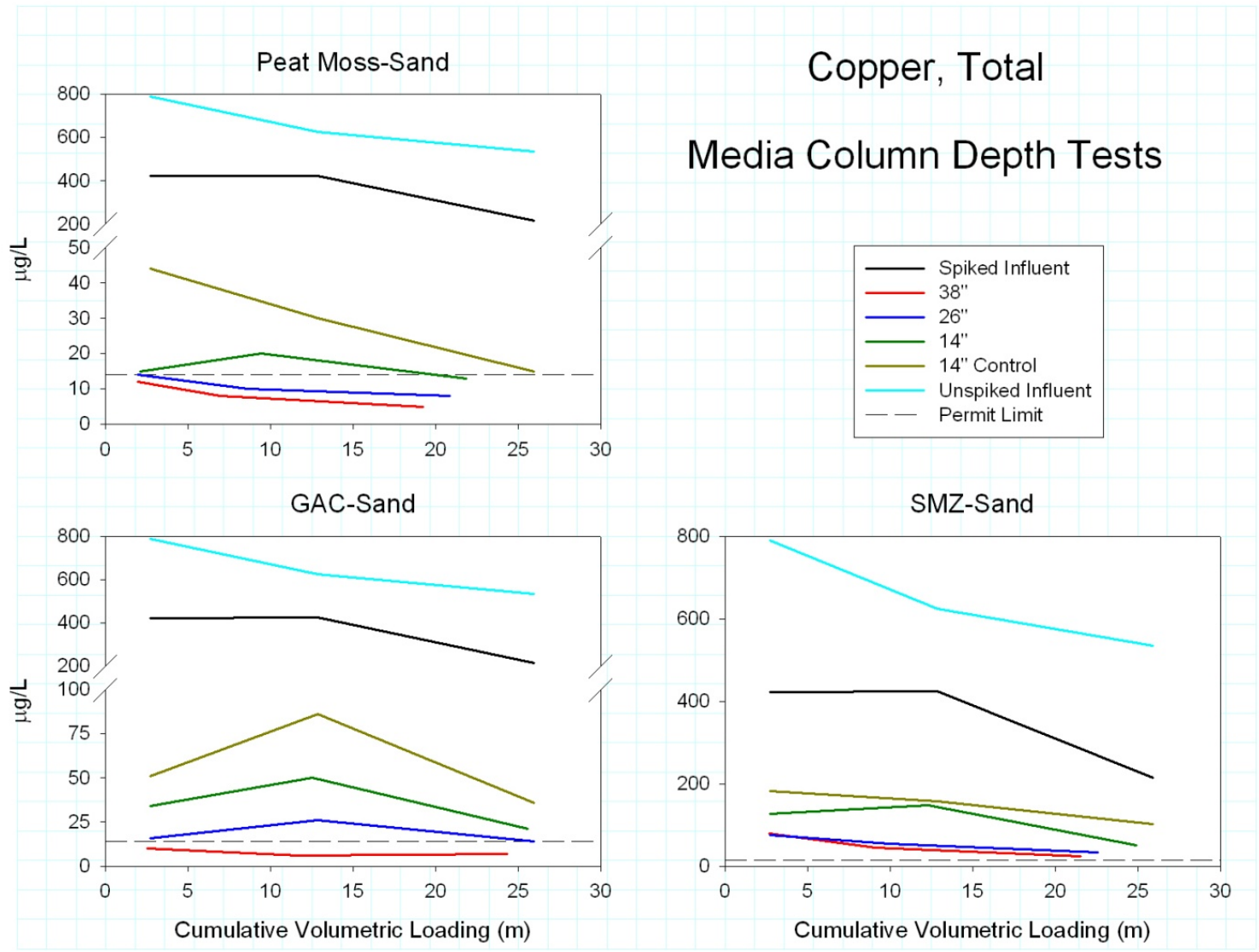


Figure B-39. Copper (Total) Removal for Component Media

Copper, Total Media Column Depth Tests

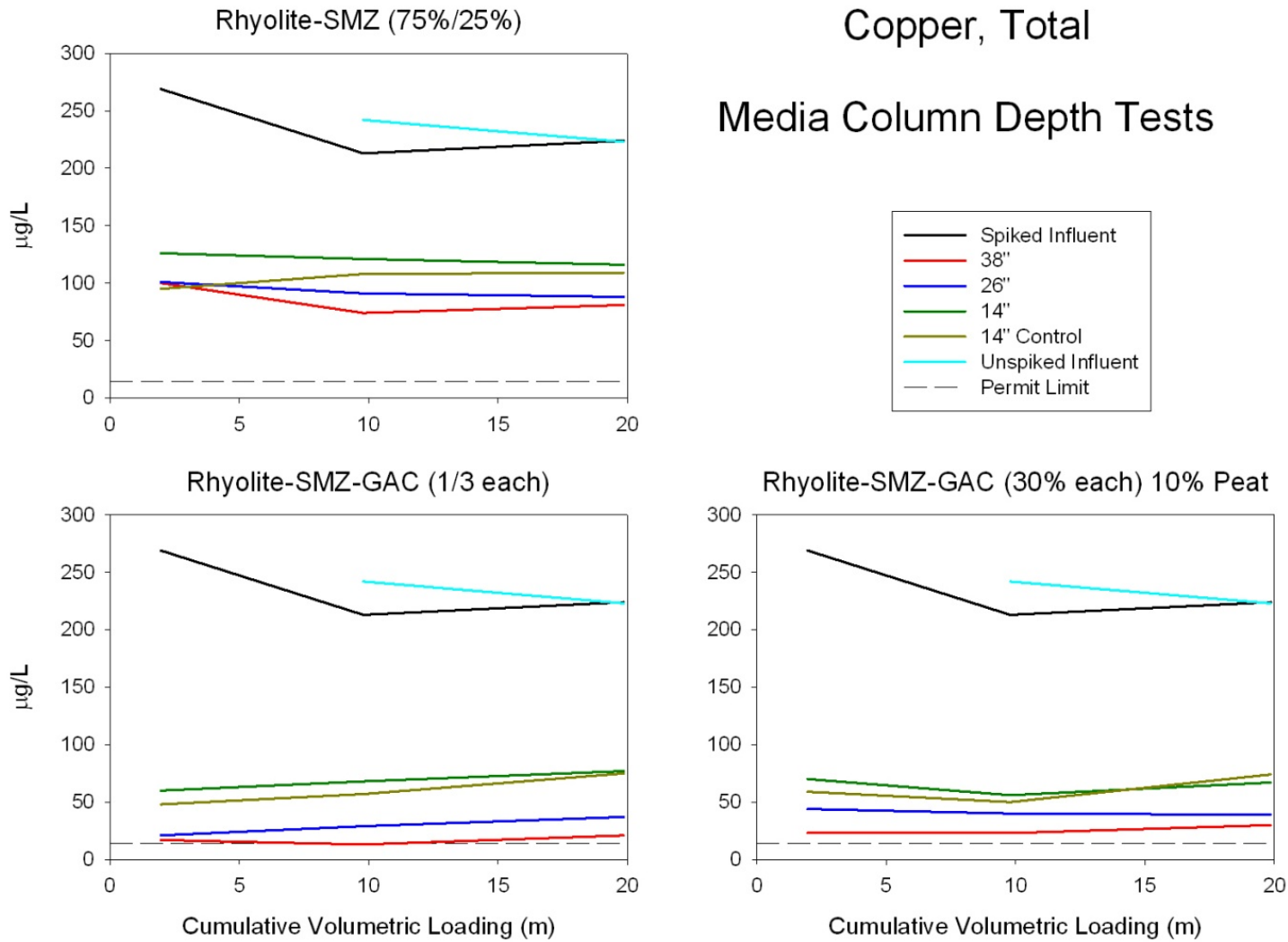


Figure B-40. Copper (Total) Removal for Media Mixtures

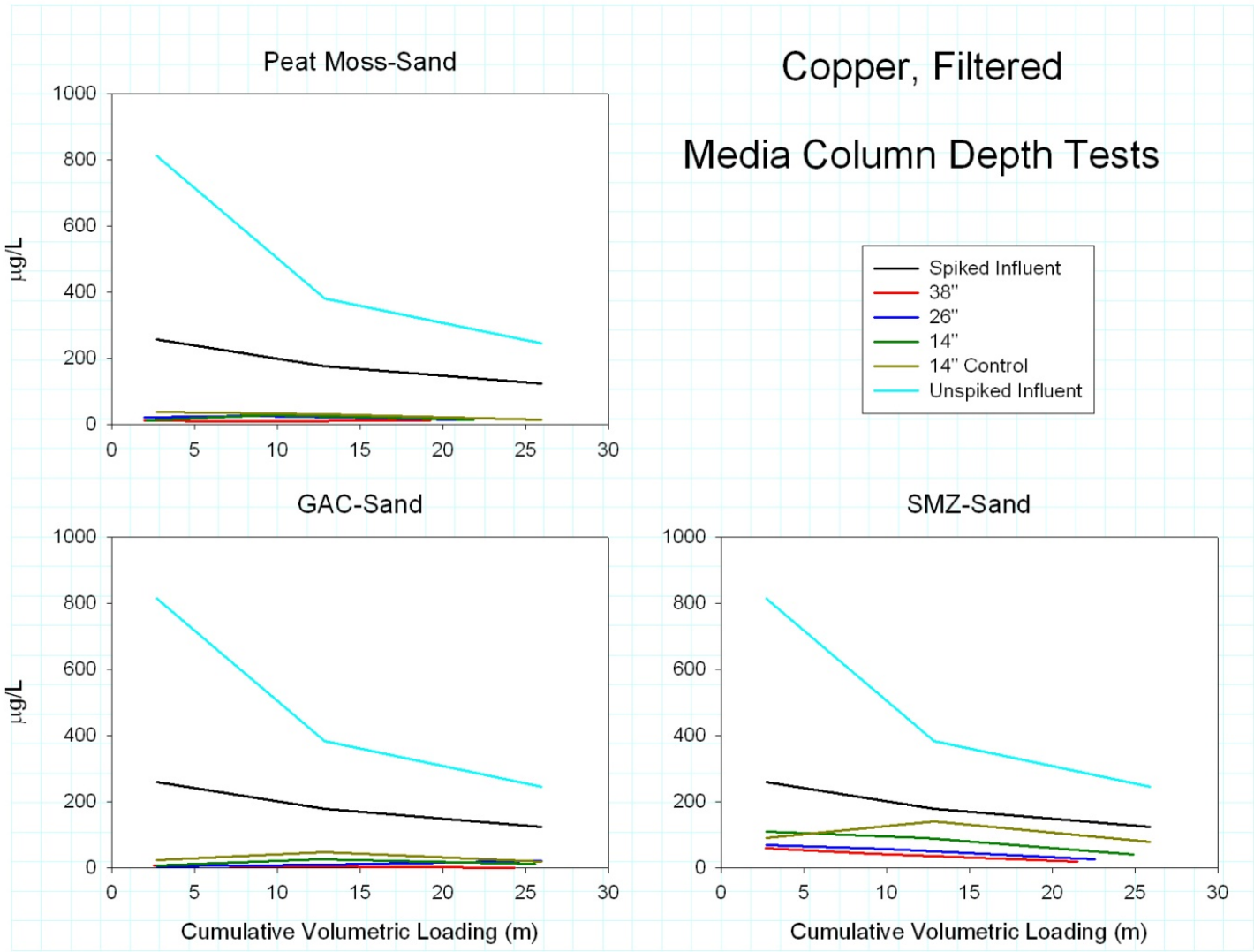
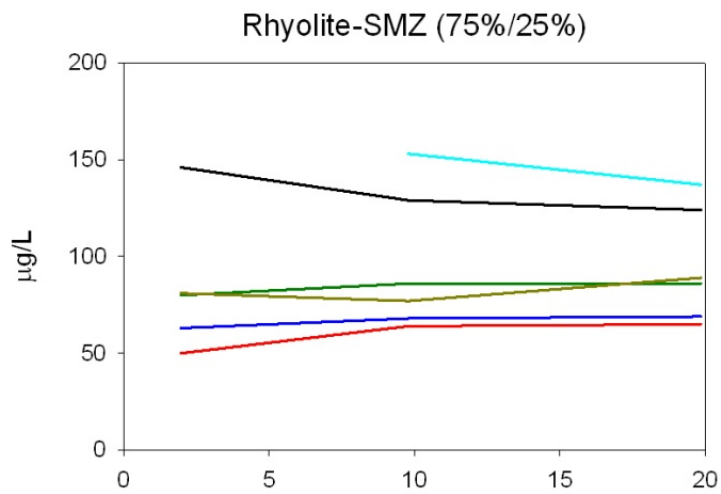


Figure B-41. Copper (Filtered) Removal for Component Media



Copper, Filtered Media Column Depth Tests

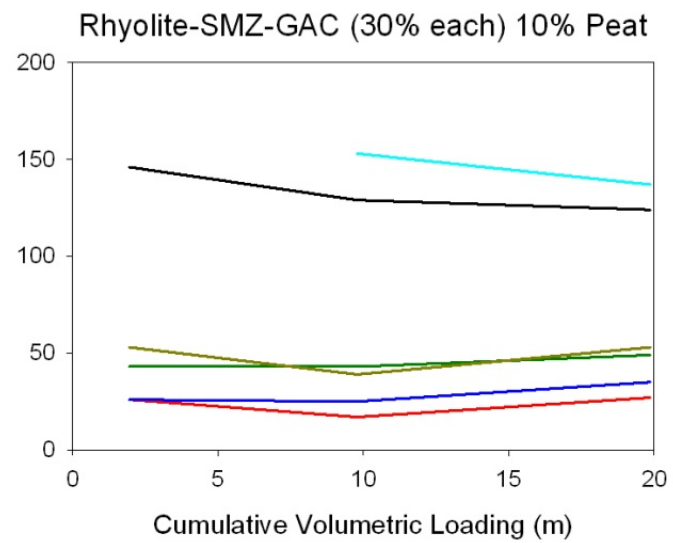
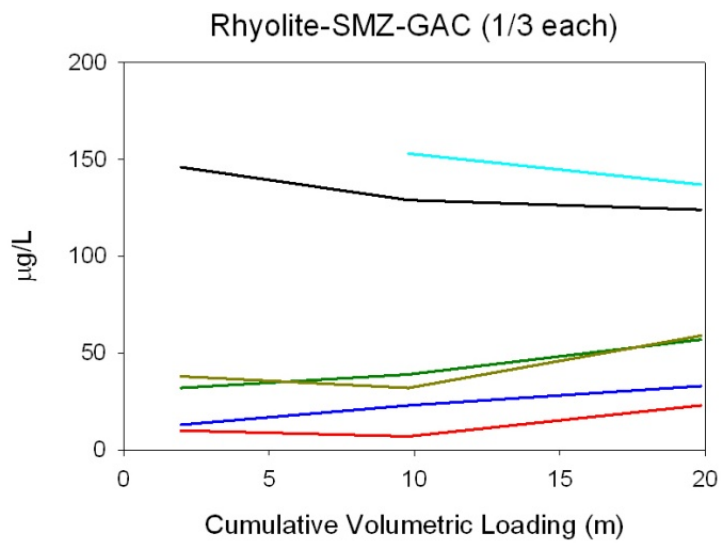
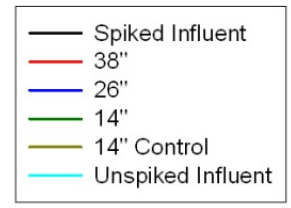


Figure B-42. Copper (Filtered) Removal

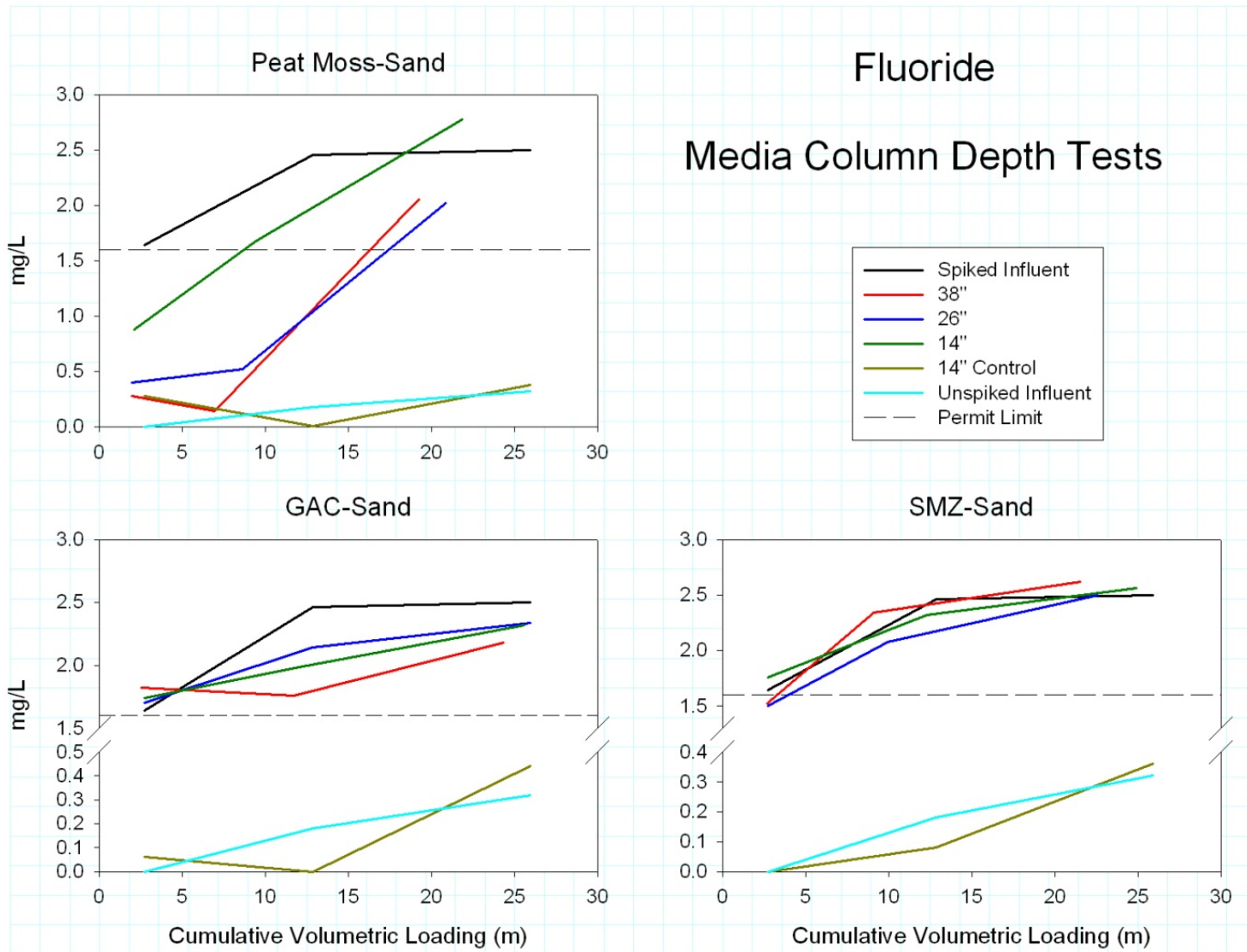


Figure B-43. Fluoride Removal for Component Media

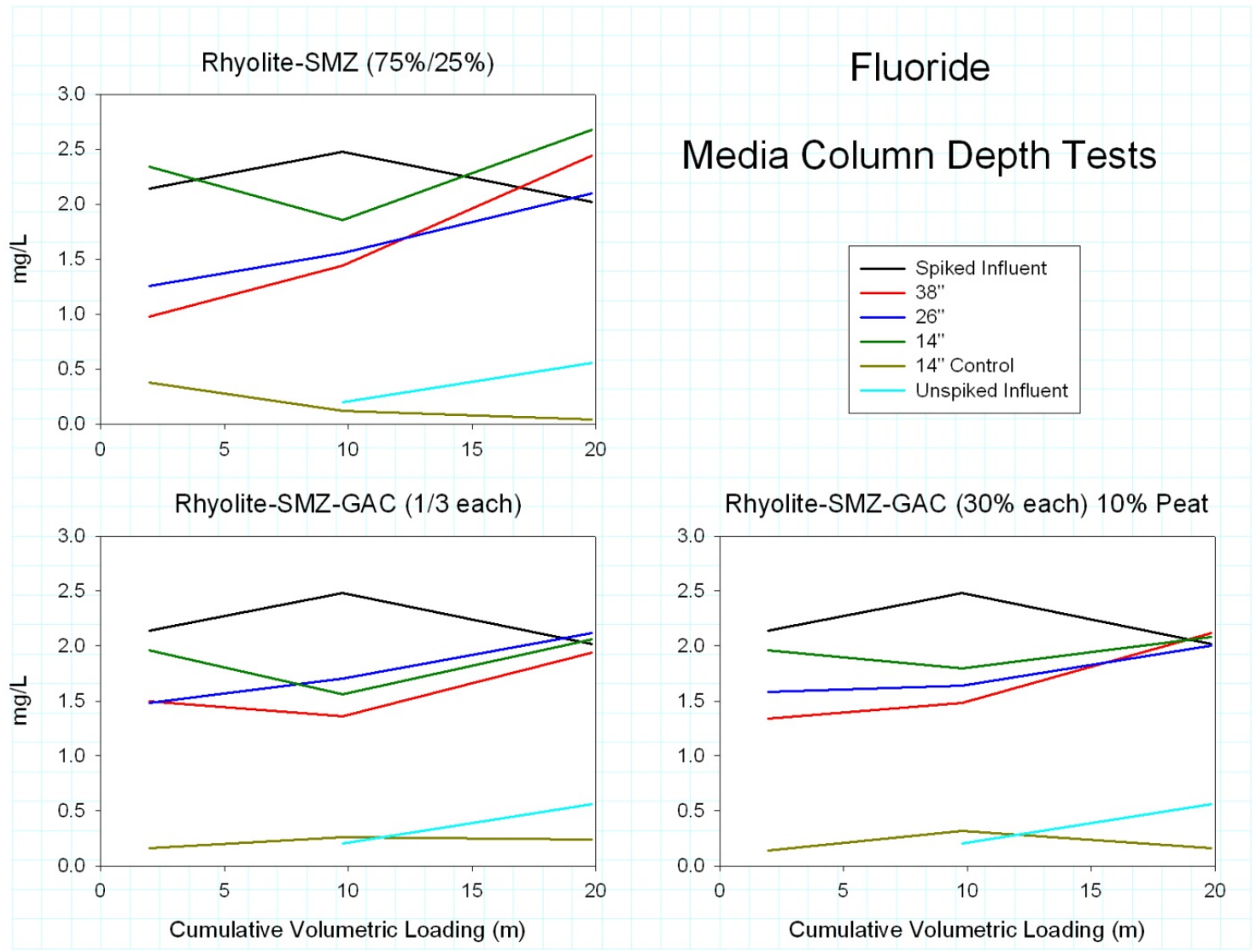
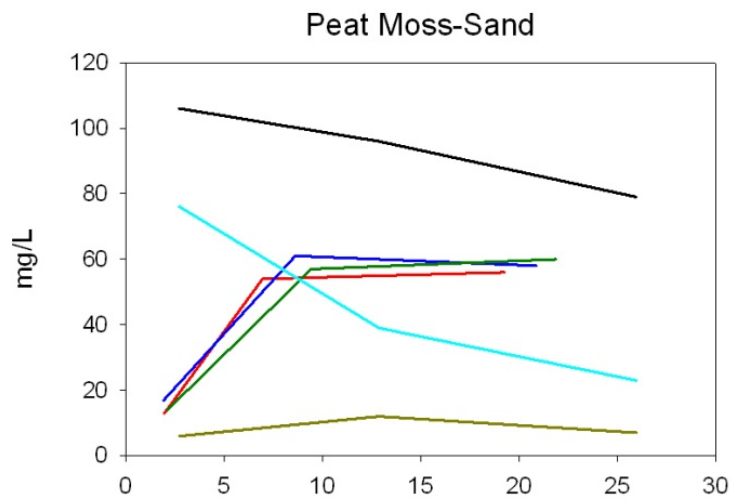


Figure B-44. Fluoride Removal for Media Mixtures



Hardness Media Column Depth Tests

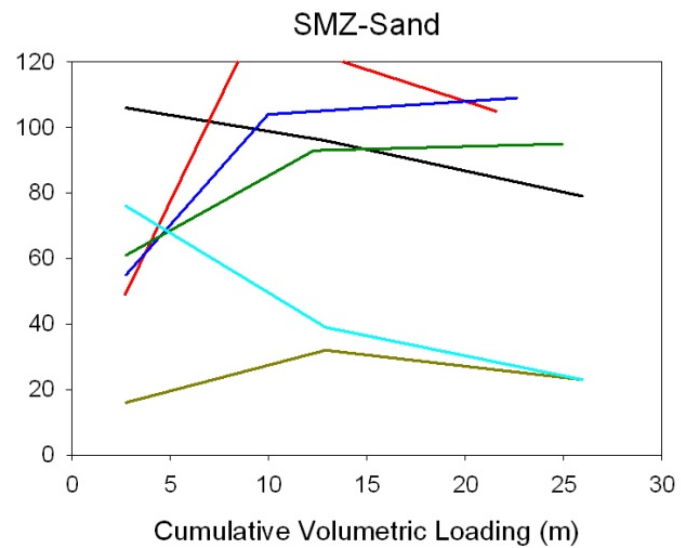
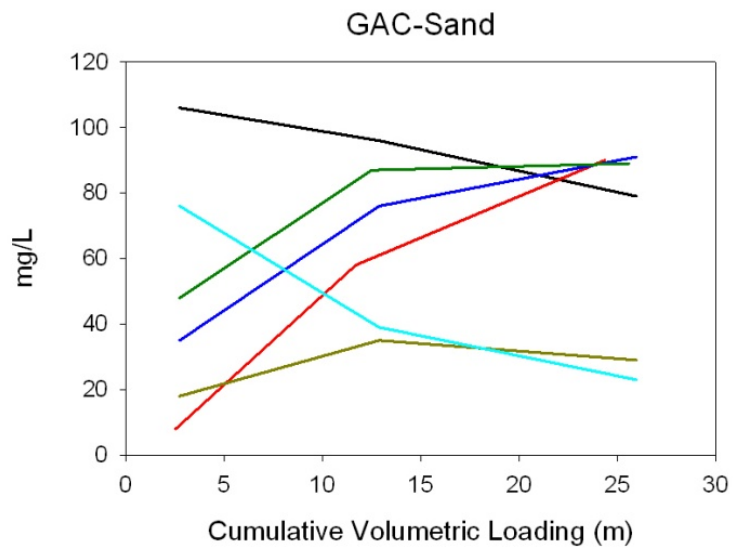
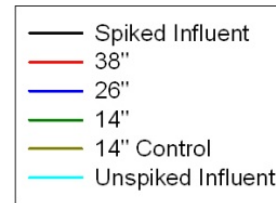


Figure B-45. Hardness Removal for Component Media

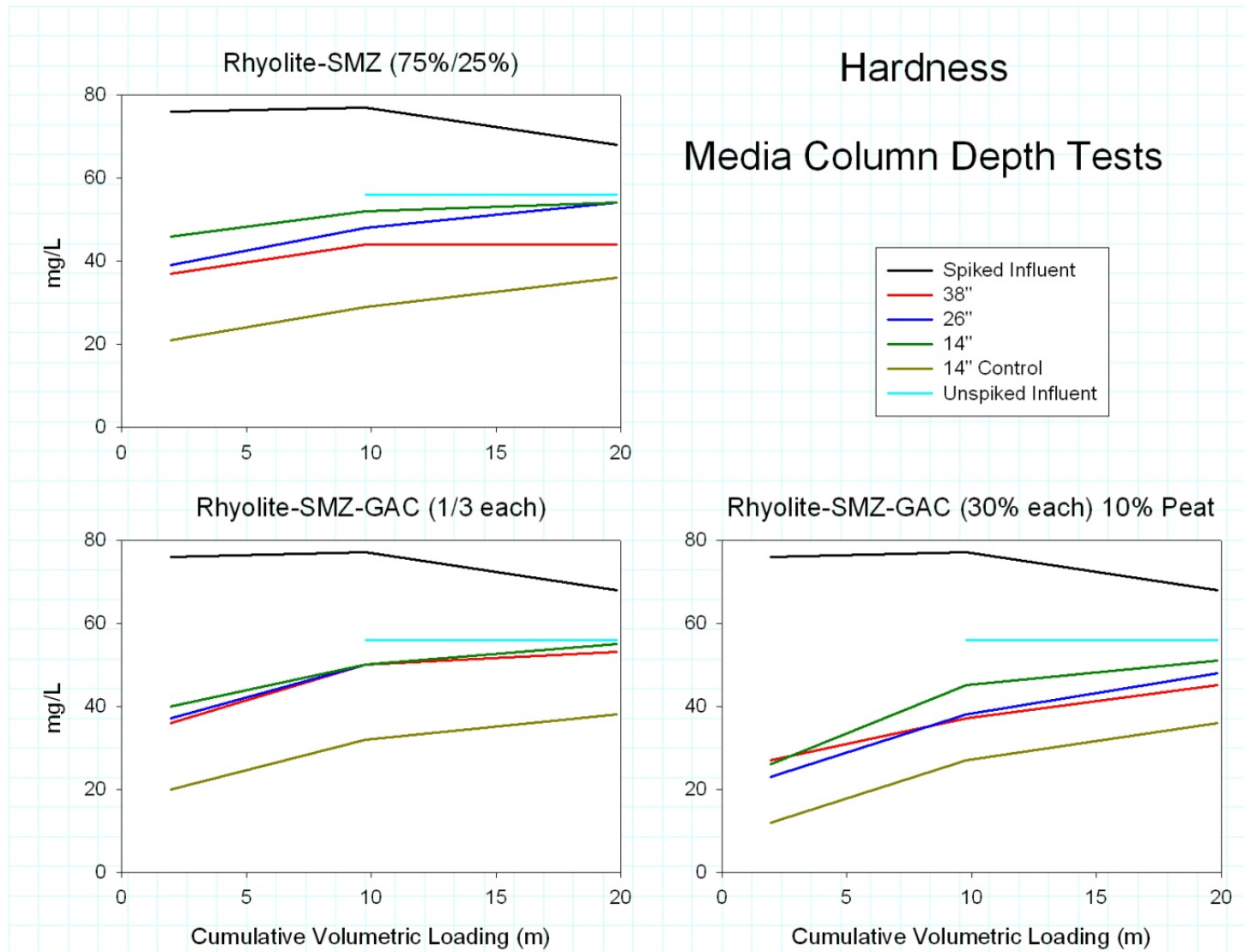


Figure B-46. Aluminum (Total) Removal for Media Mixtures

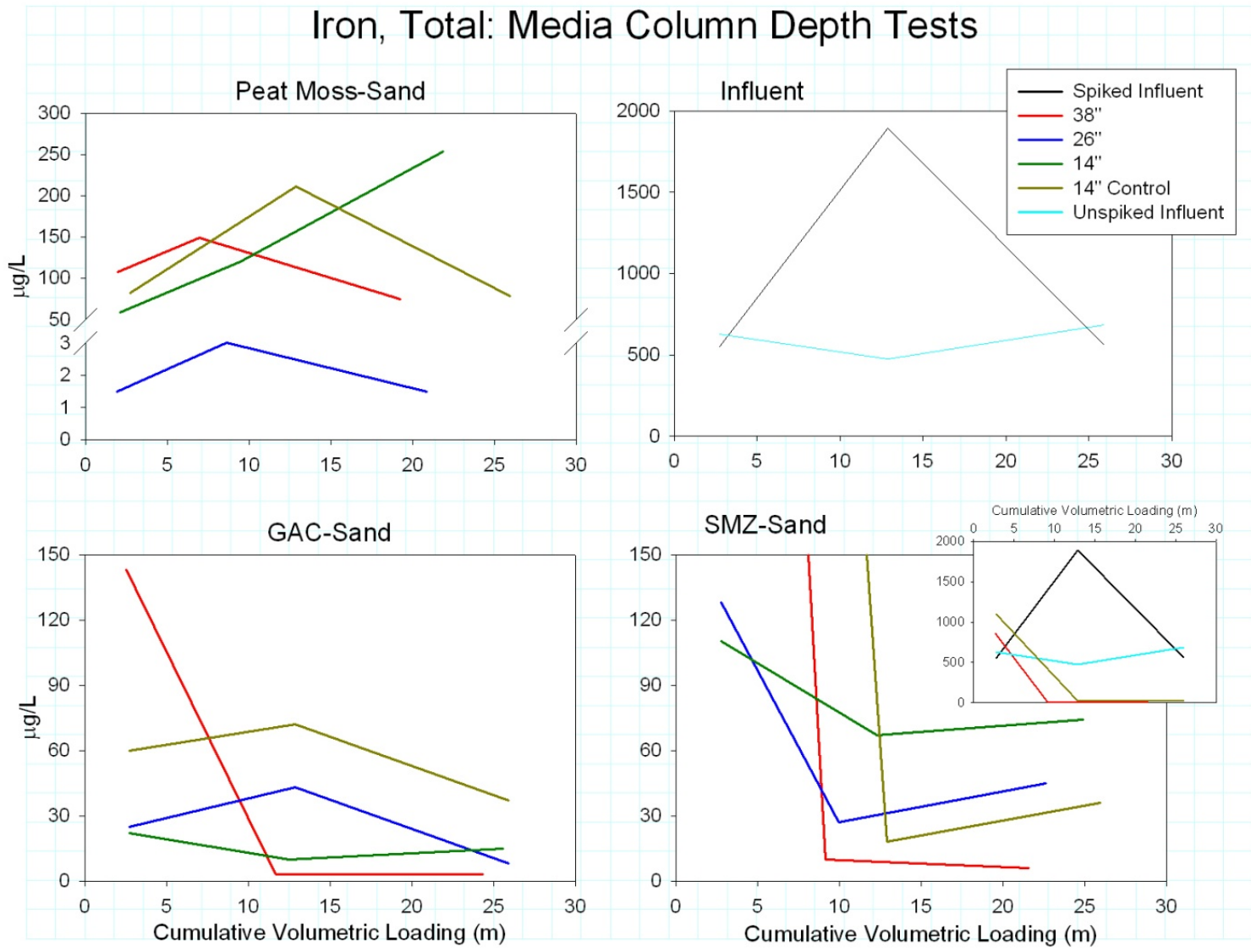
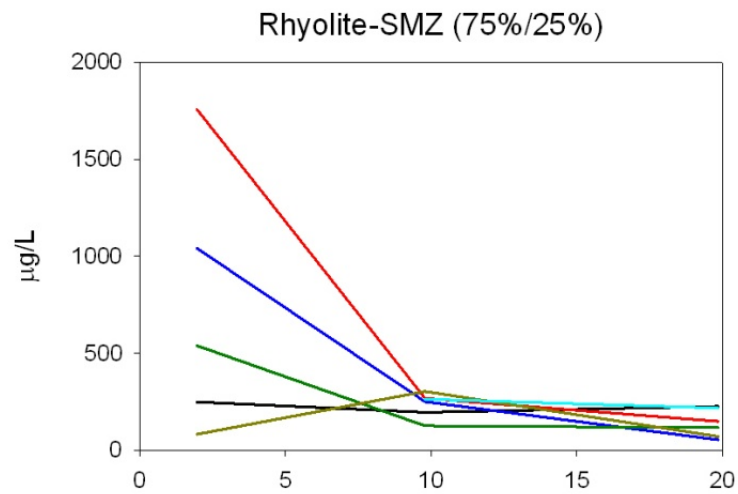


Figure B-47. Iron (Total) Removal for Component Media



Iron, Total Media Column Depth Tests

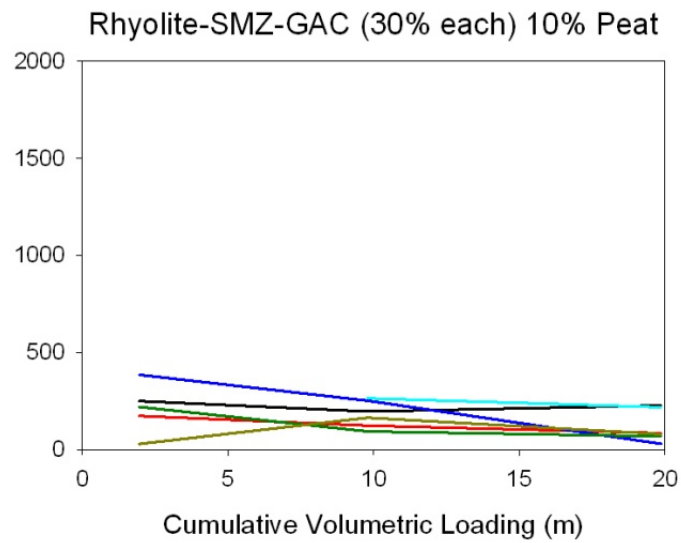
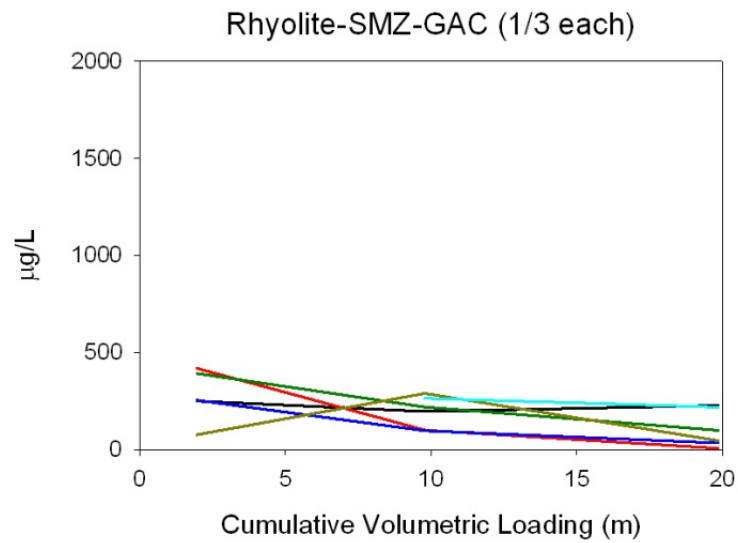
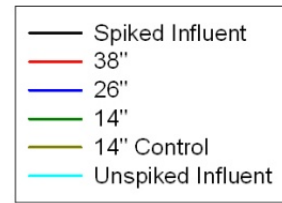


Figure B-48. Iron (Total) Removal for Media Mixtures

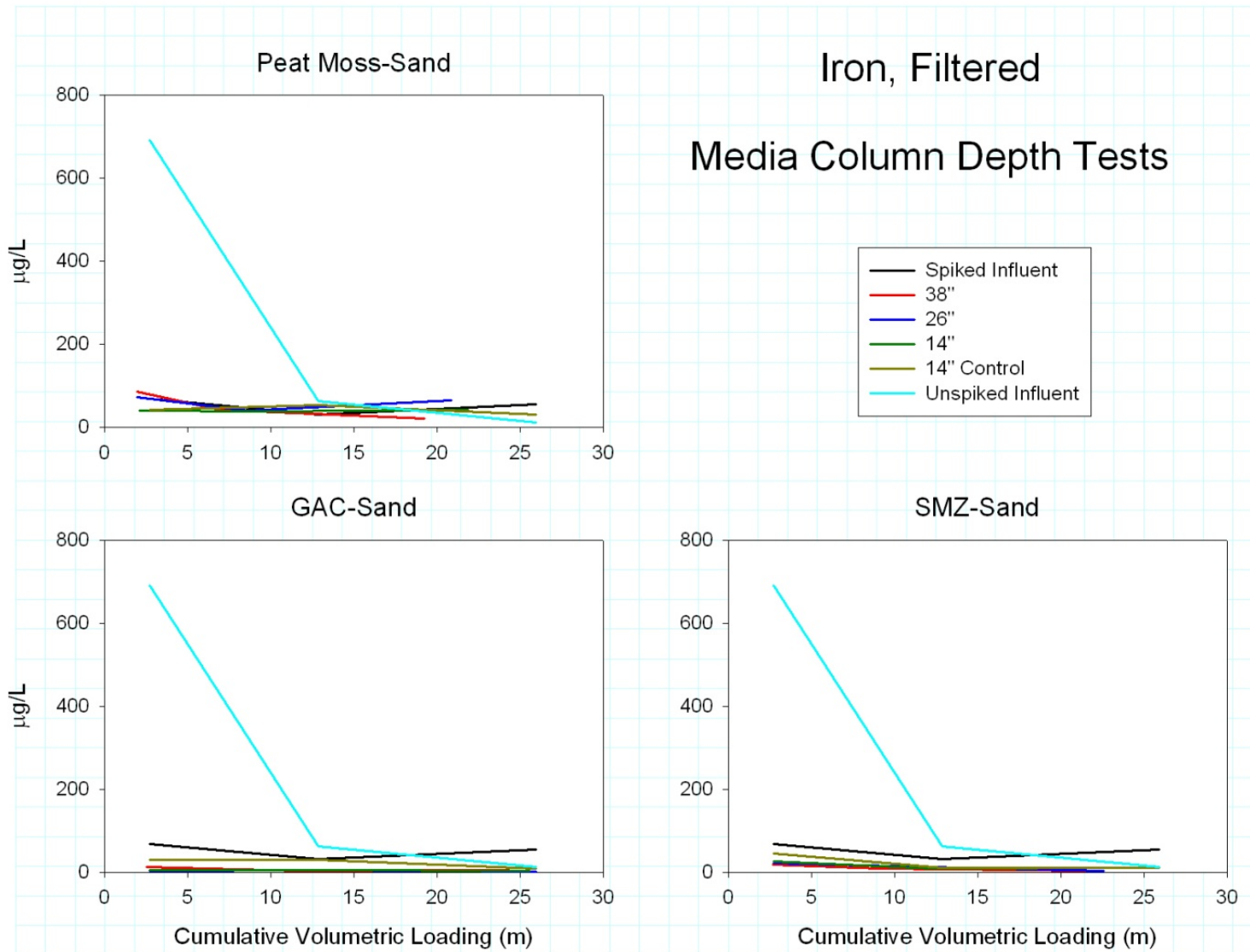
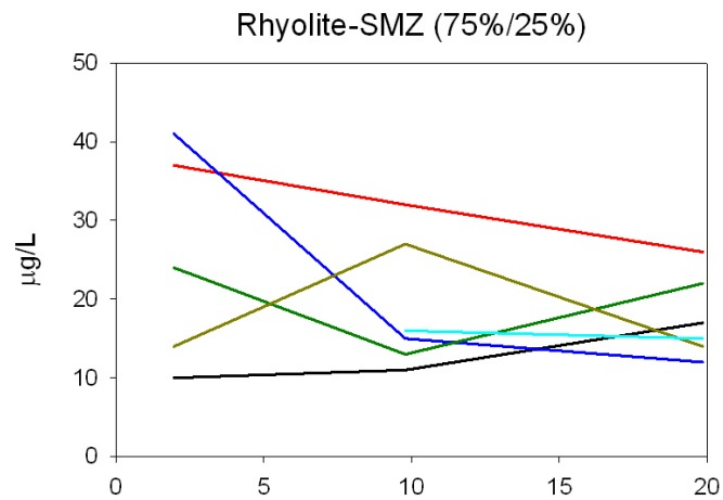


Figure B-49. Iron (Filtered) Removal for Component Media



Iron, Filtered Media Column Depth Tests

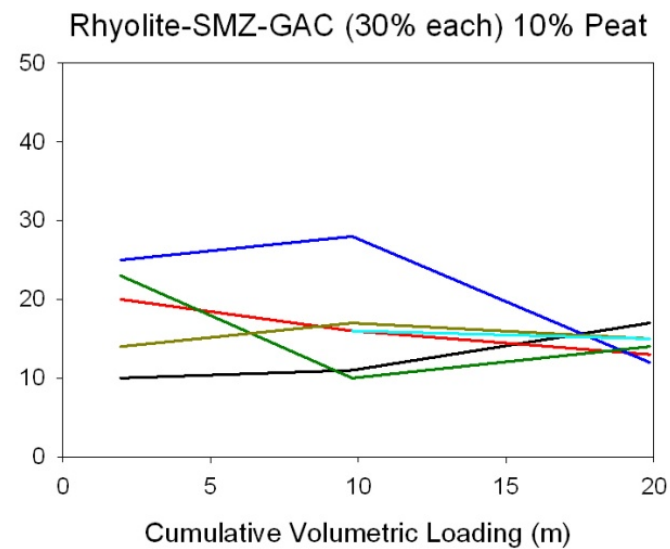
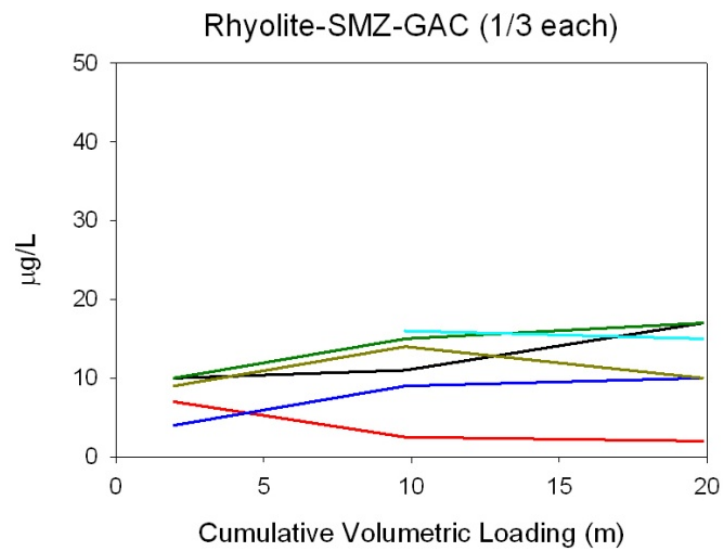
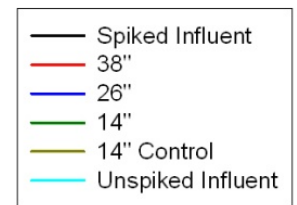


Figure B-50. Iron (Filtered) Removal for Media Mixtures

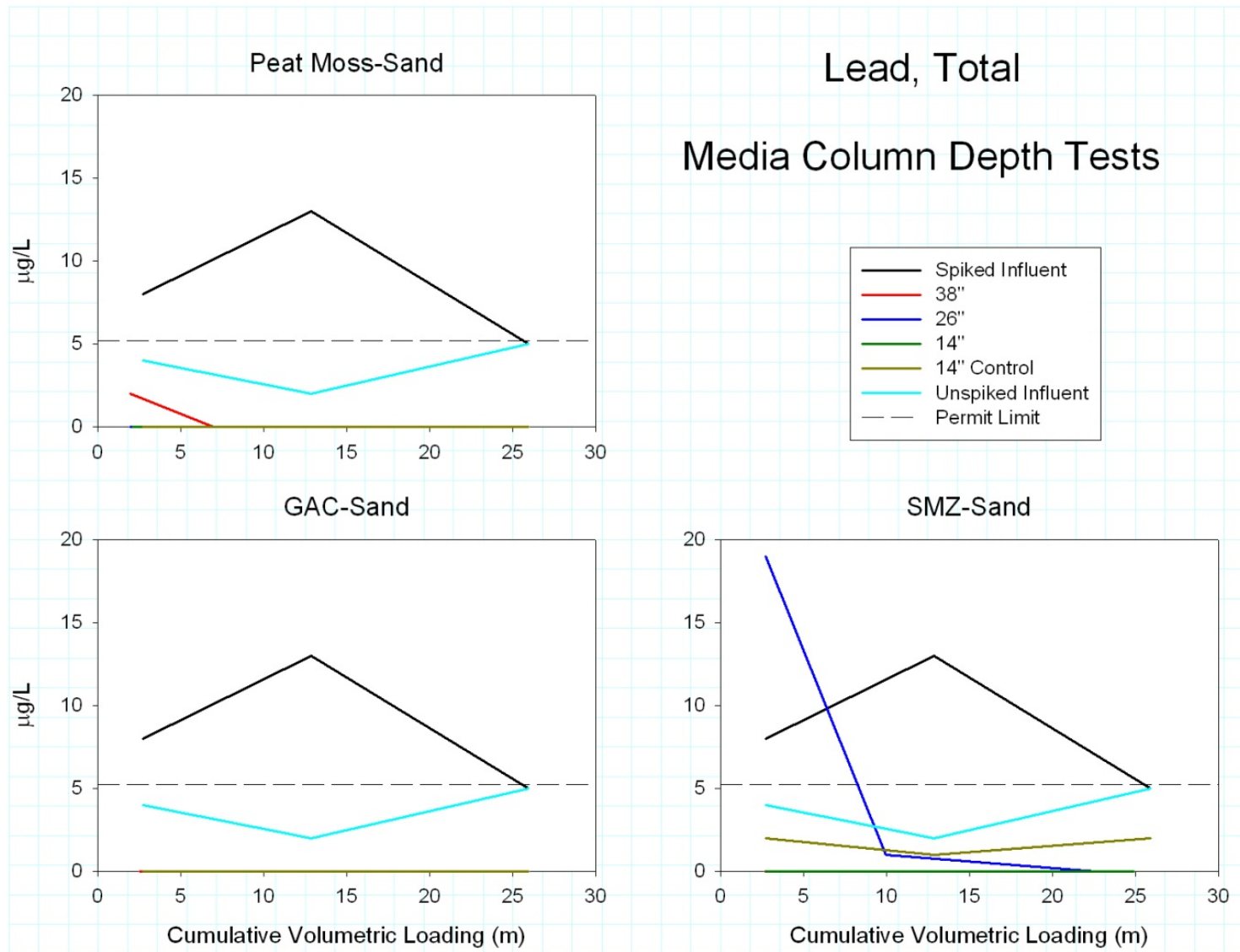


Figure B-51. Lead (Total) Removal for Component Media

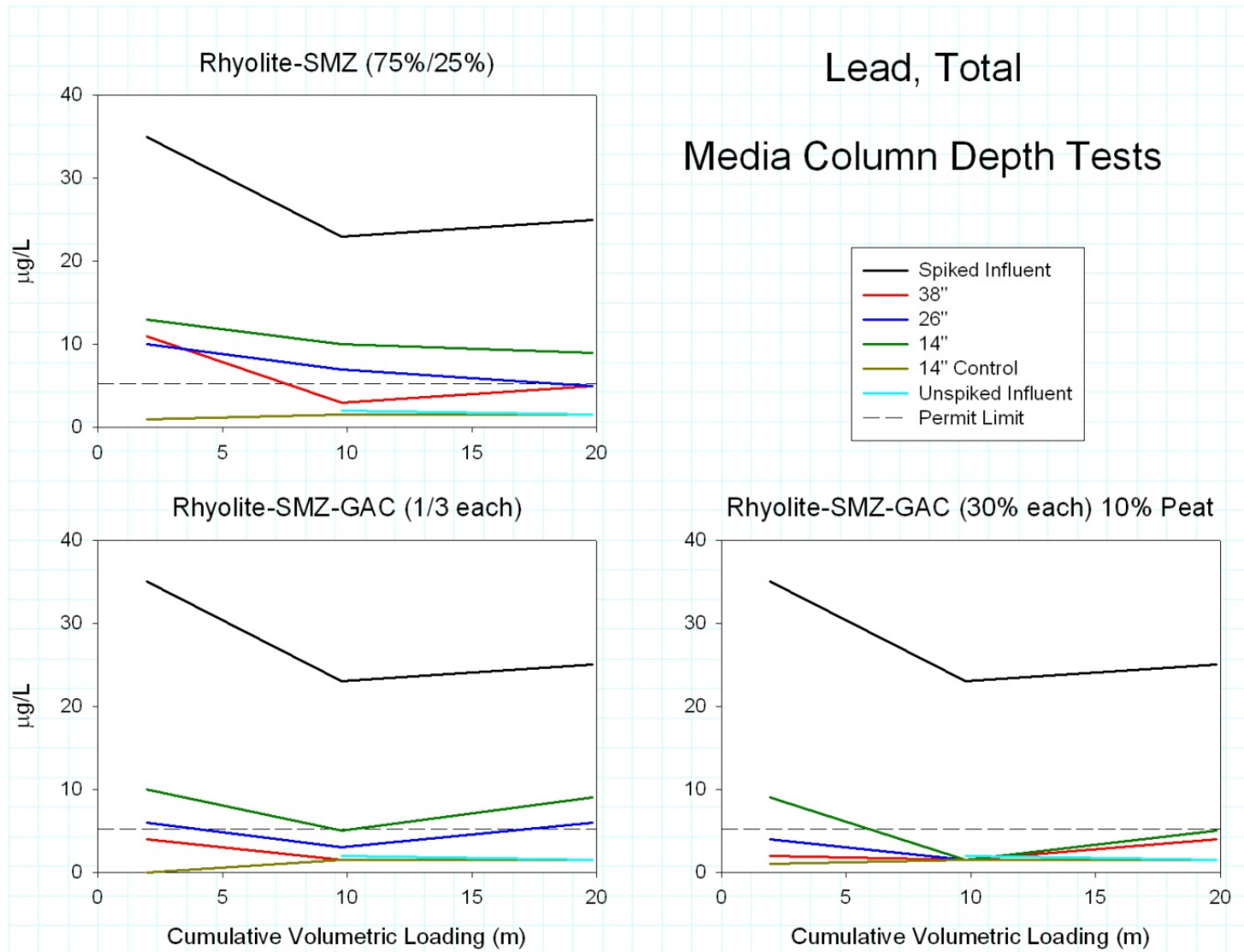


Figure B-52. Lead (Total) Removal for Media Mixtures

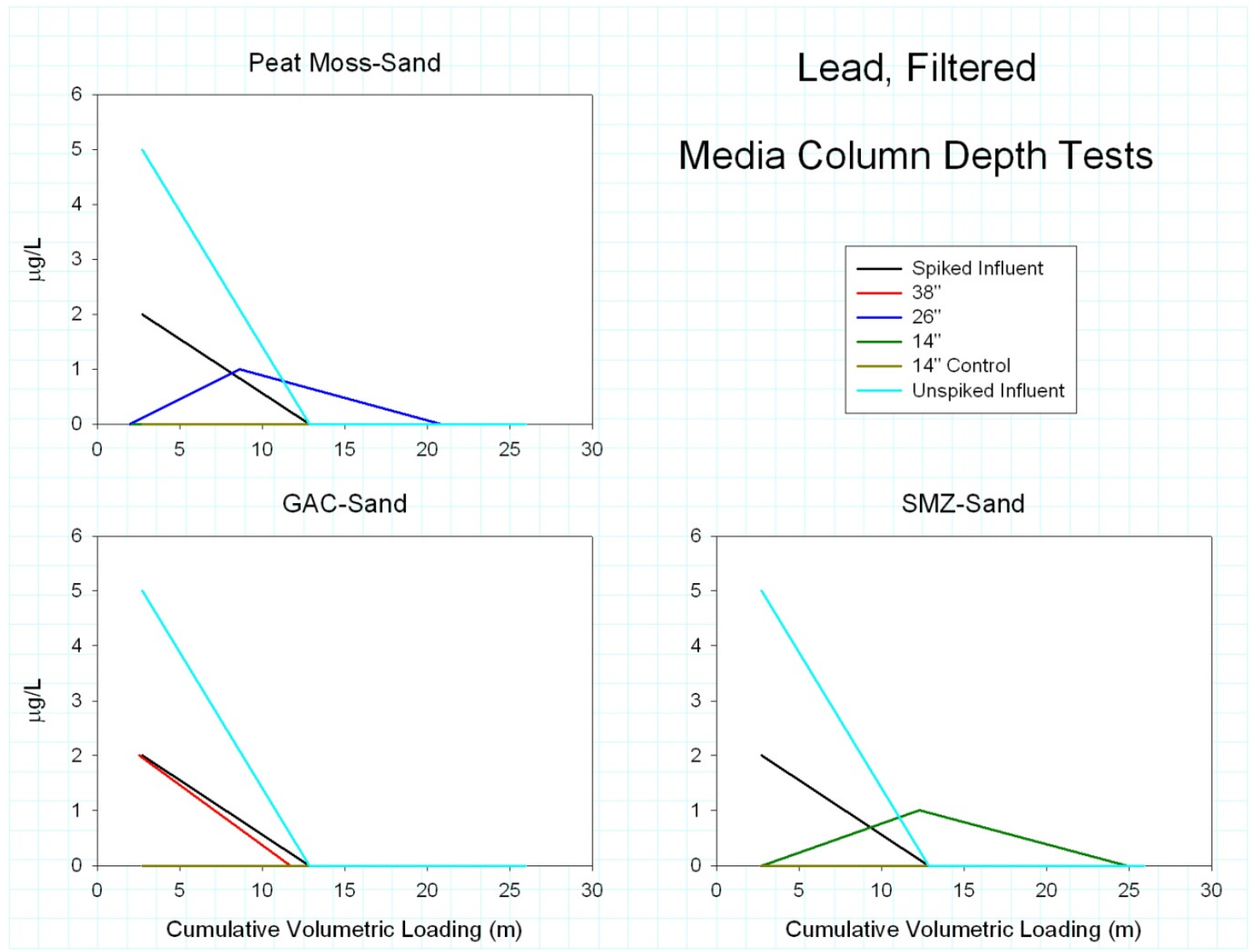


Figure B-53. Lead (Filtered) Removal for Component Media

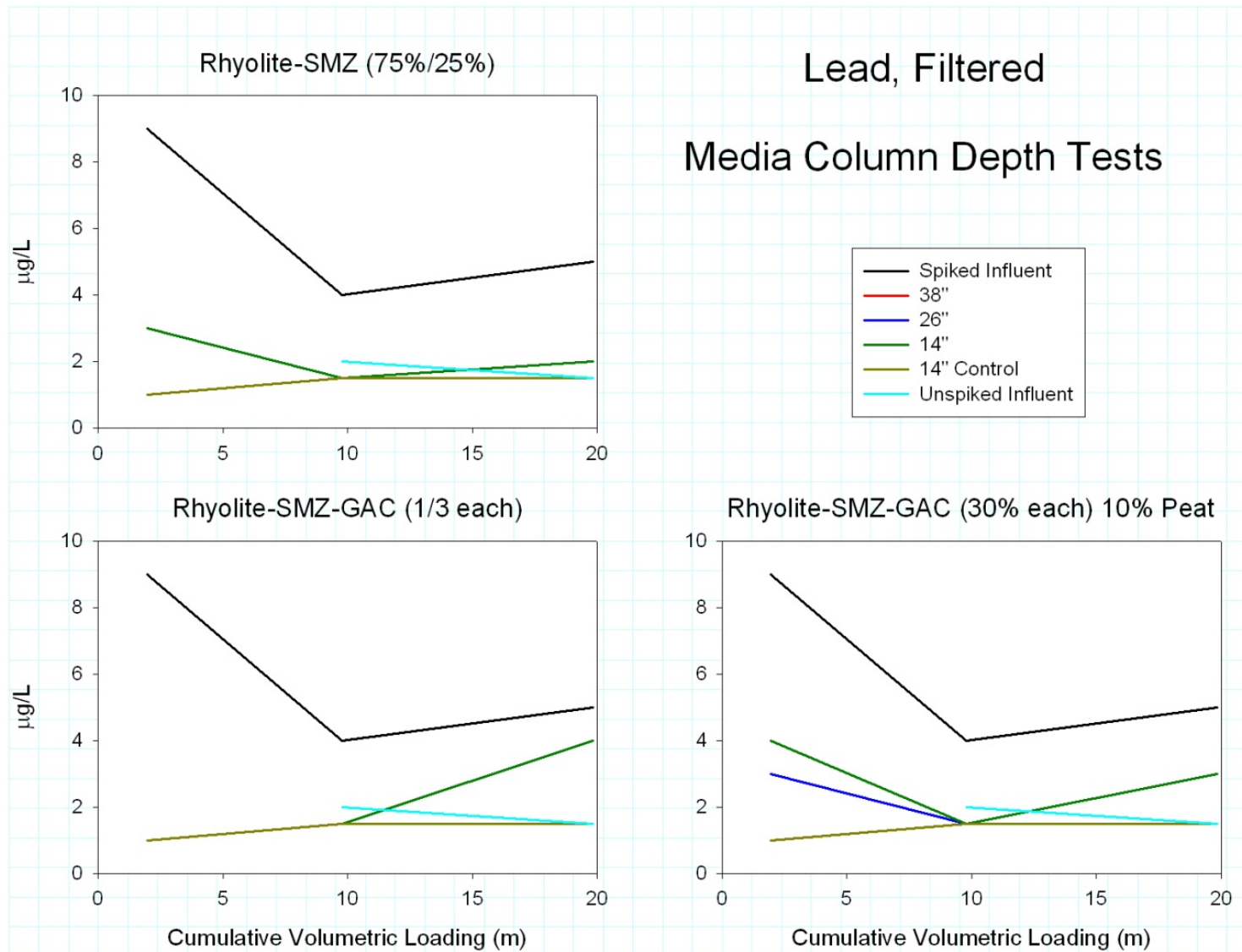


Figure B-54. Lead (Filtered) Removal for Media Mixtures

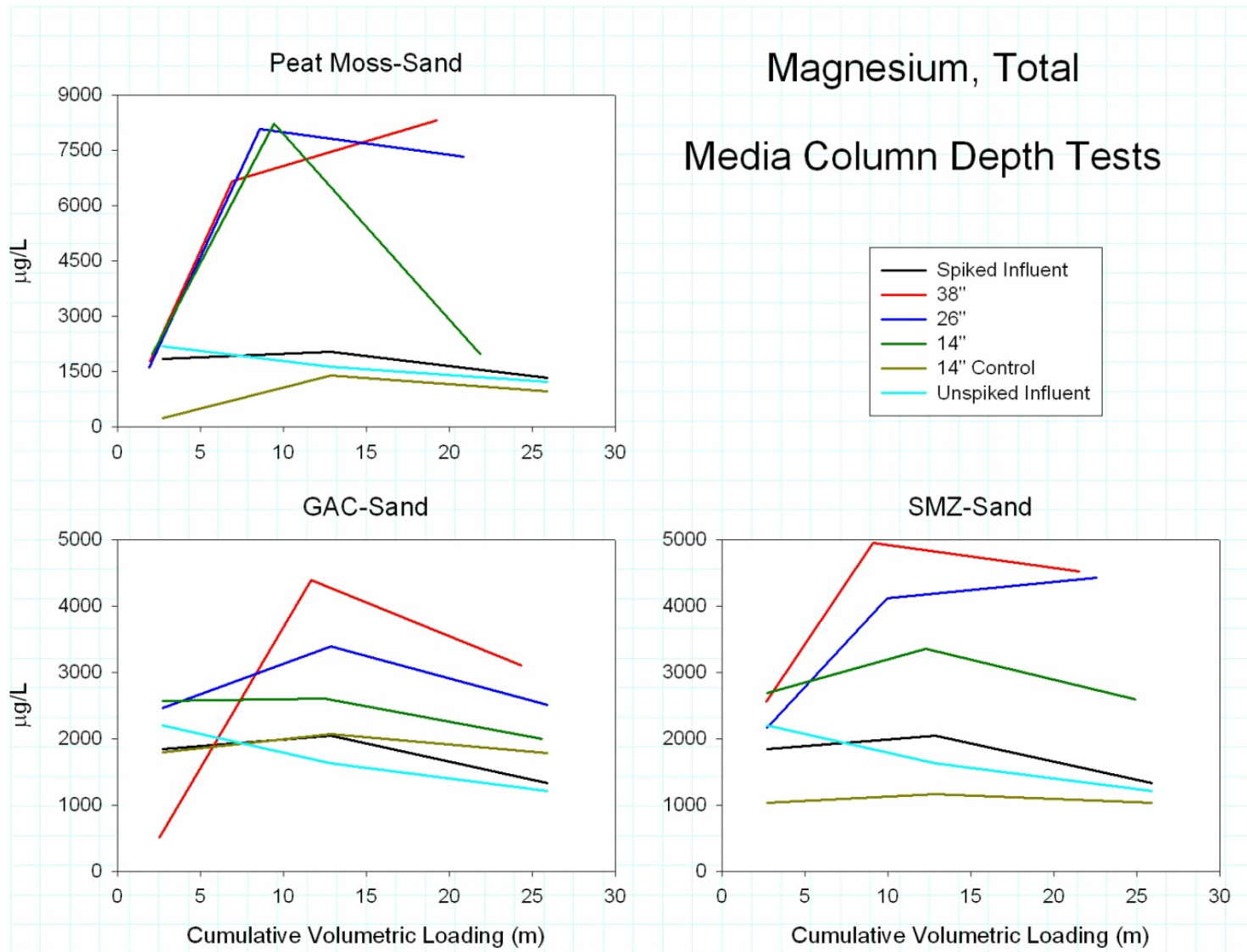
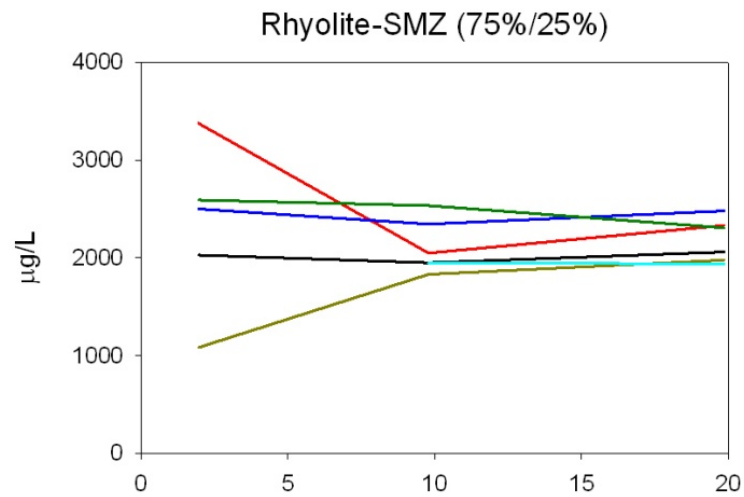


Figure B-55. Magnesium (Total) Removal for Component Media



Magnesium, Total Media Column Depth Tests

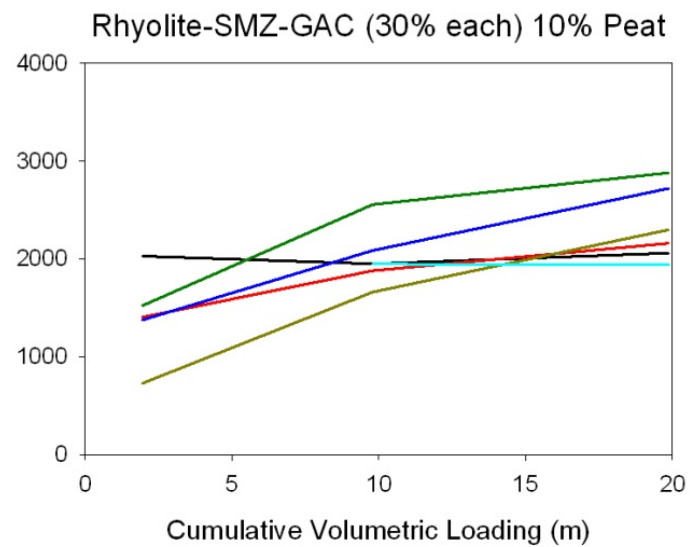
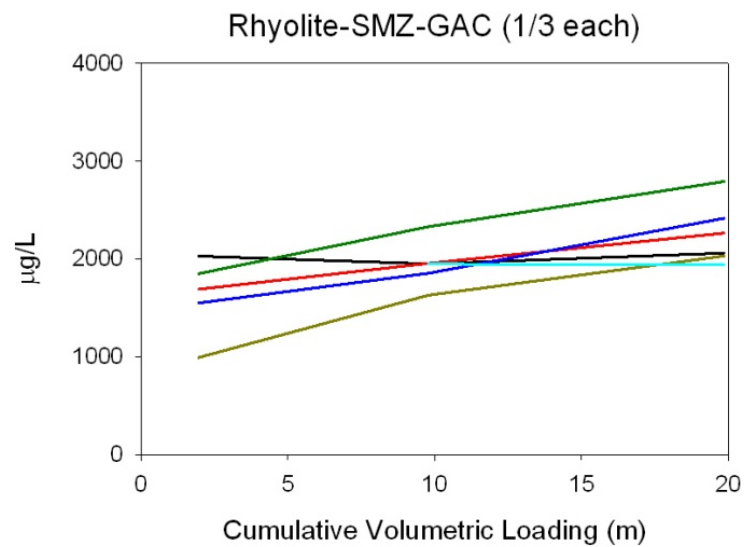
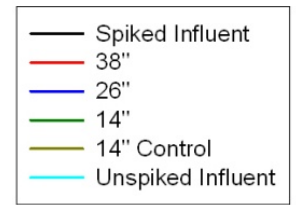


Figure B-56. Magnesium (Total) Removal for Media Mixtures

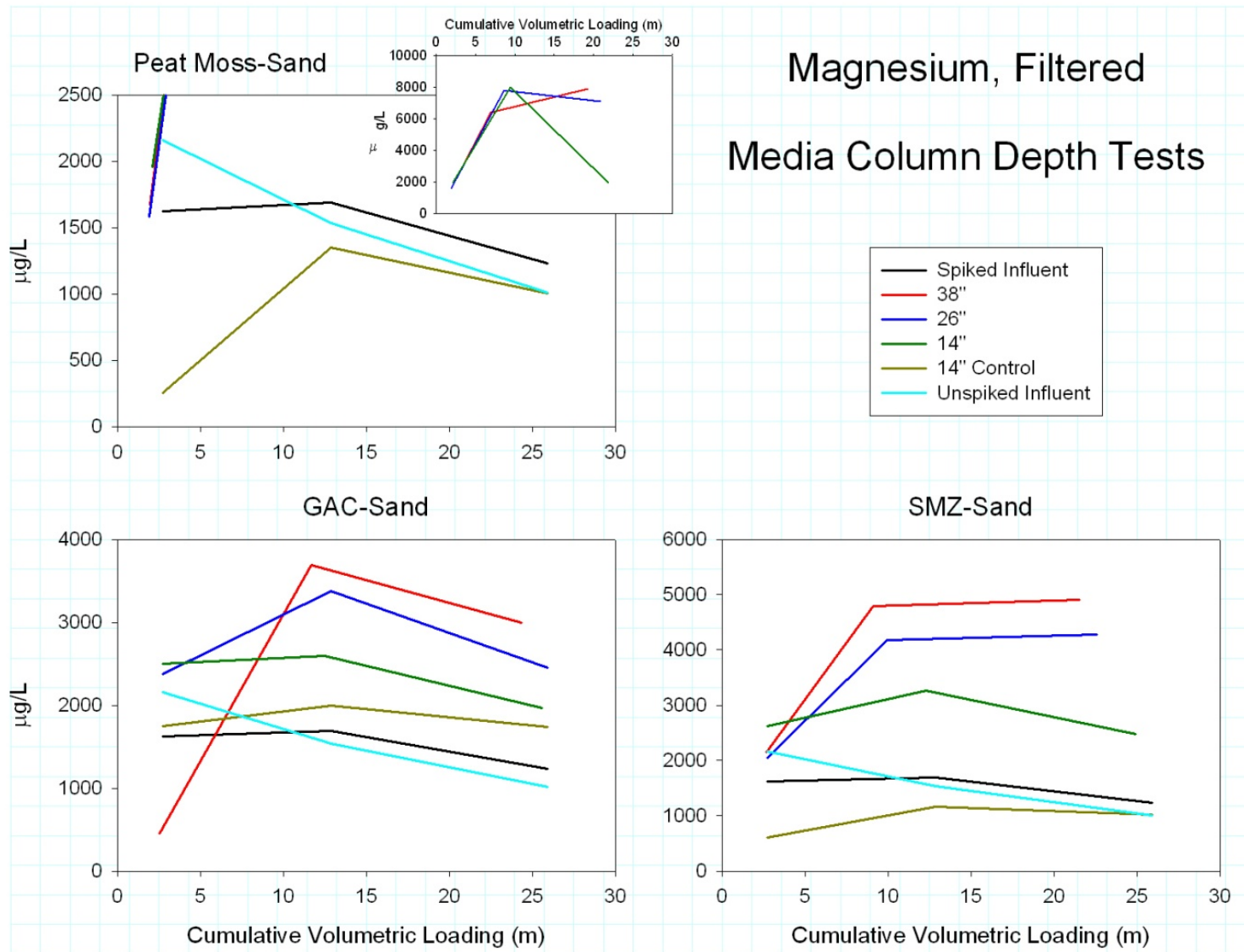
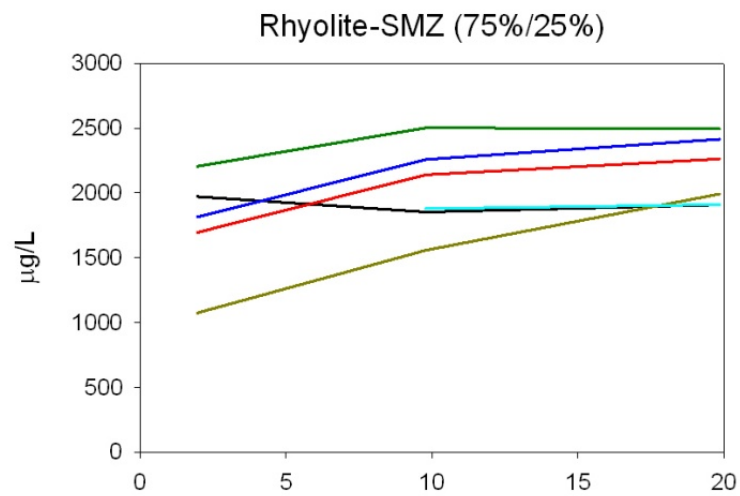


Figure B-57. Magnesium (Filtered) Removal for Component Media



Magnesium, Filtered Media Column Depth Tests

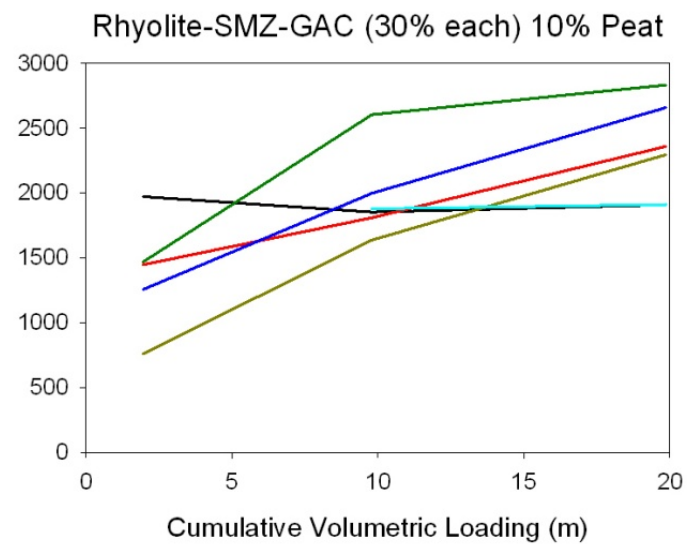
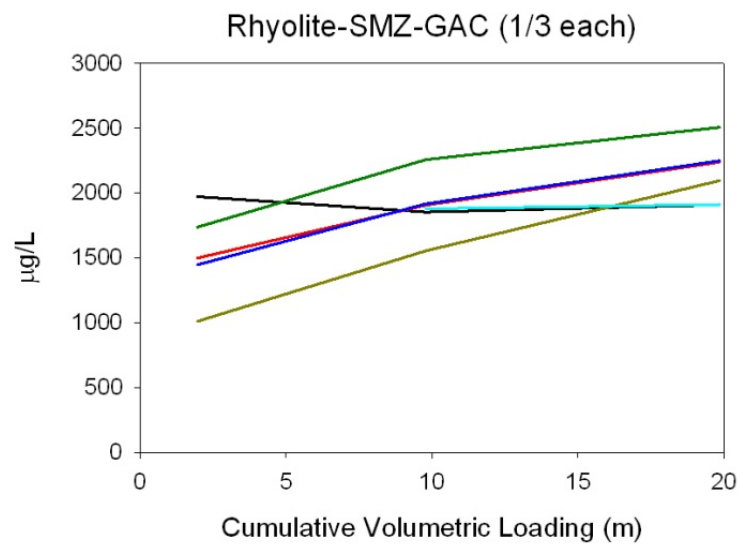
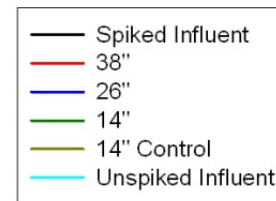


Figure B-58. Magnesium (Filtered) Removal for Media Mixtures

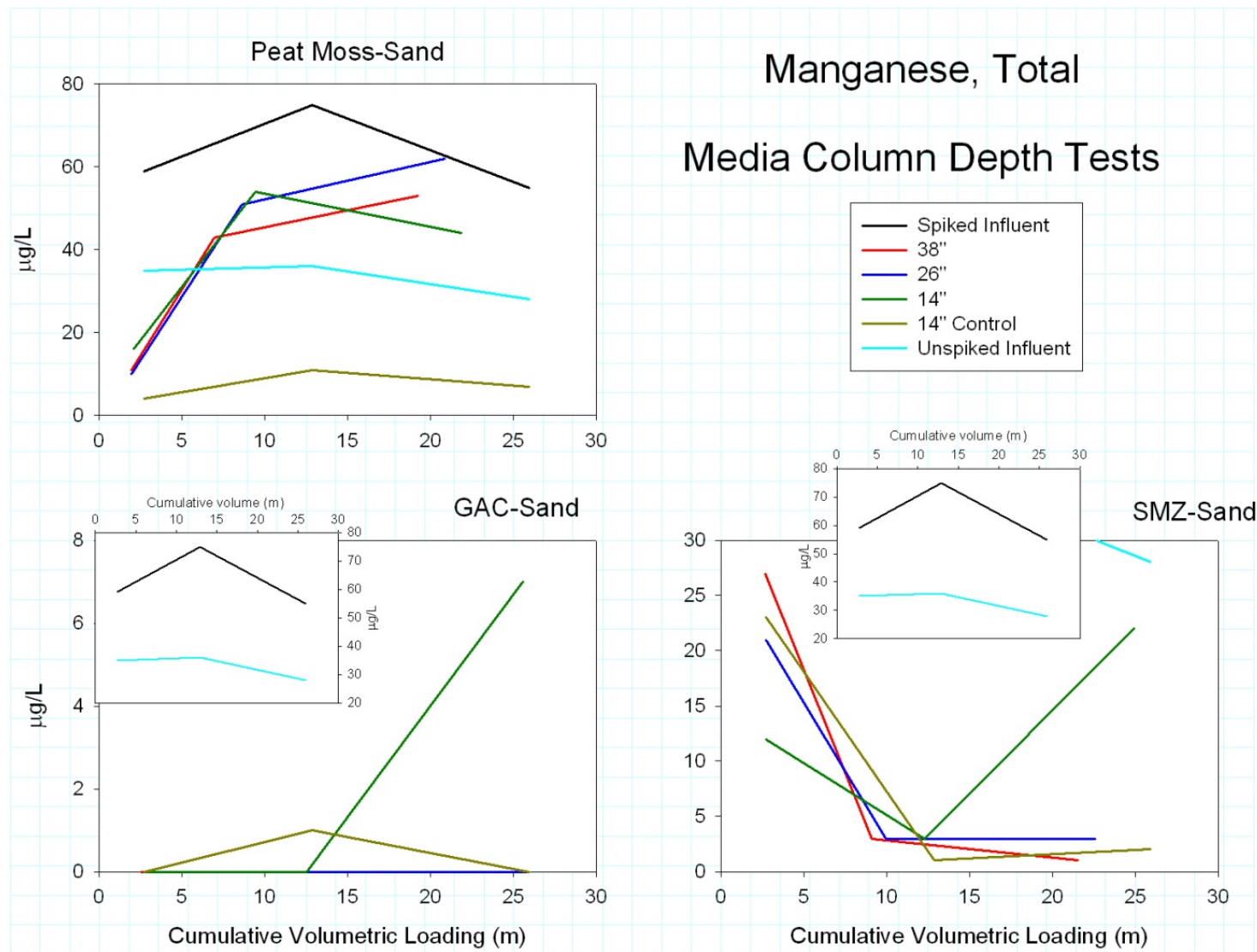


Figure B-59. Manganese (Total) Removal for Component Media

Manganese, Total Media Column Depth Tests

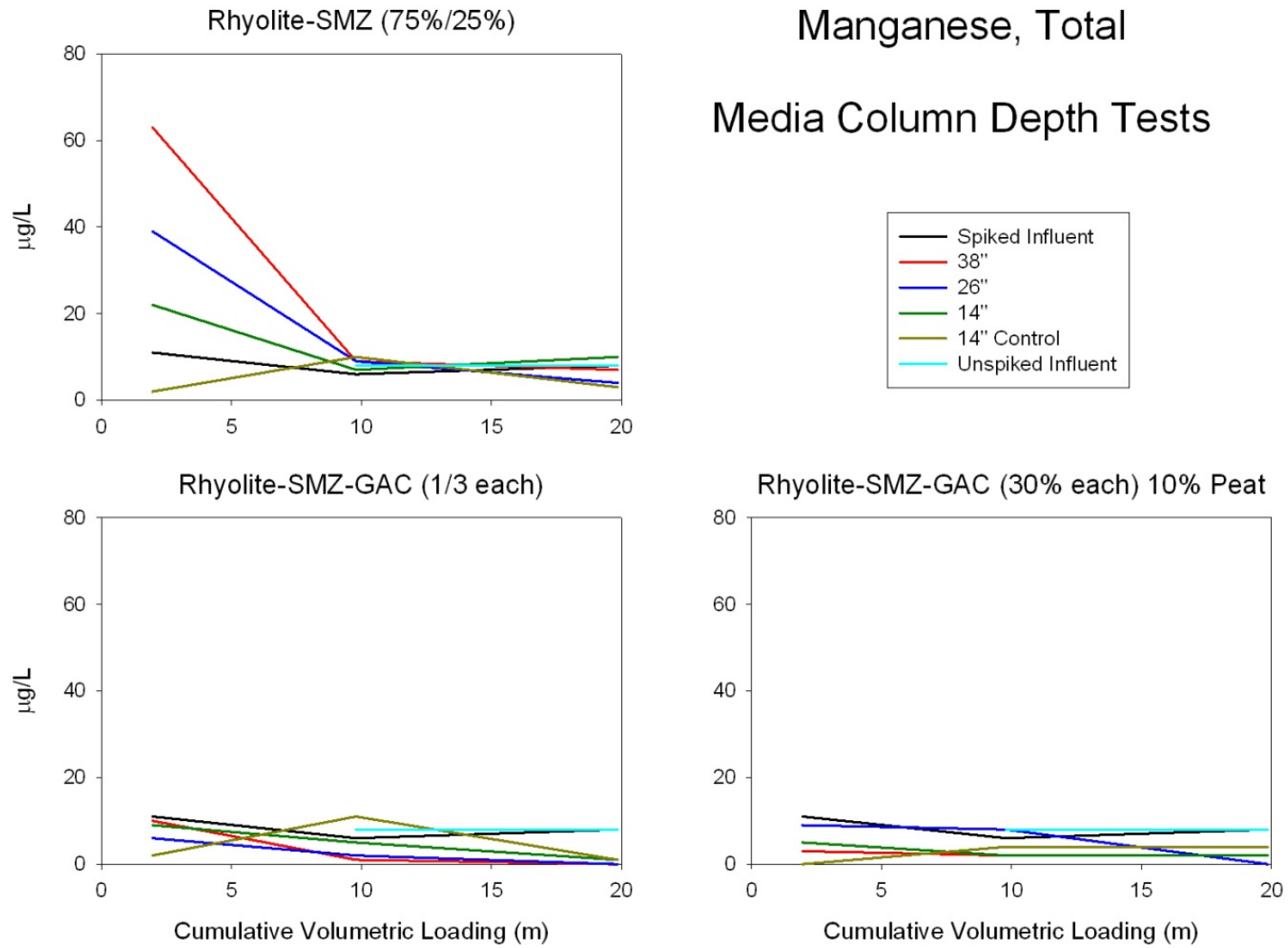


Figure B-60. Manganese (Total) Removal for Media Mixtures

Manganese, Filtered: Media Column Depth Tests

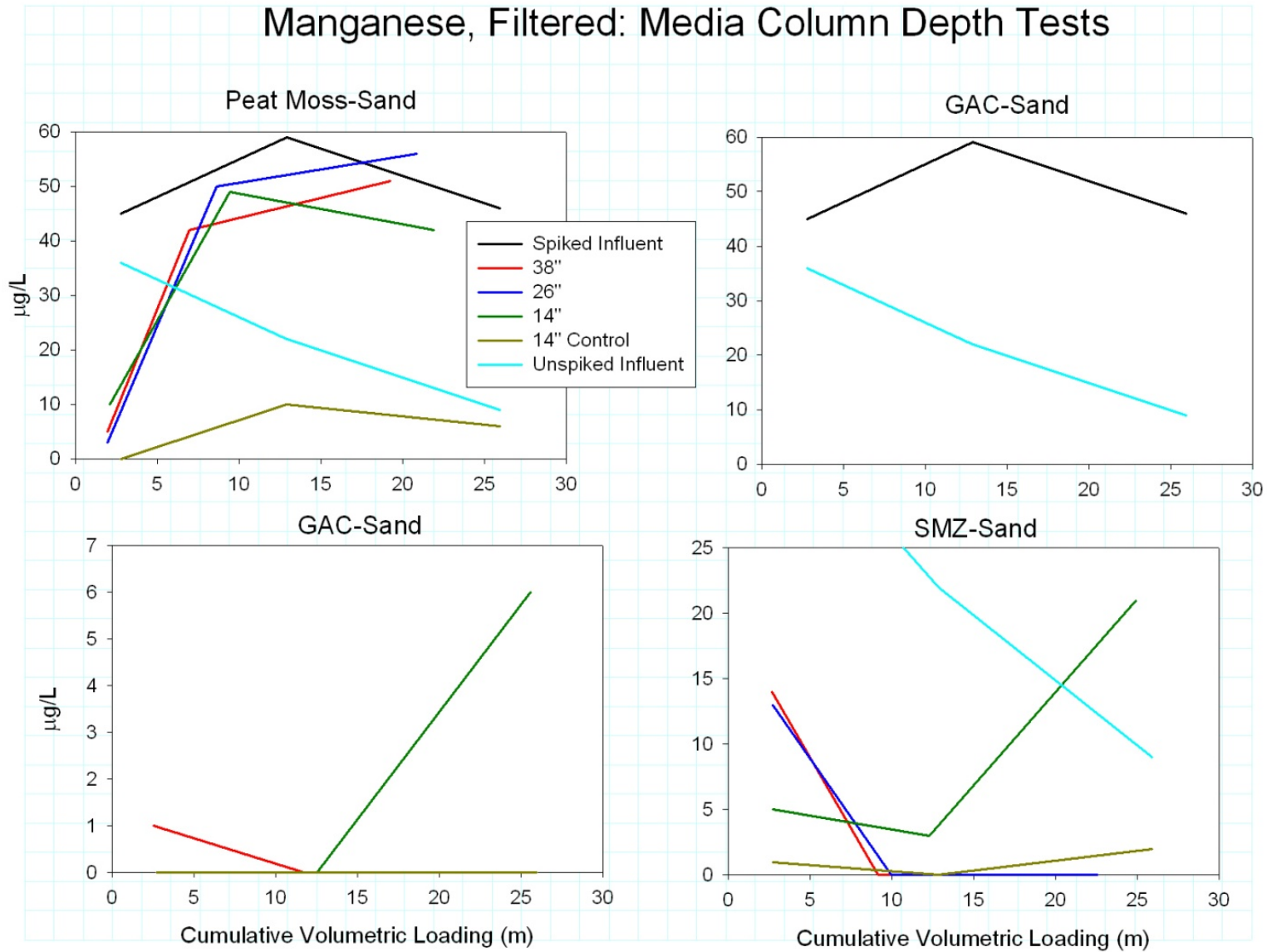
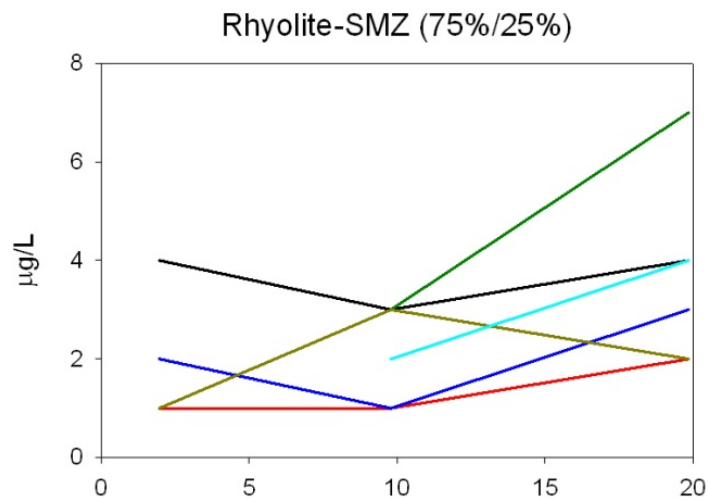


Figure B-61. Manganese (Filtered) Removal



Manganese, Filtered Media Column Depth Tests

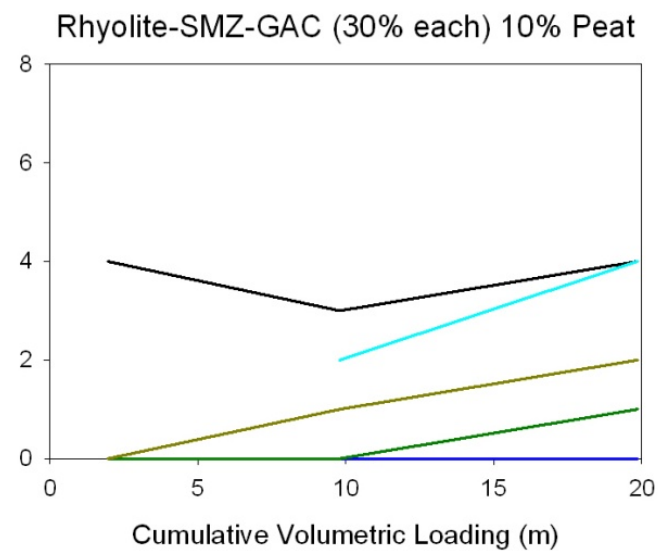
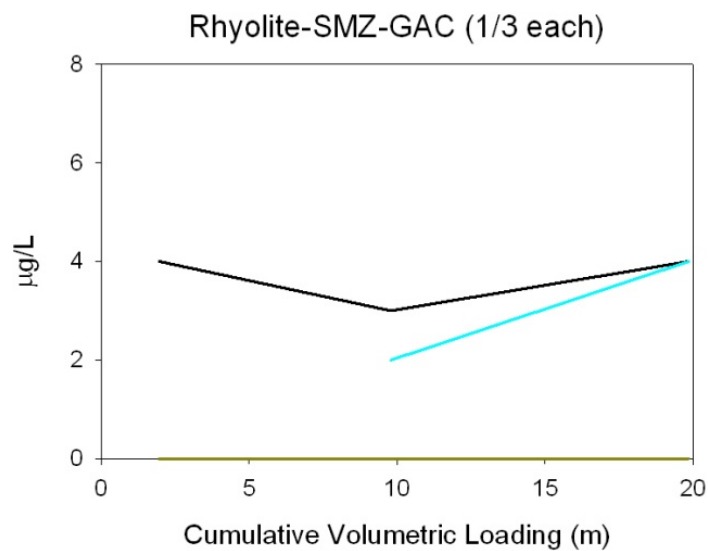
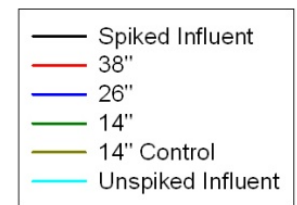


Figure B-62. Manganese (Filtered) Removal for Media Mixtures

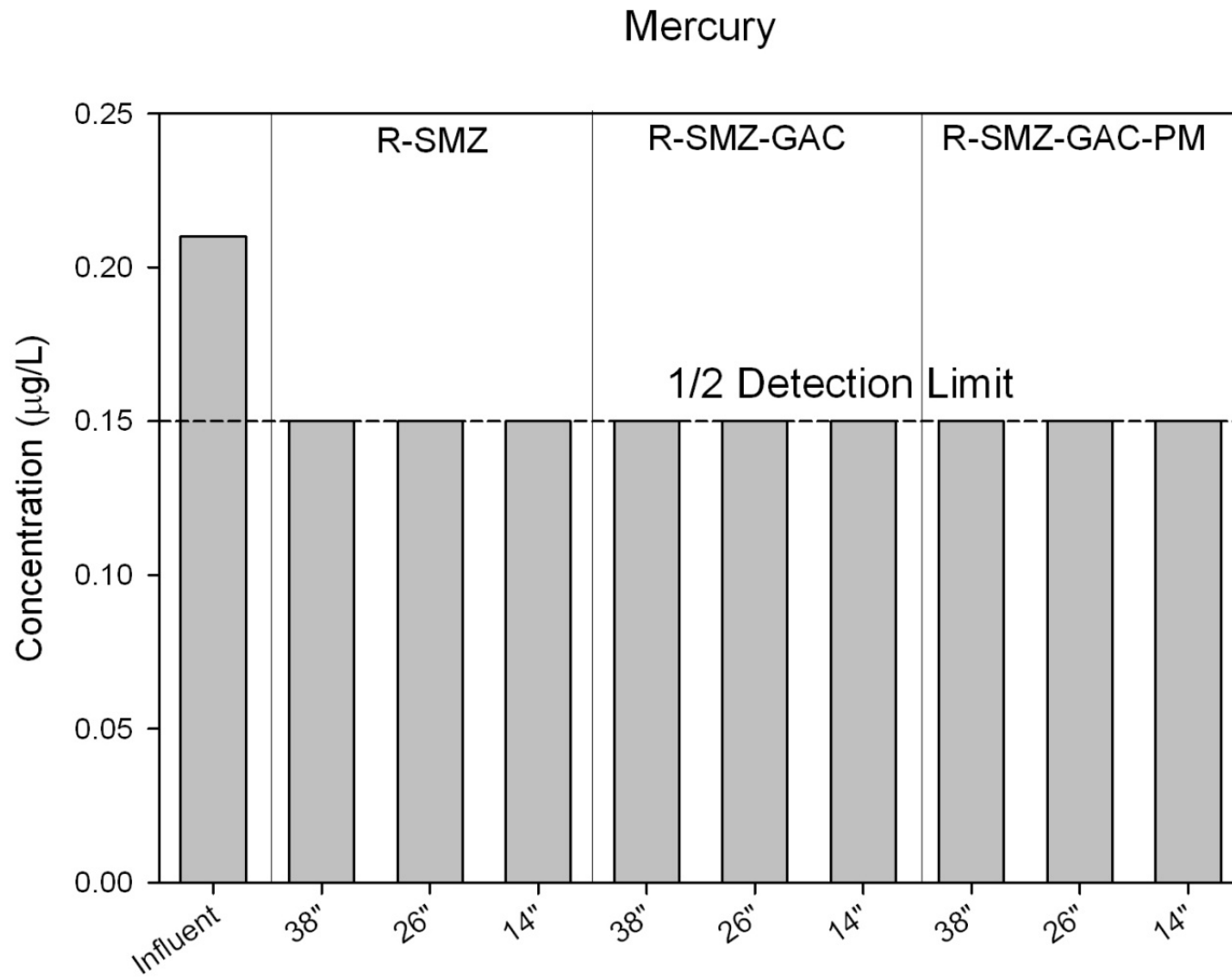


Figure B-63. Mercury (Total) Removal for Media Mixtures

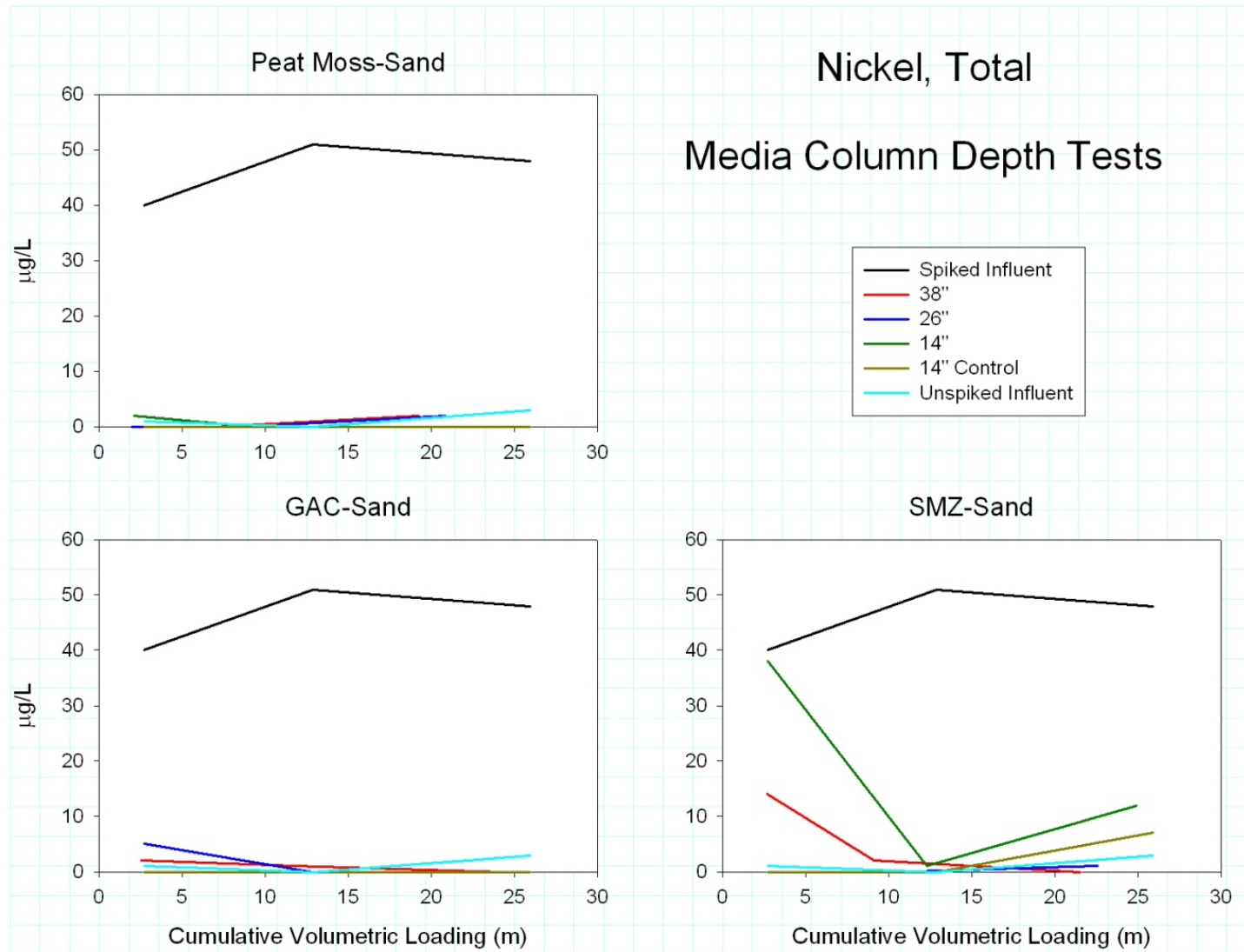


Figure B-64. Nickel (Total) Removal for Component Media

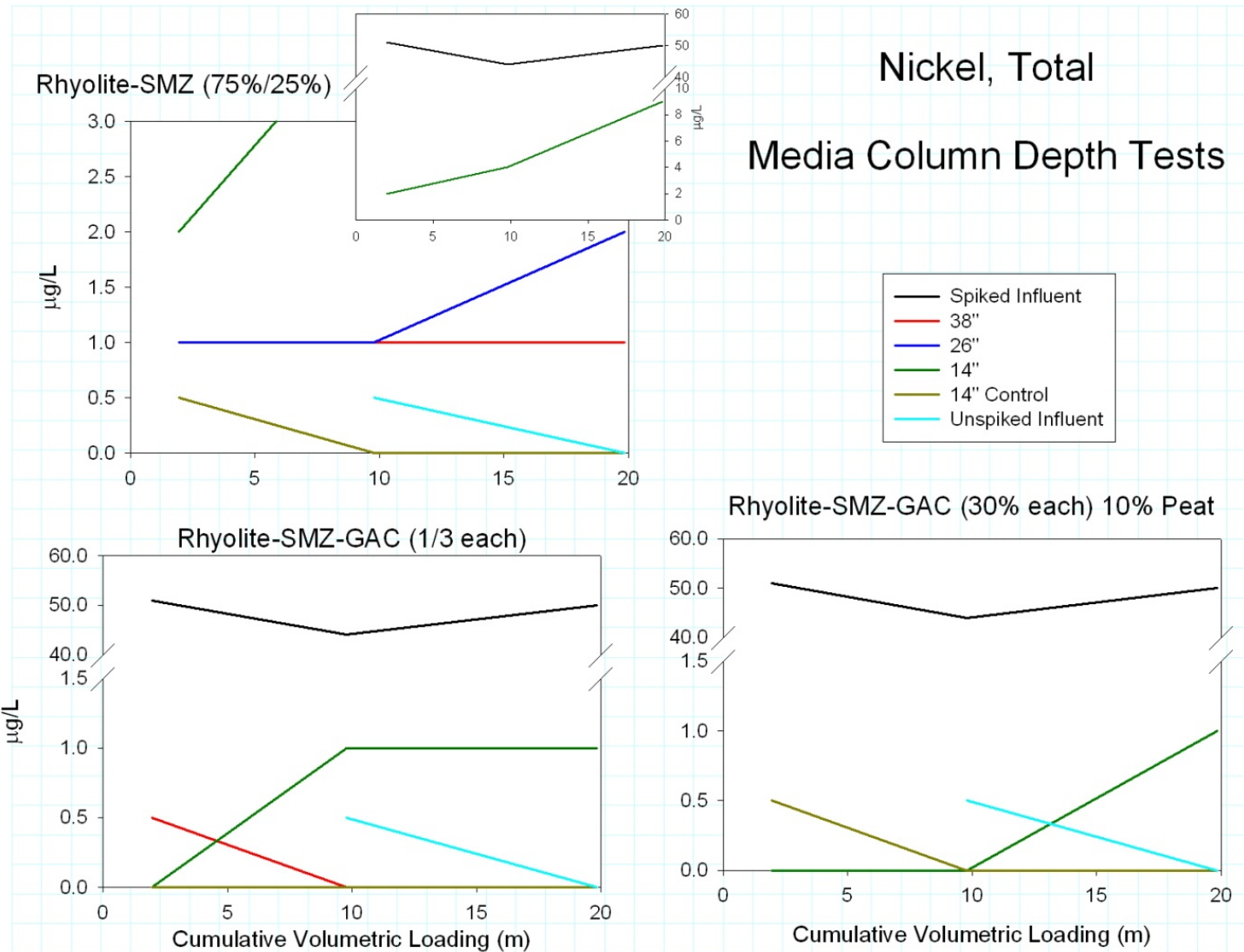


Figure B-65. Nickel (Total) Removal for Media Mixtures

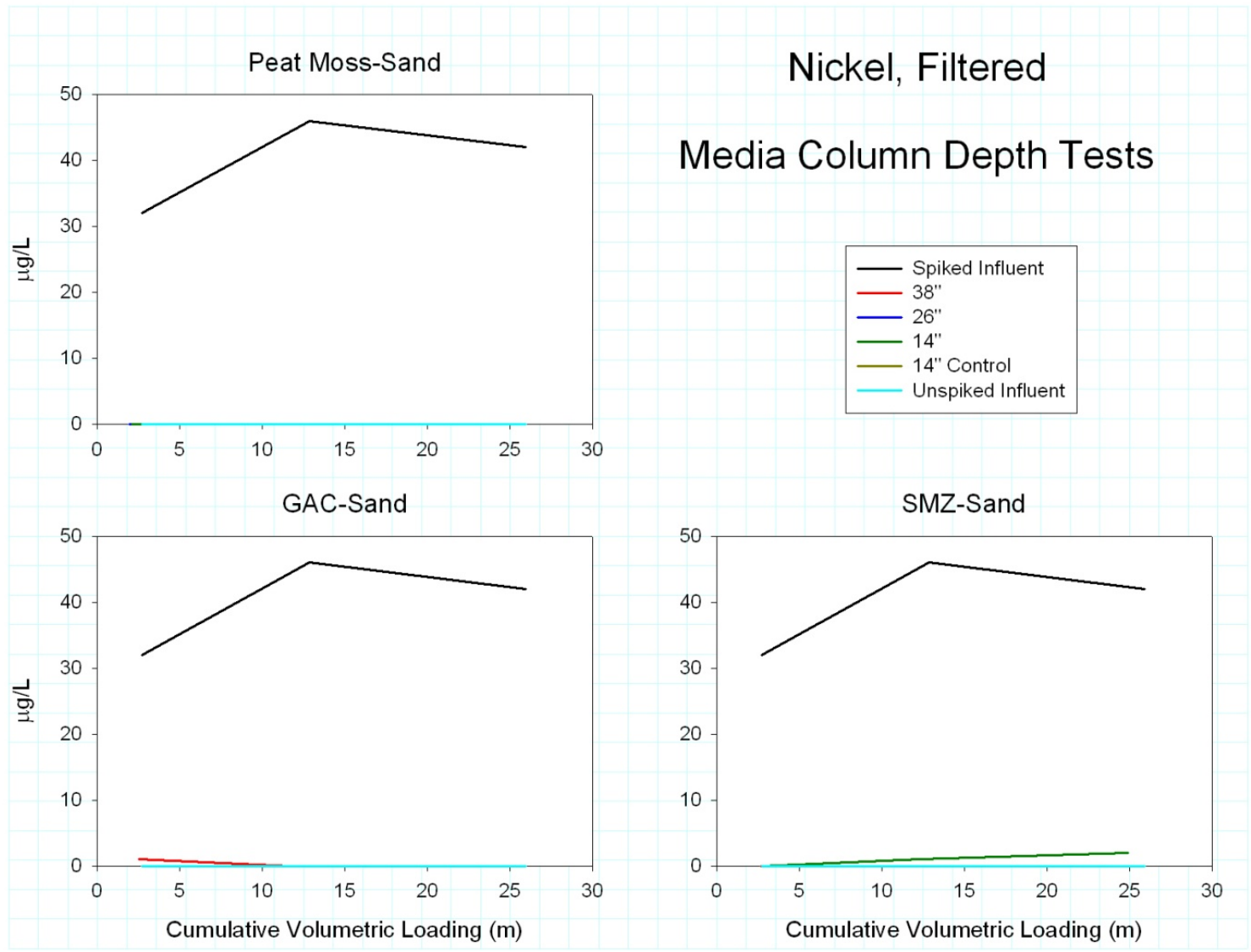


Figure B-66. Nickel (Filtered) Removal for Component Media

Nickel, Filtered Media Column Depth Tests

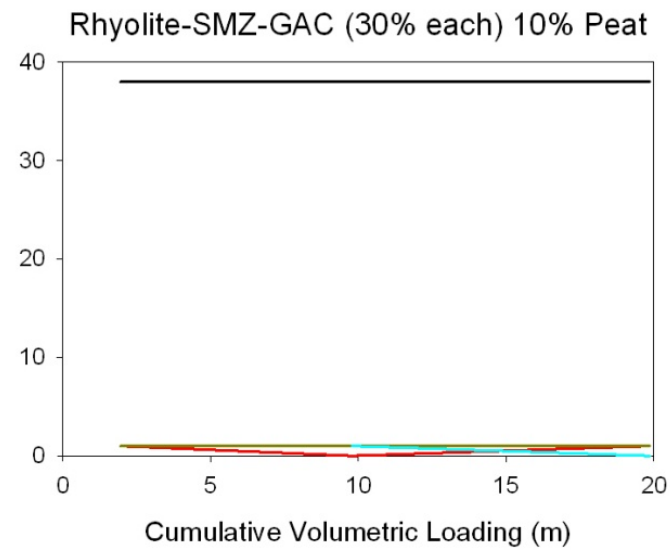
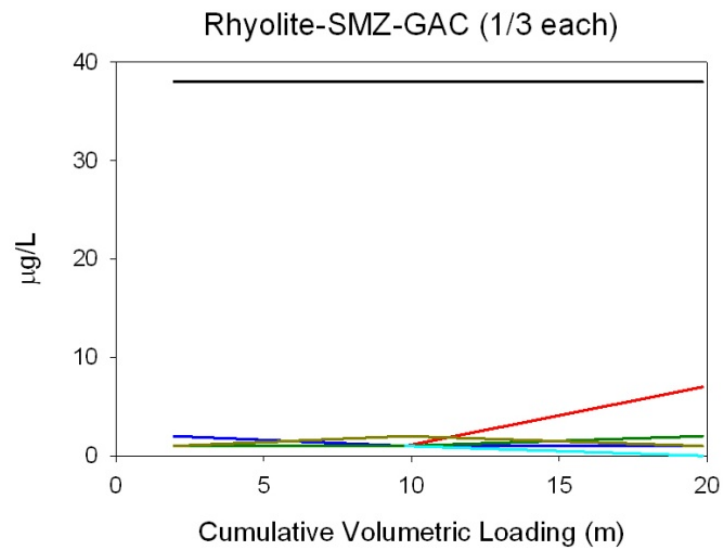
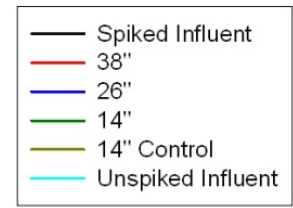
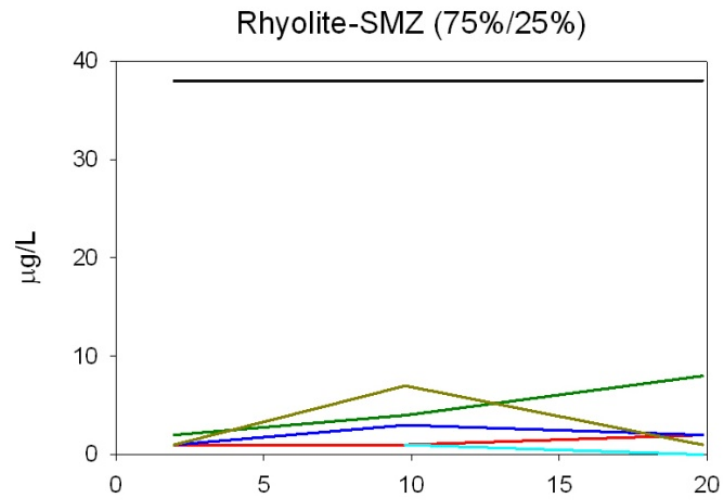
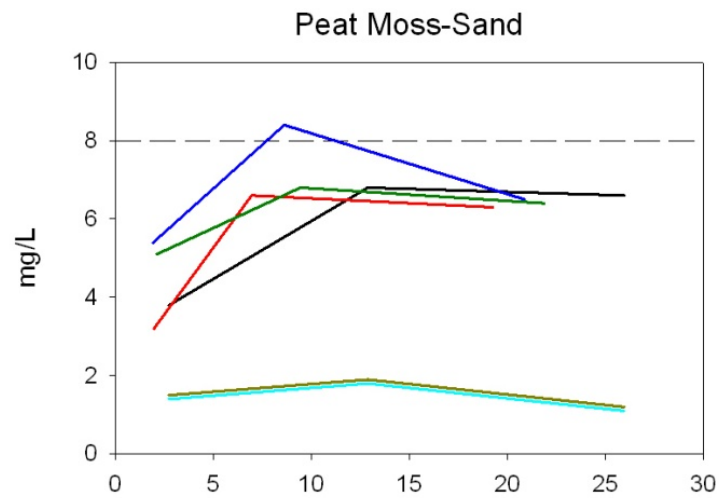


Figure B-67. Nickel (Filtered) Removal for Media Mixtures



Nitrate Media Column Depth Tests

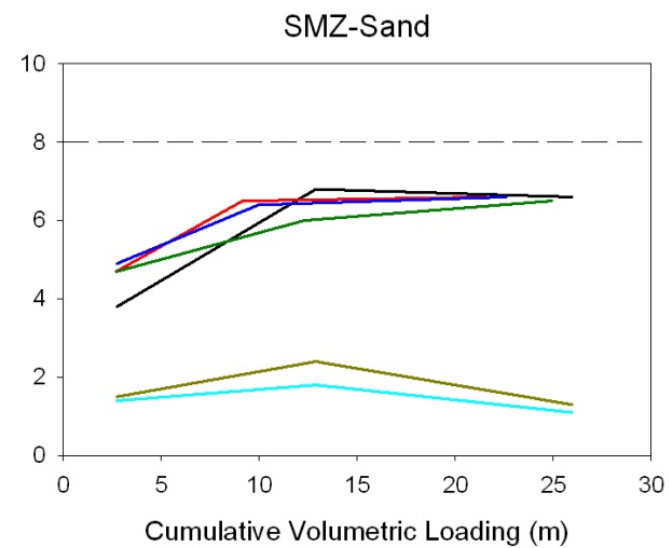
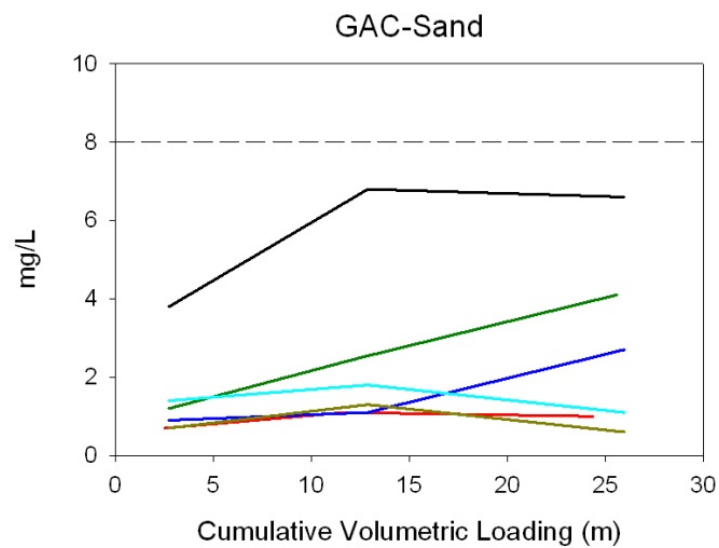
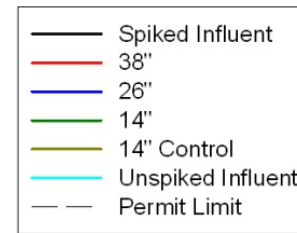
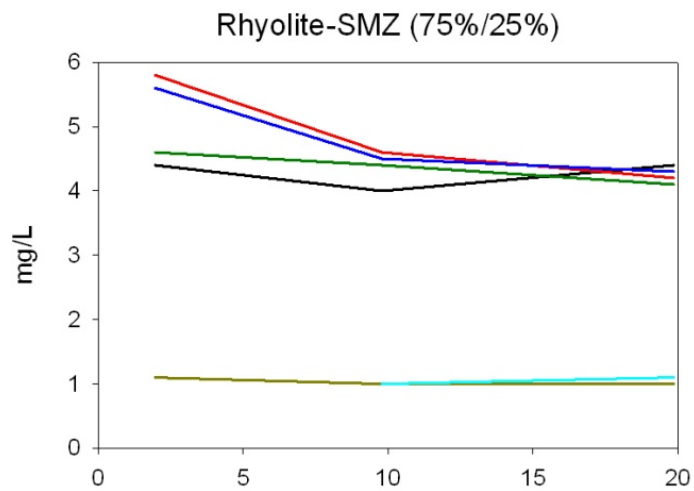


Figure B-68. Aluminum (Total) Removal for Component Media



Nitrate Media Column Depth Tests

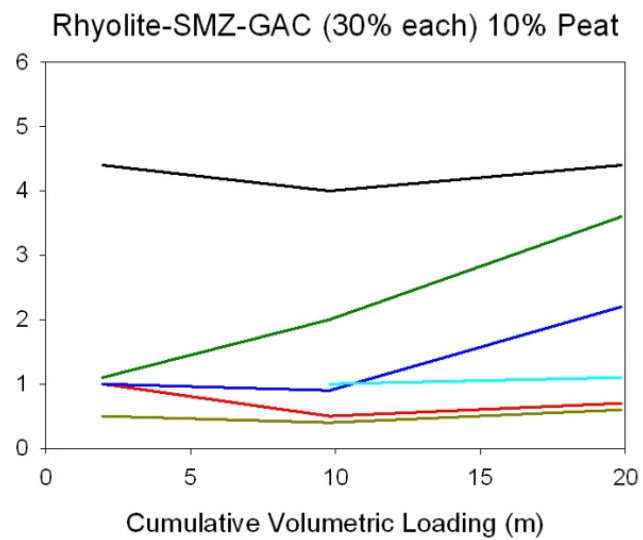
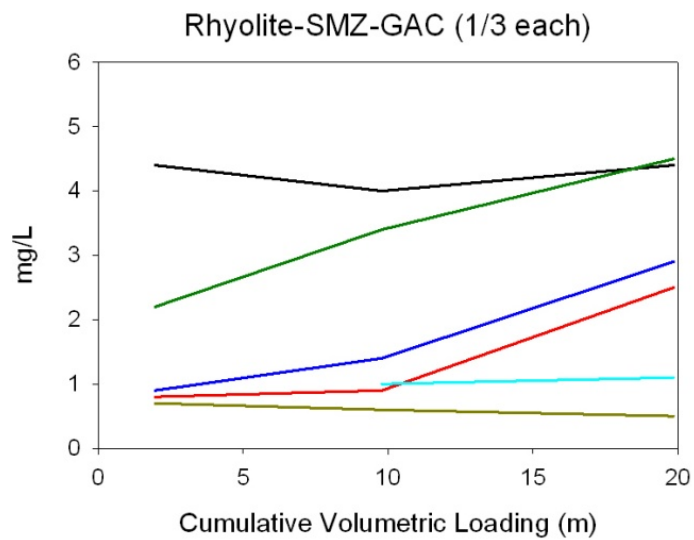
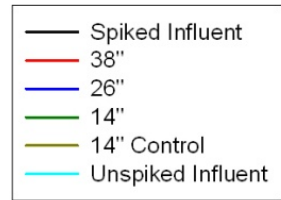


Figure B-69. Nitrate Removal for Media Mixtures

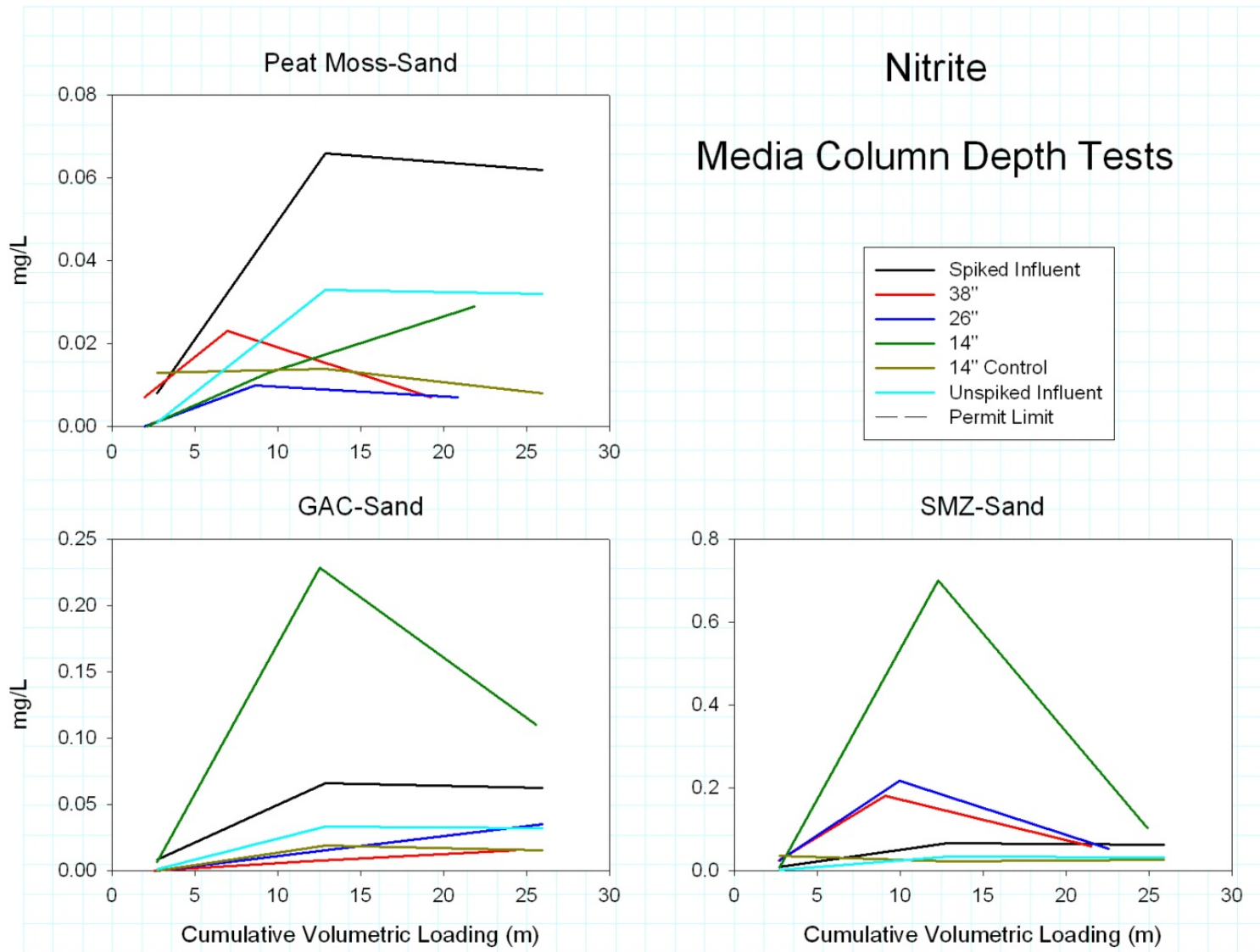
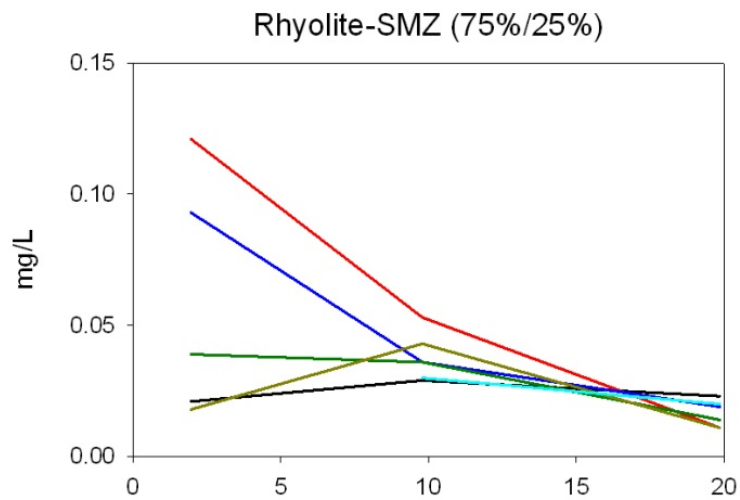


Figure B-70. Nitrite Removal for Component Media



Nitrite Media Column Depth Tests

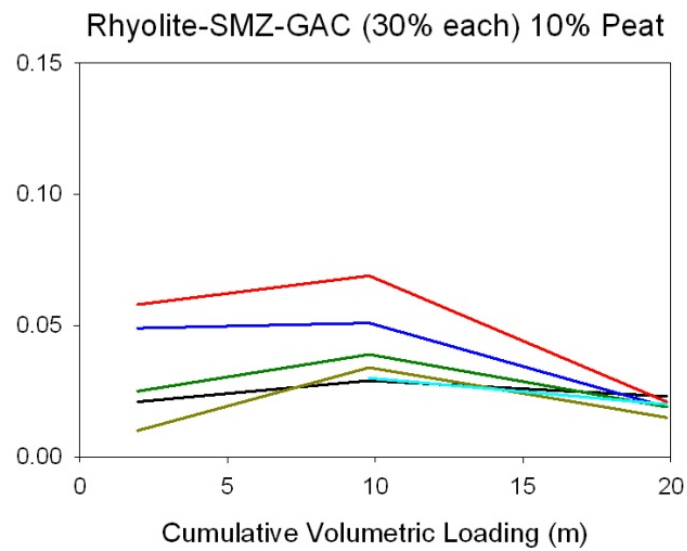
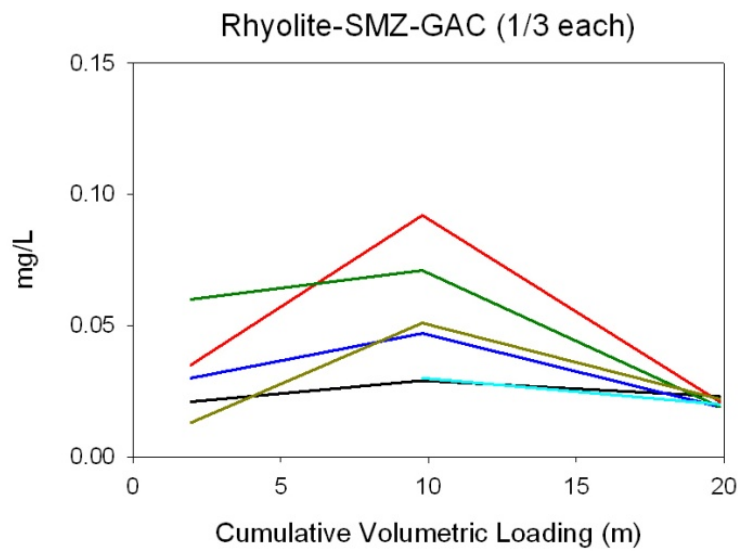
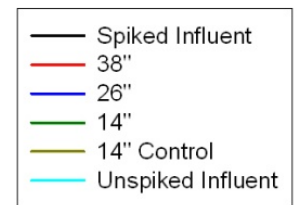


Figure B-71. Nitrite Removal for Media Mixtures

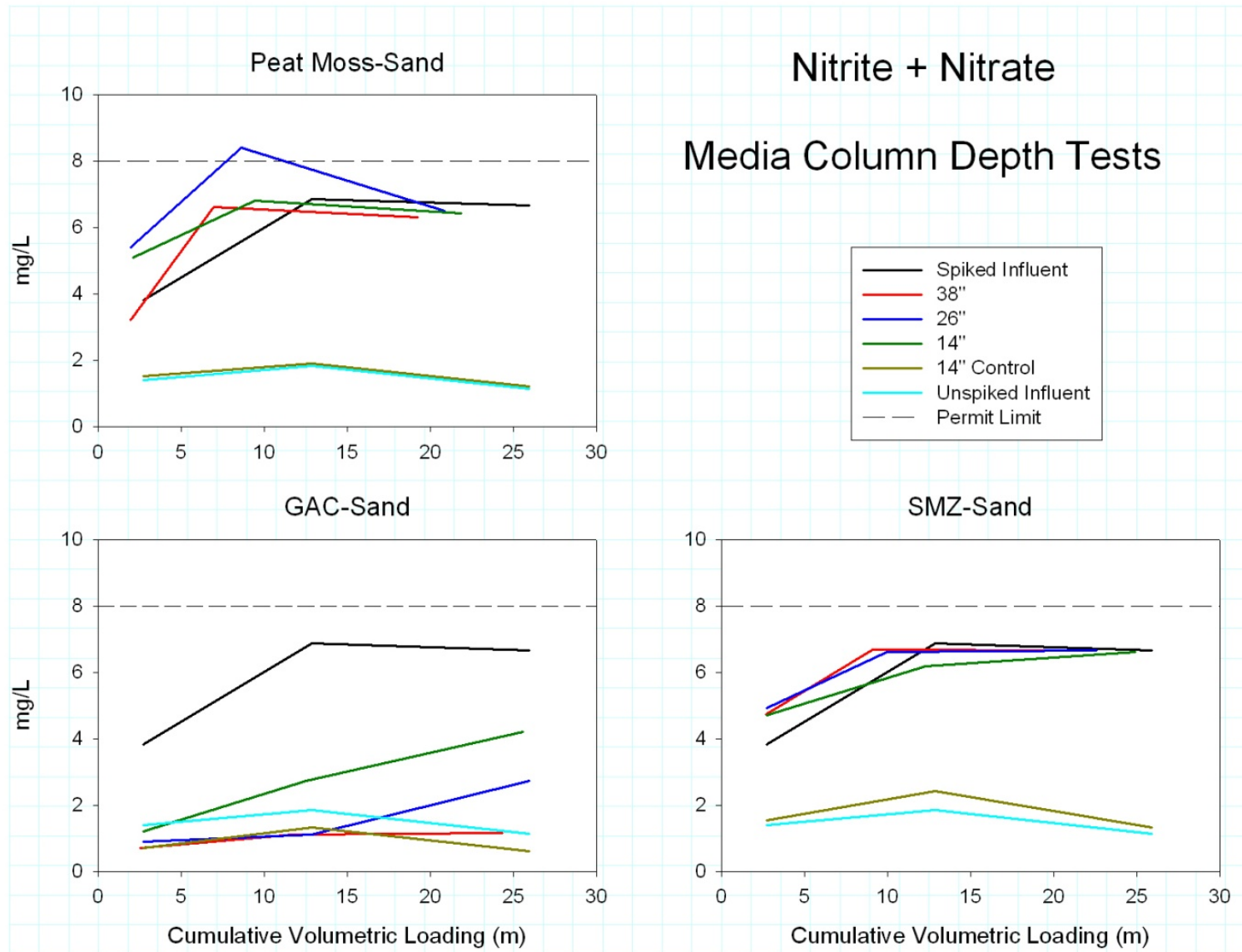
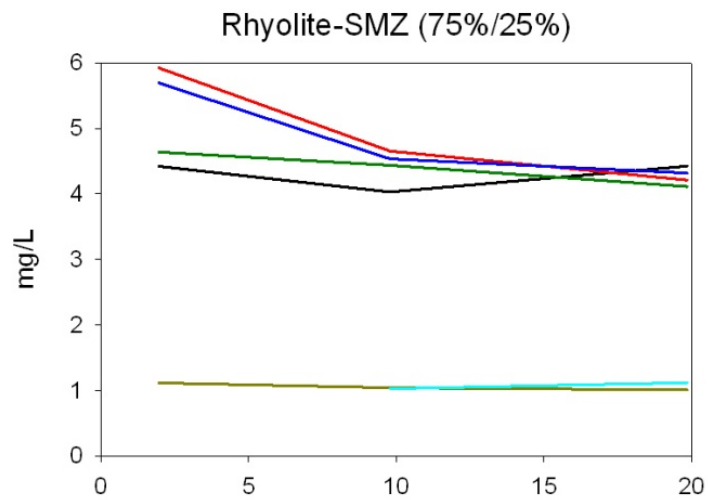


Figure B-72. Nitrite + Nitrate Removal for Component Media



Nitrite + Nitrate Media Column Depth Tests

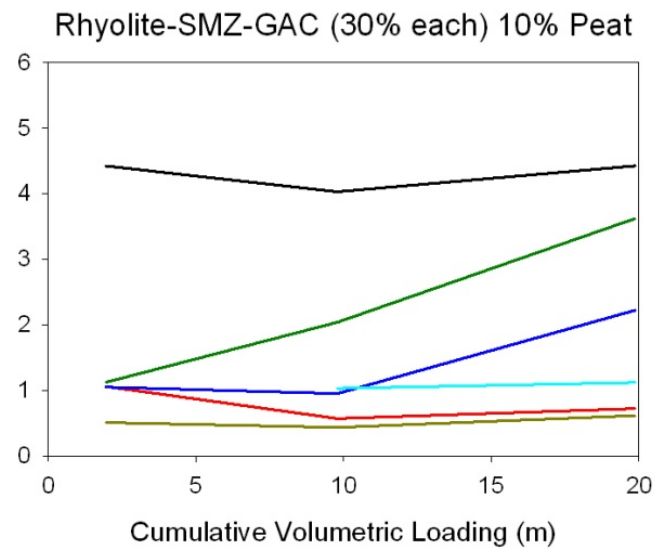
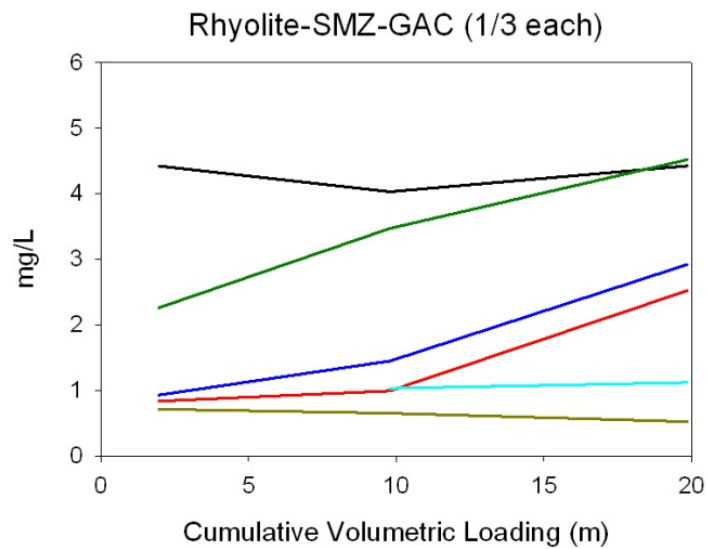
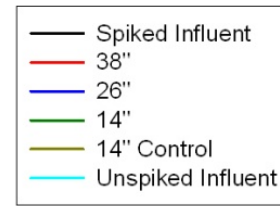


Figure B-73. Nitrite + Nitrate Removal for Media Mixtures

Oil and Grease

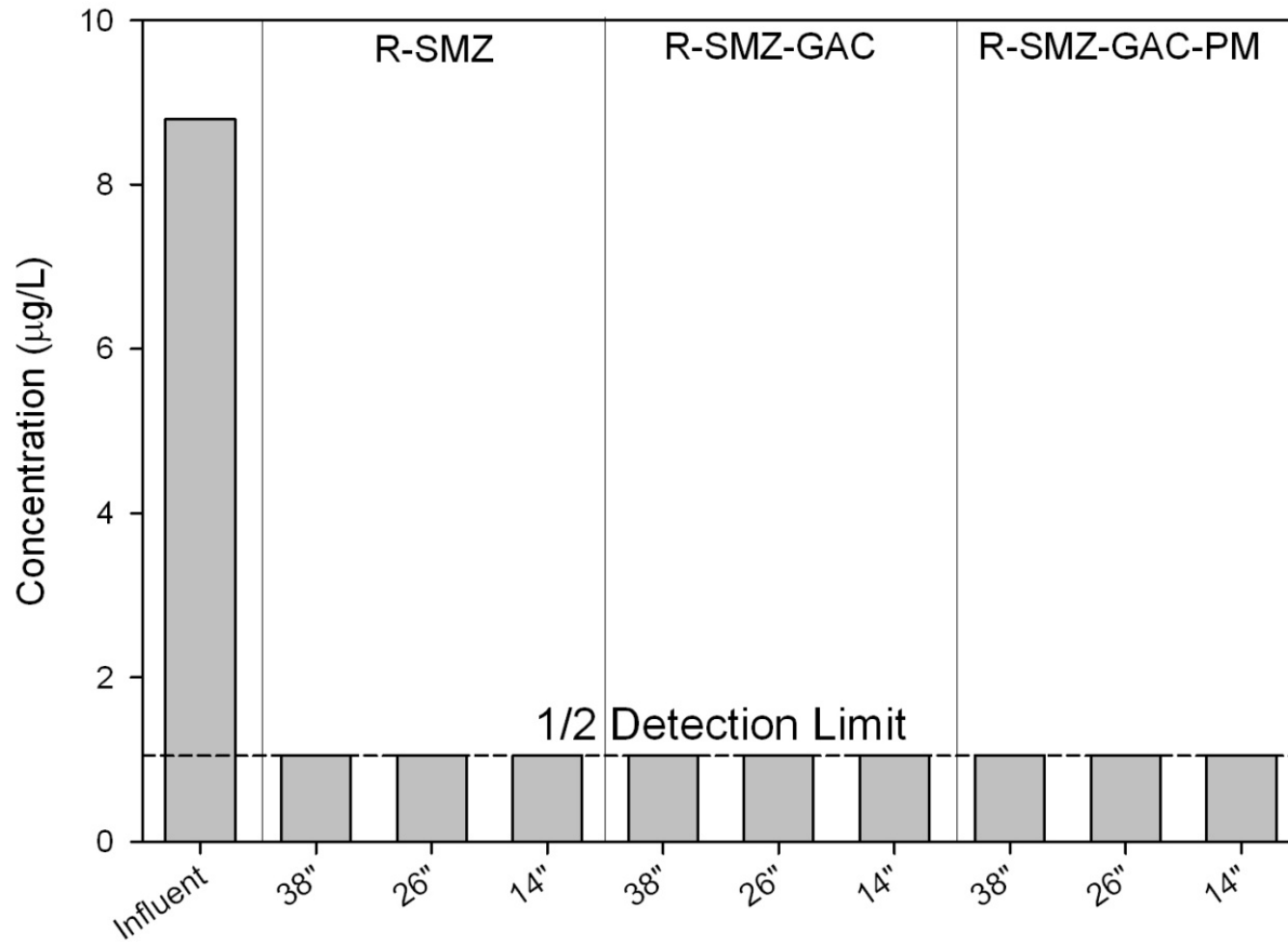


Figure B-74. Oil and Grease Removal for Media Mixtures

Oxidation-Reduction Potential Media Column Depth Tests

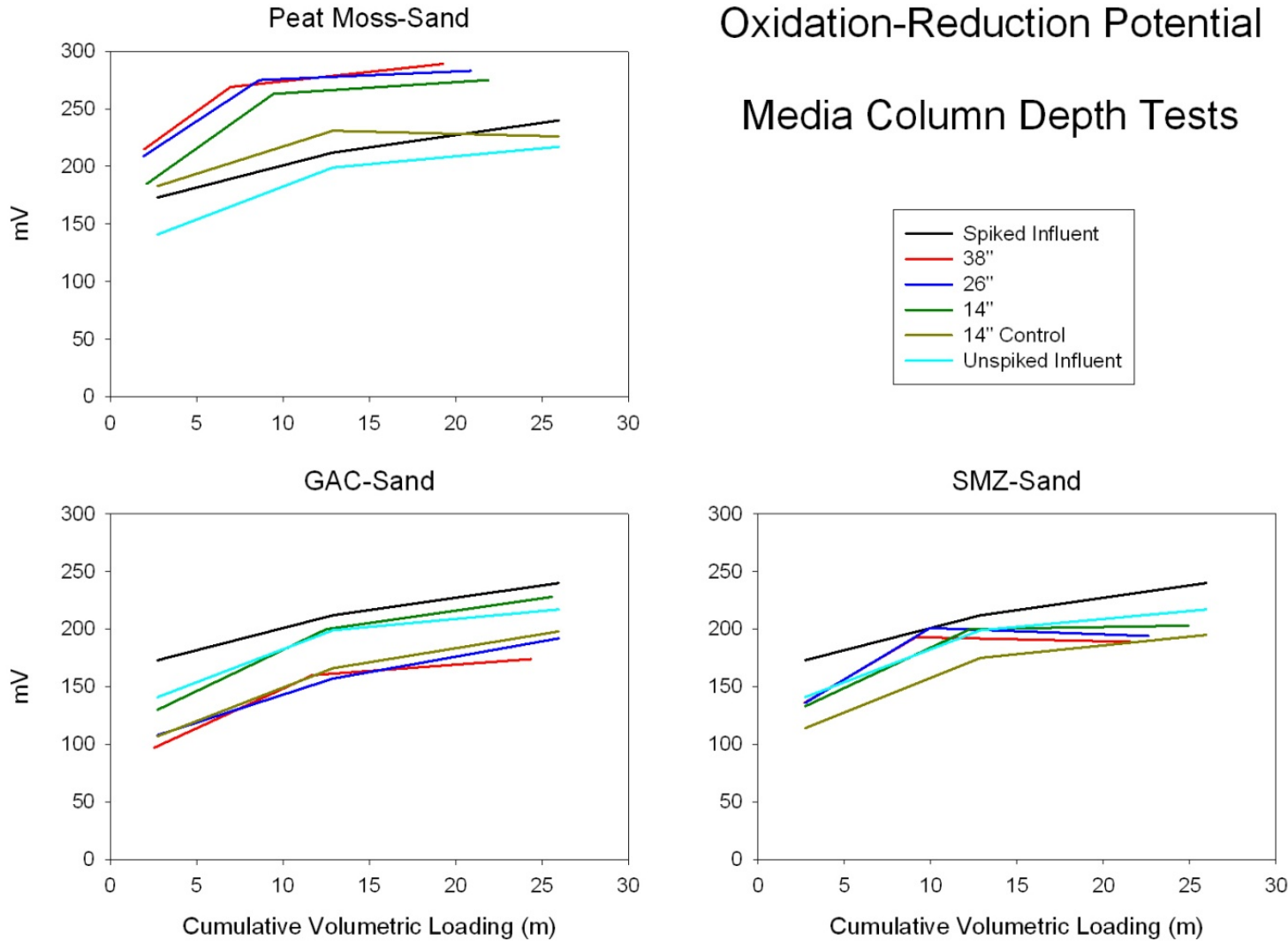


Figure B-75. Oxidation-Reduction Potential Behavior for Component Media

Oxidation-Reduction Potential Media Column Depth Tests

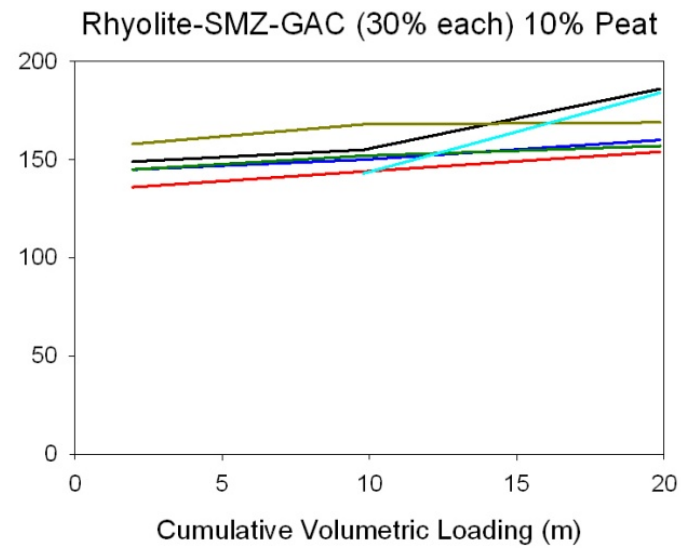
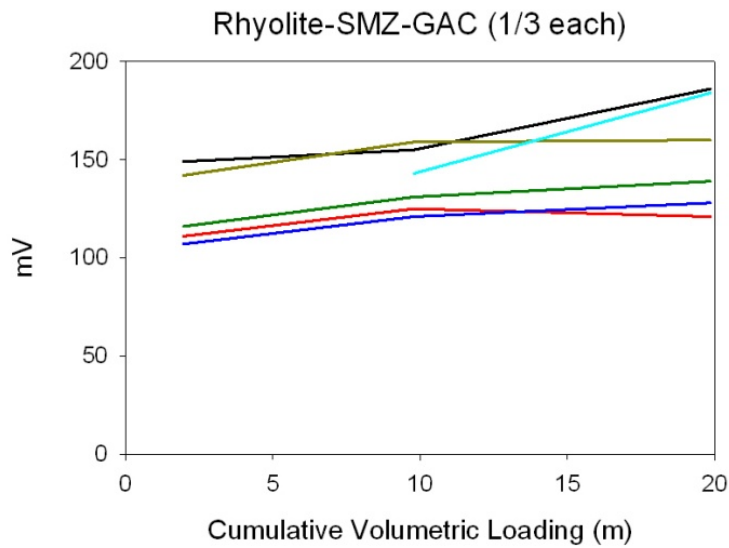
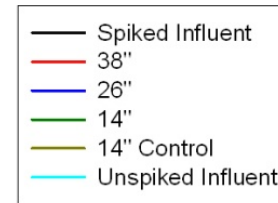
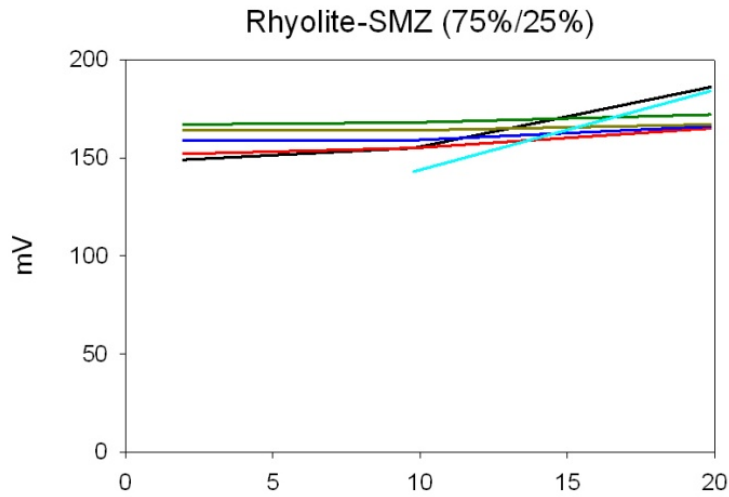
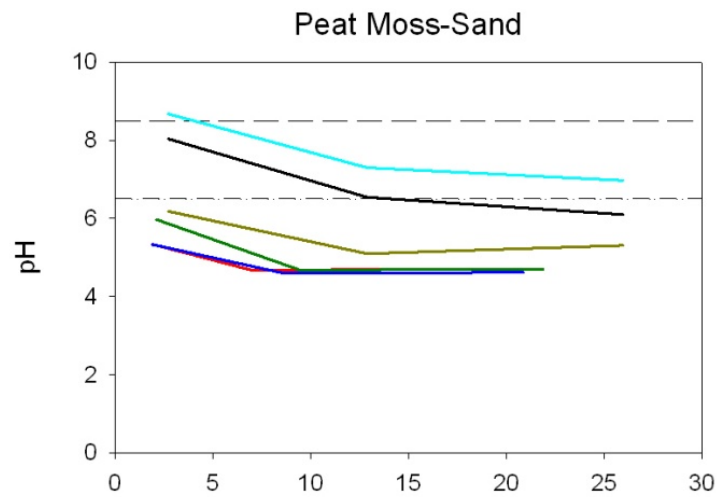


Figure B-76. Oxidation-Reduction Potential Behavior for Media Mixtures



pH Media Column Depth Tests

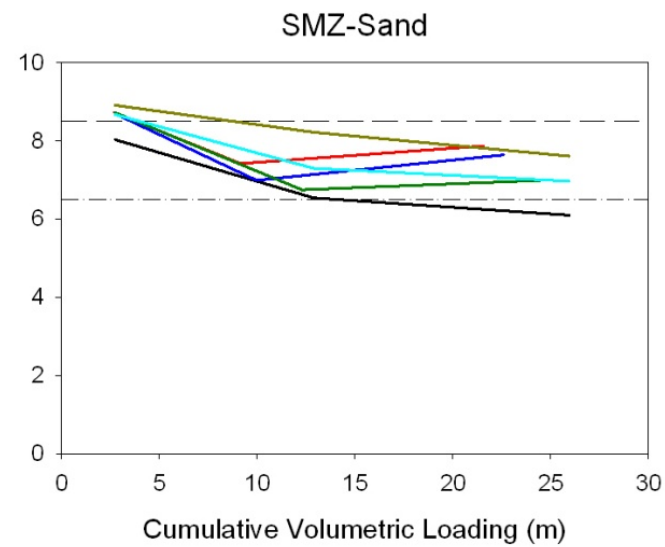
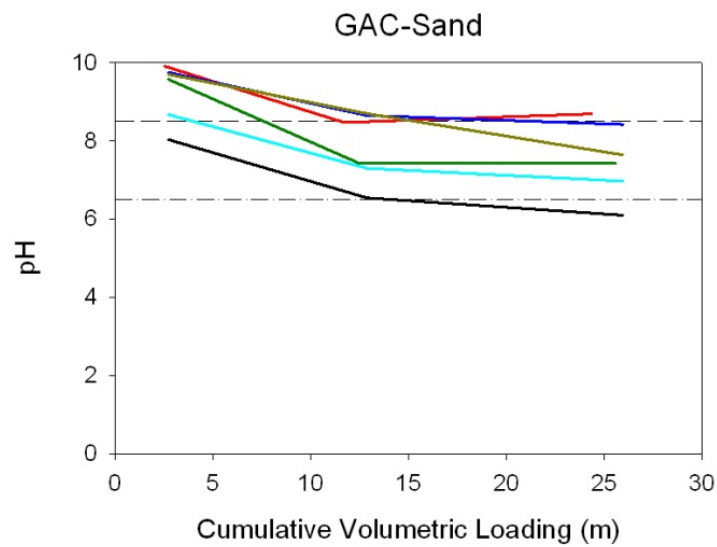
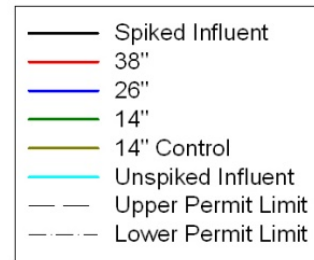


Figure B-77. pH Behavior for Component Media

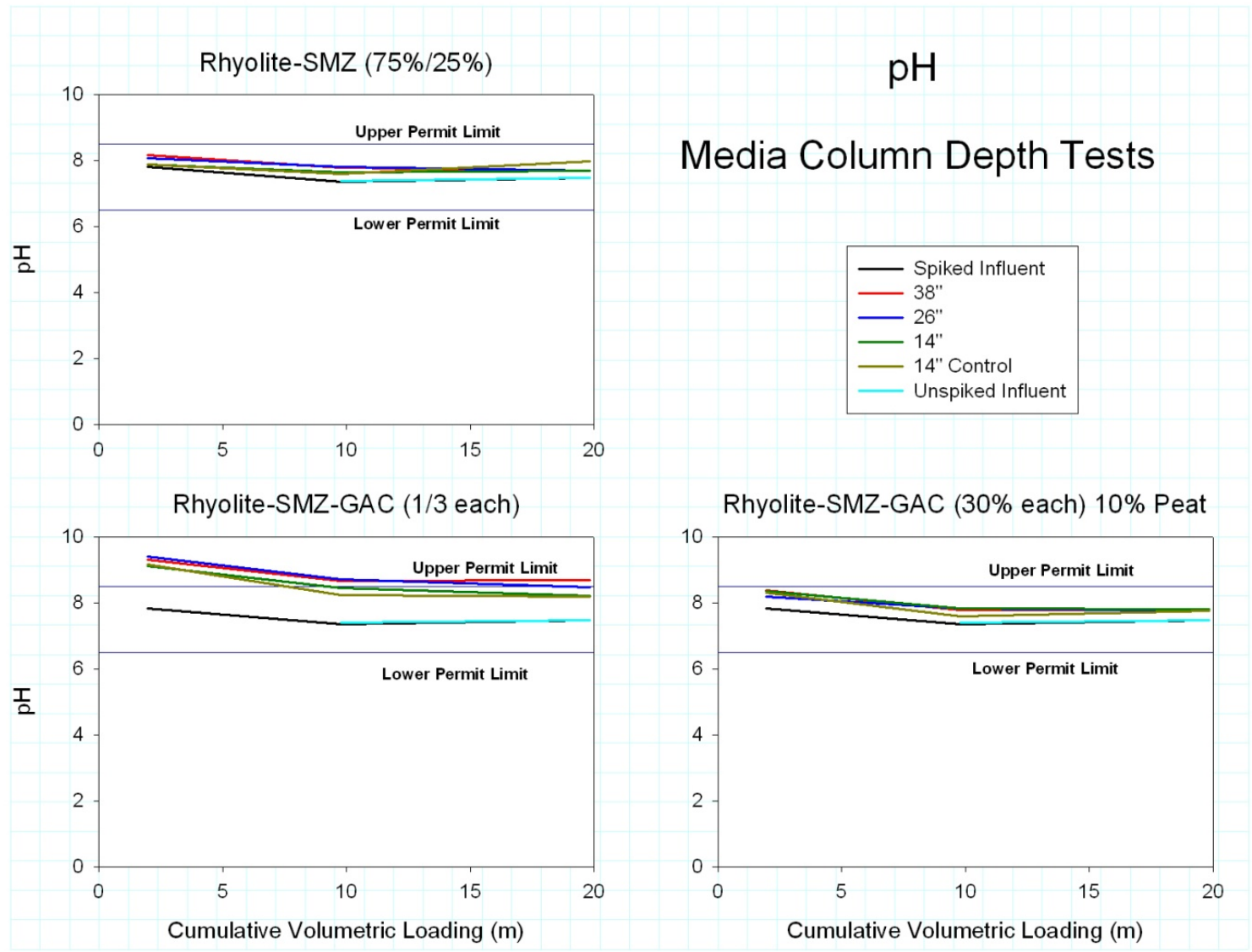


Figure B-78. pH Behavior for Media Mixtures

Perchlorate

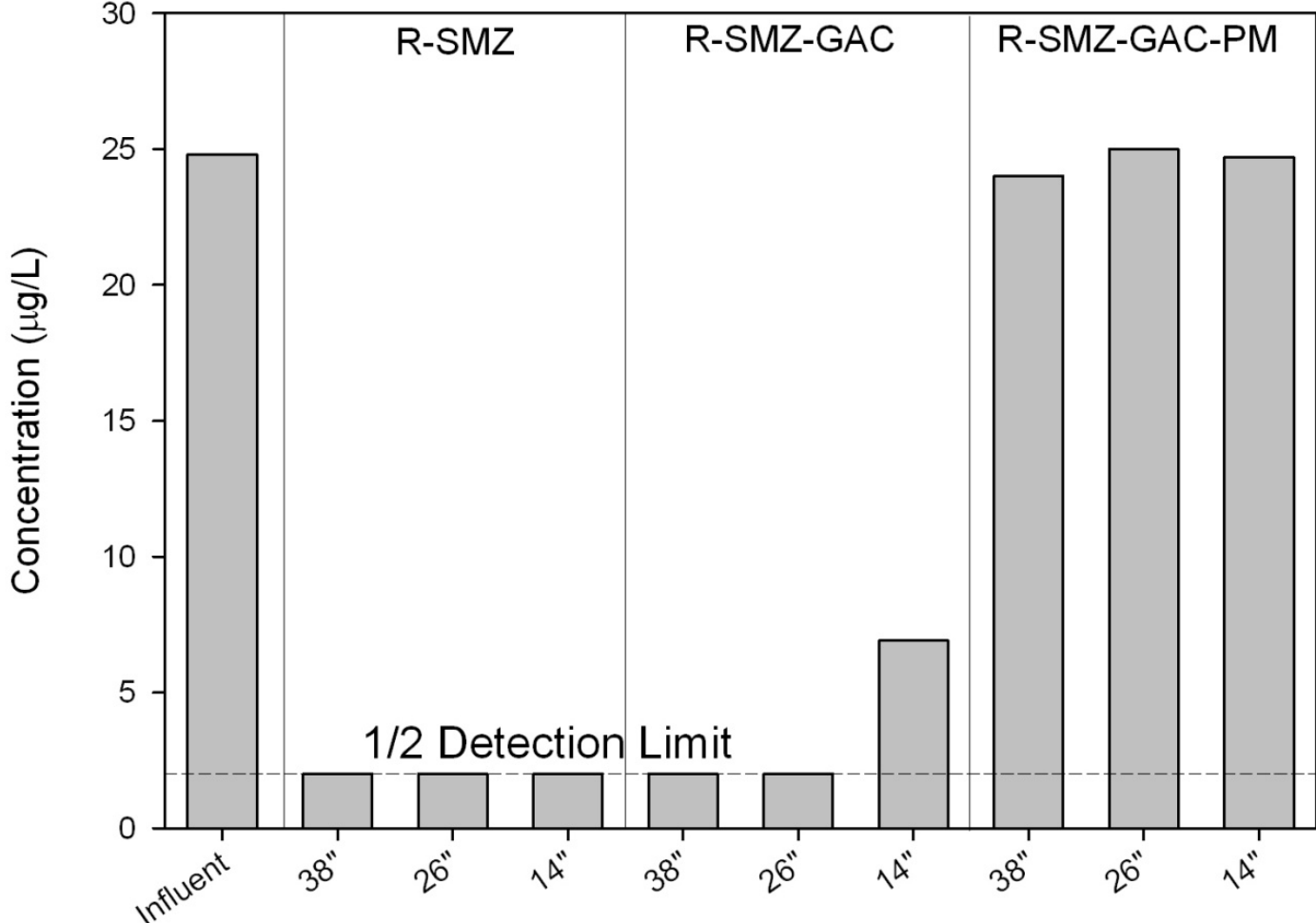


Figure B-79. Perchlorate Removal for Media Mixtures

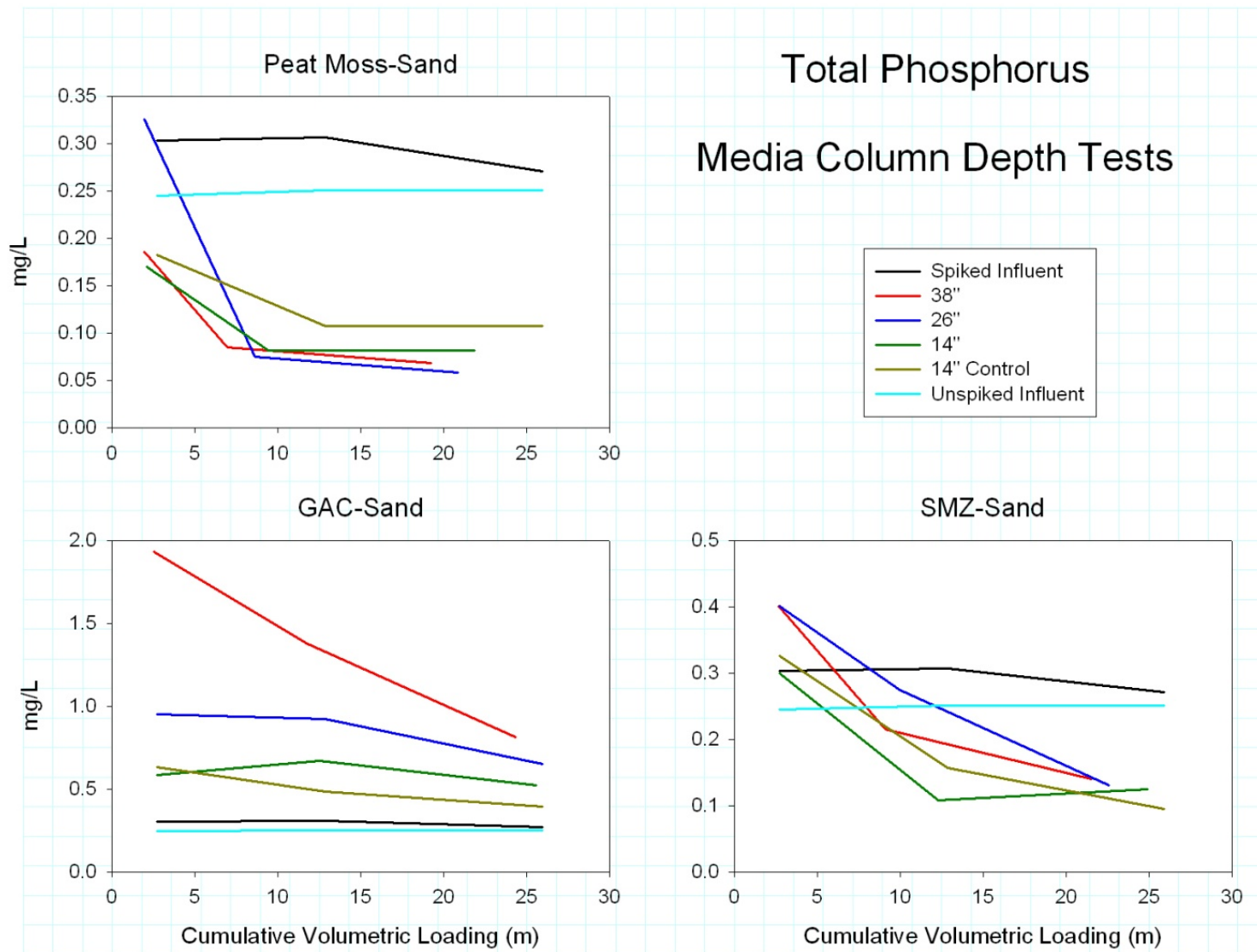
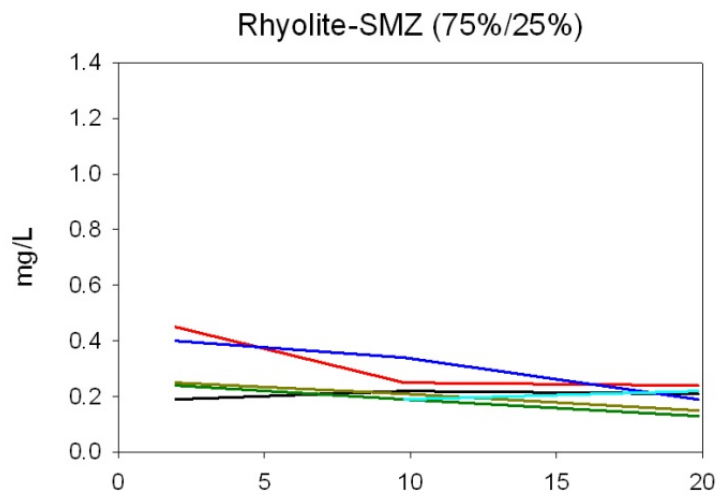


Figure B-80. Total Phosphorus Removal for Component Media



Total Phosphorus Media Column Depth Tests

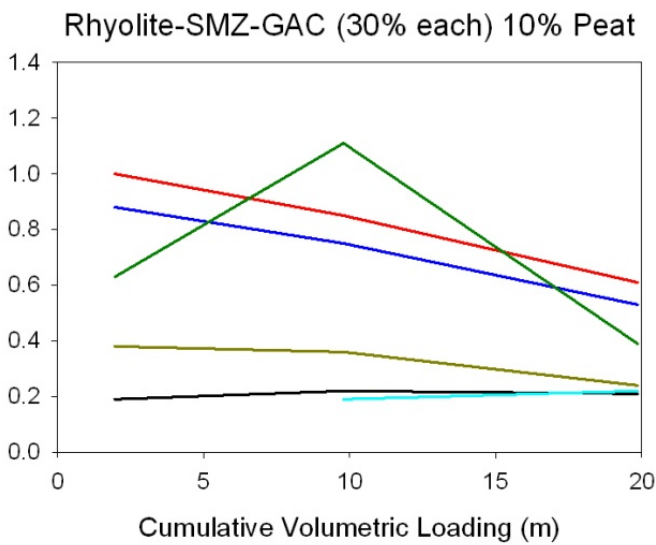
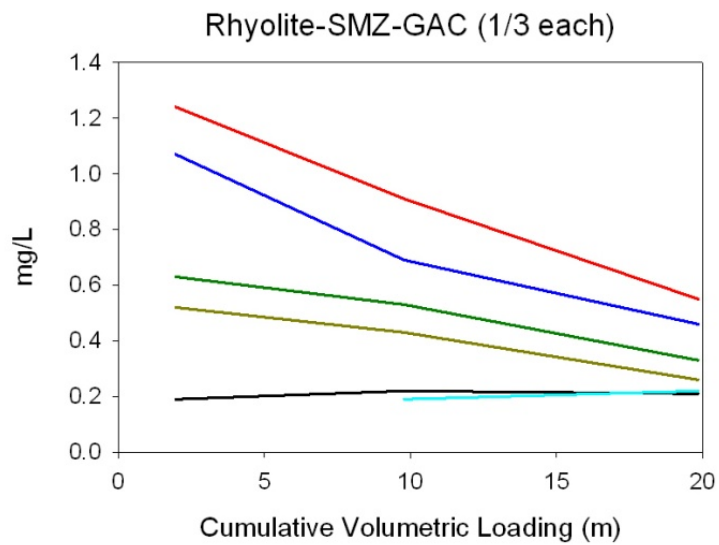
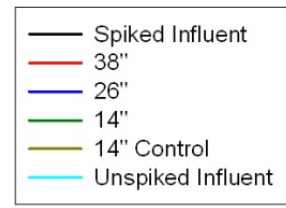


Figure B-81. Total Phosphorus Removal for Media Mixtures

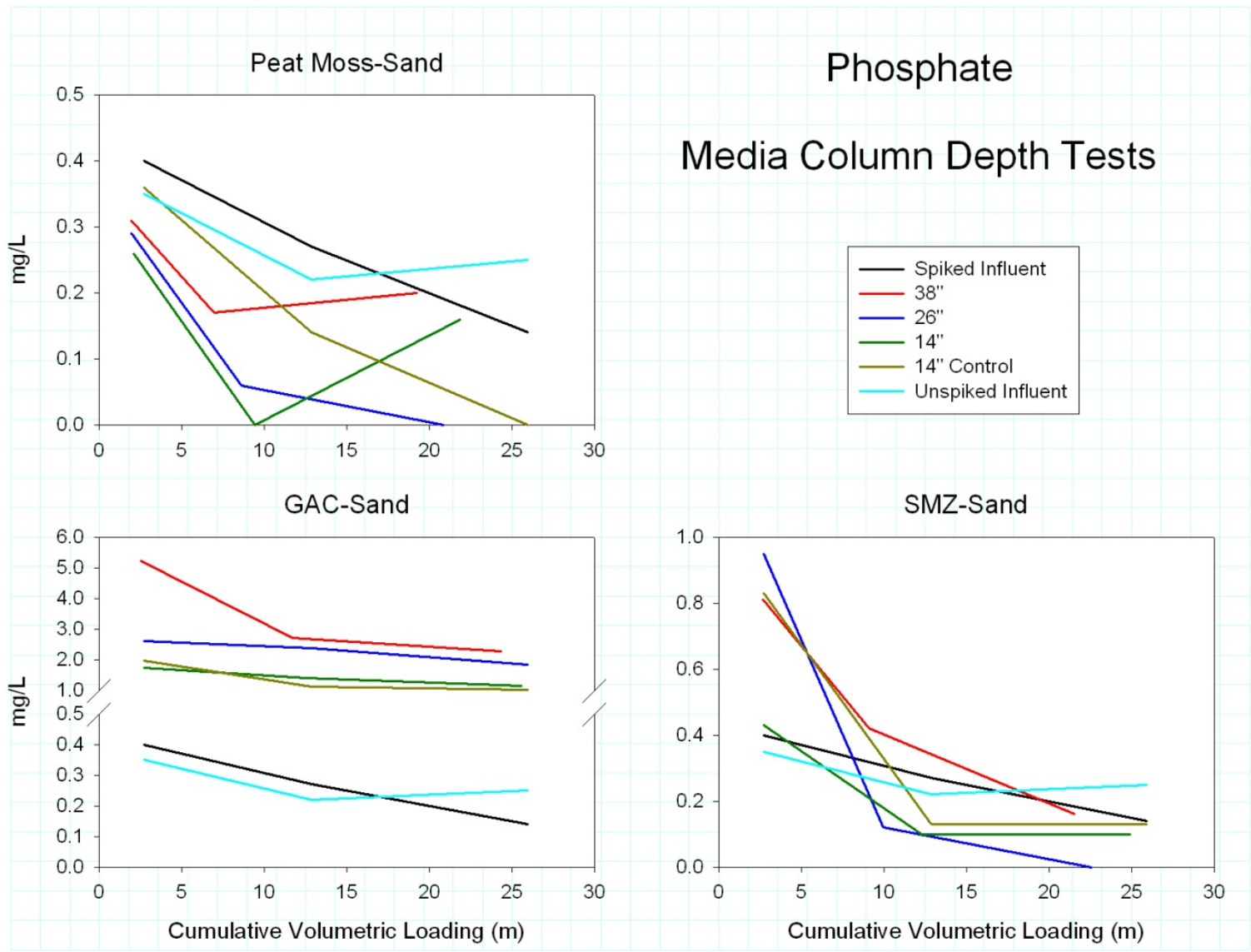
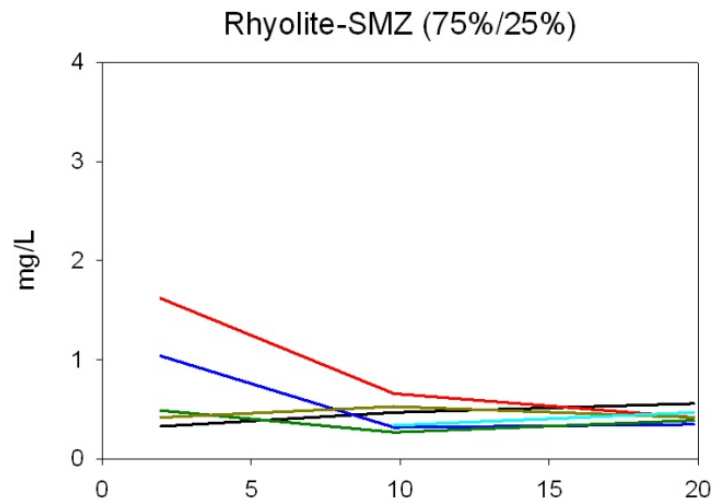


Figure B-82. Phosphate Removal for Component Media



Phosphate Media Column Depth Tests

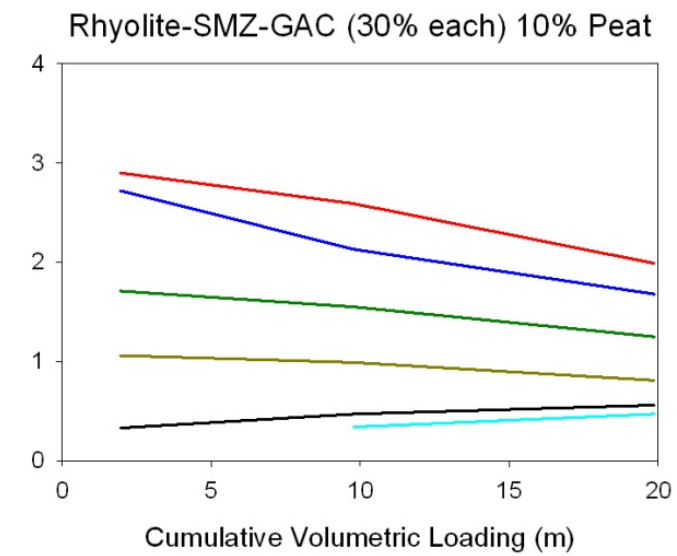
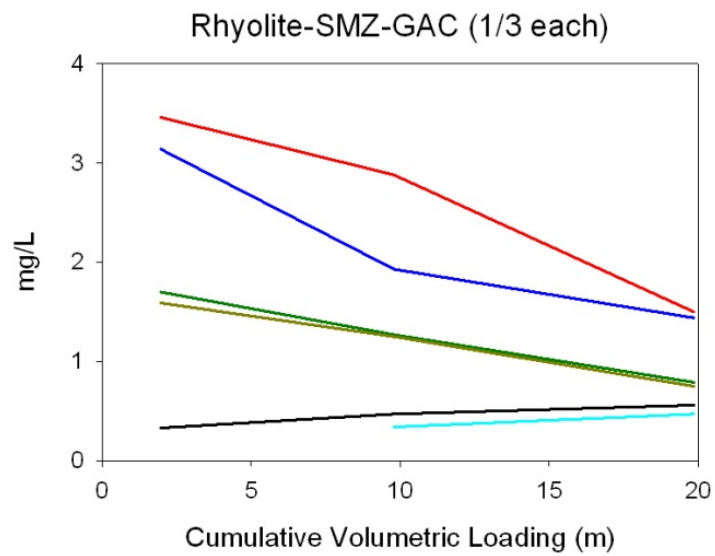
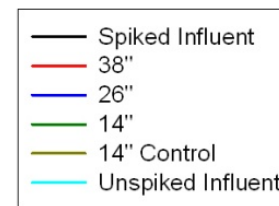


Figure B-83. Phosphate Removal for Media Mixtures

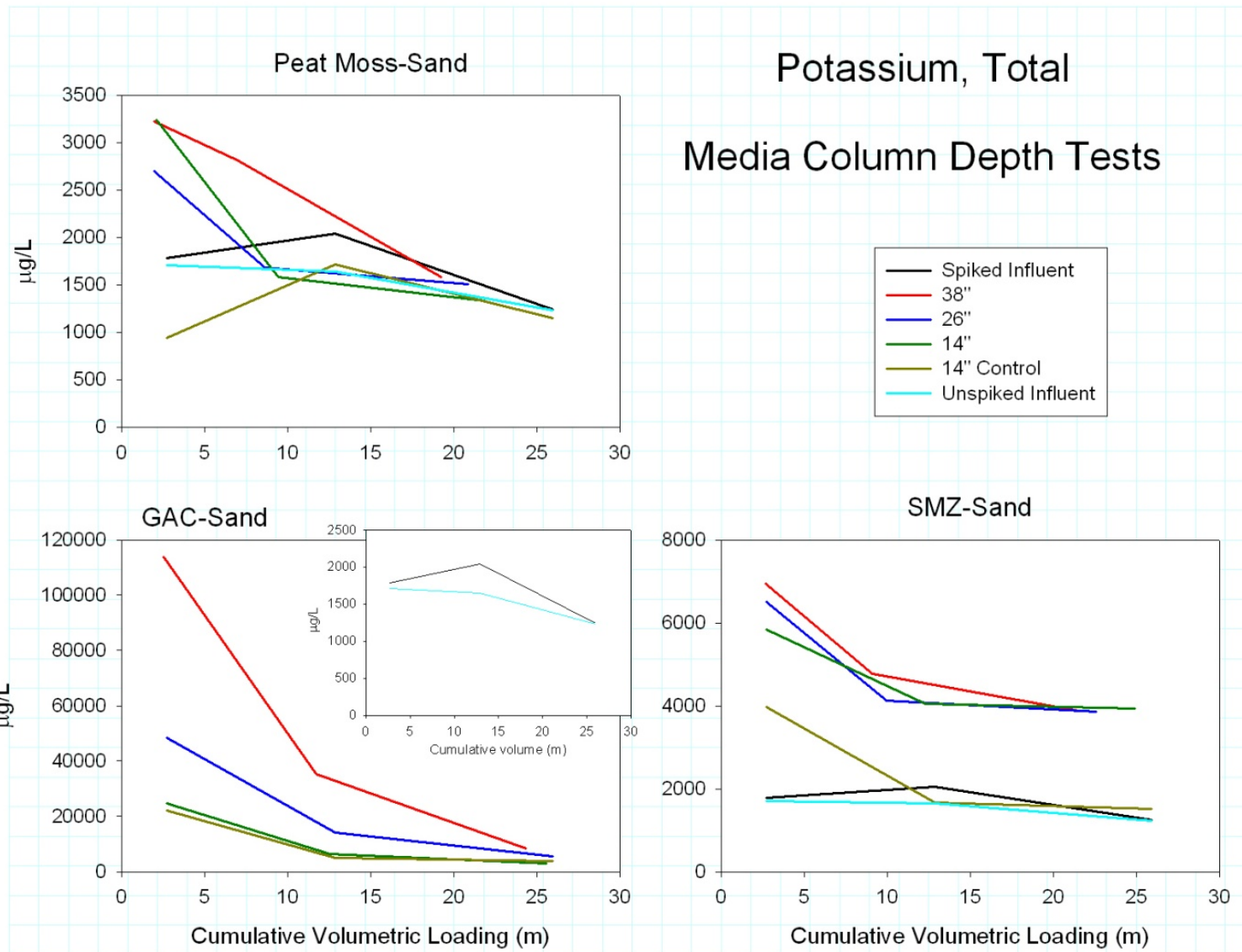
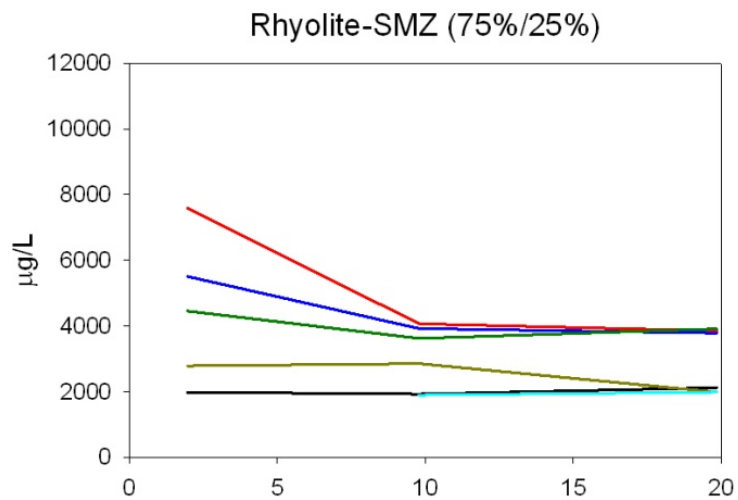


Figure B-84. Potassium (Total) Removal for Component Media



Potassium, Total Media Column Depth Tests

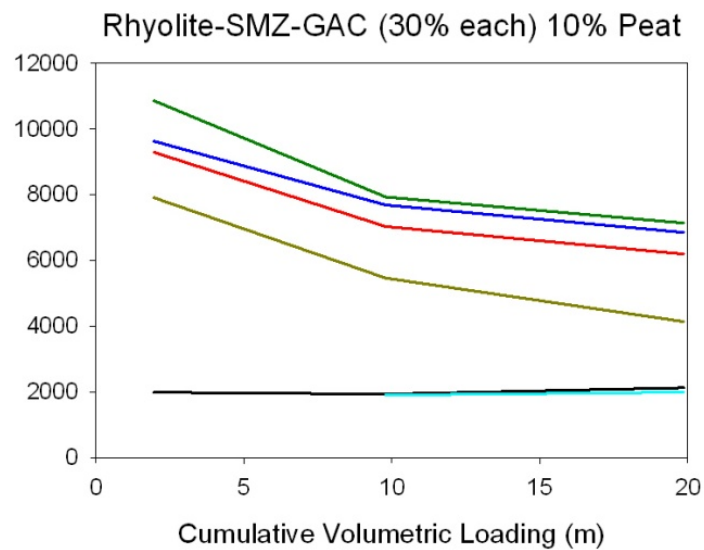
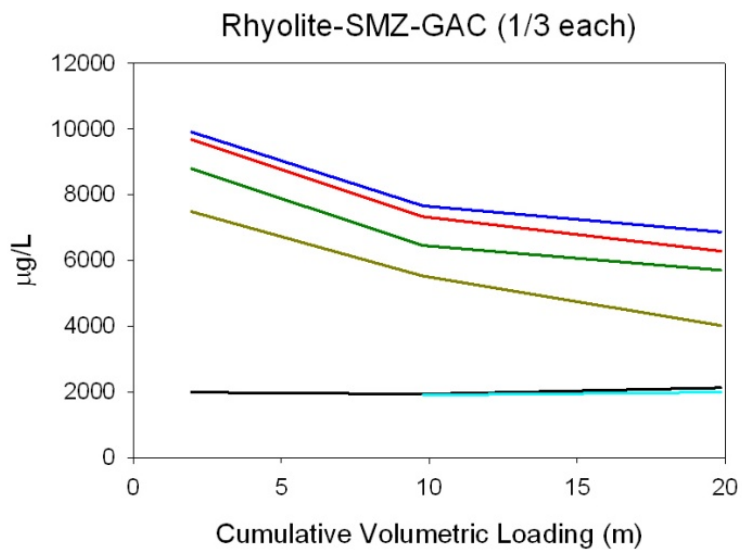
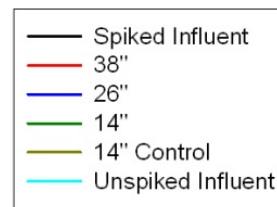


Figure B-85. Potassium (Total) Removal for Media Mixtures

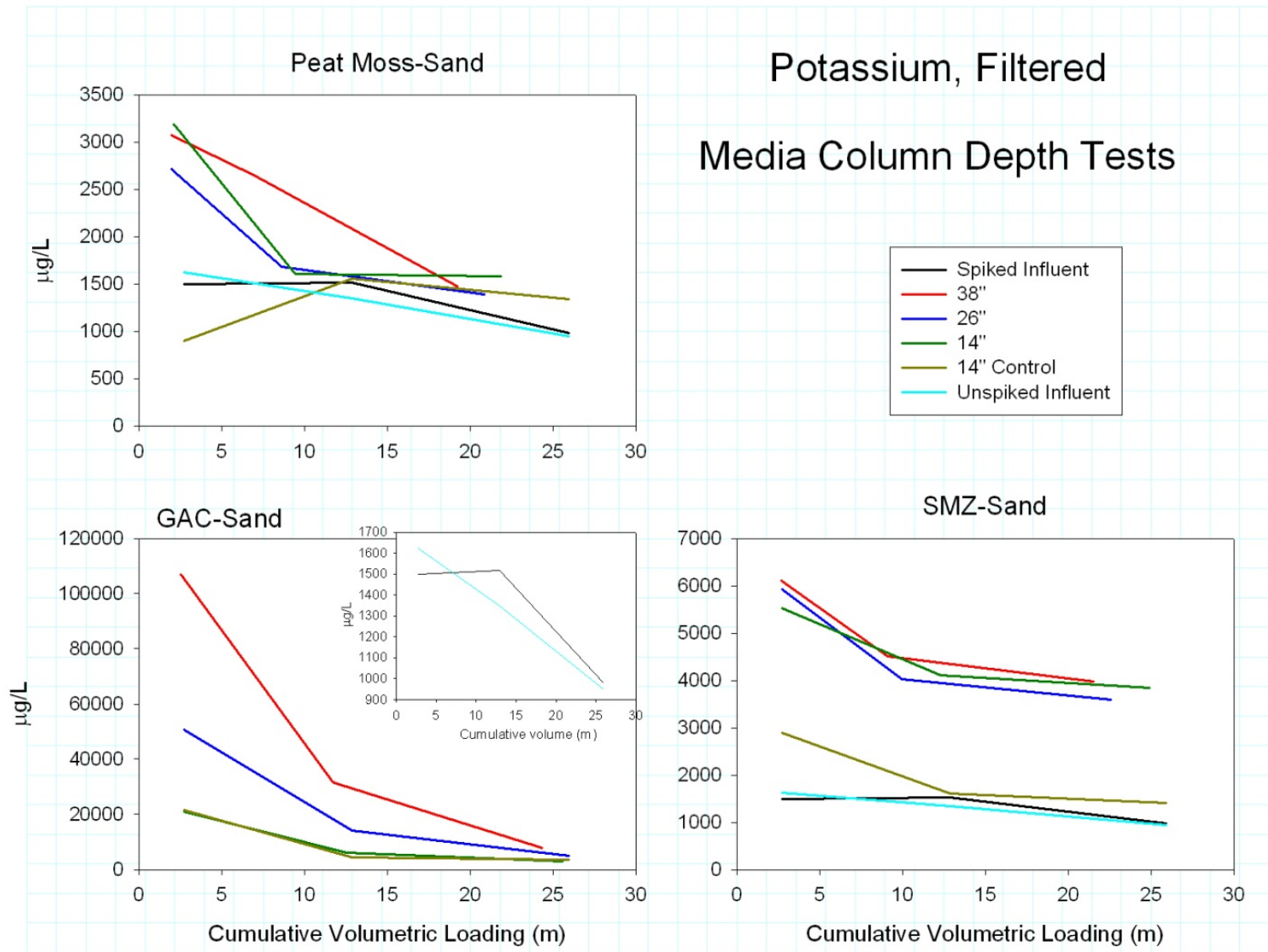
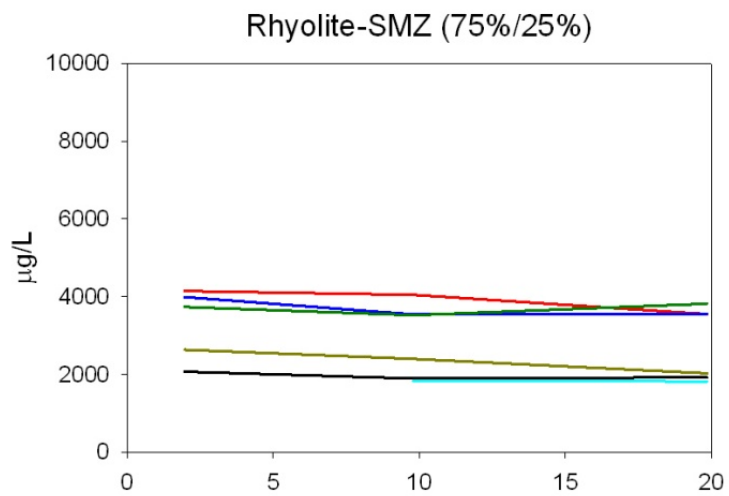


Figure B-86. Potassium (Filtered) Removal for Component Media



Potassium, Filtered Media Column Depth Tests

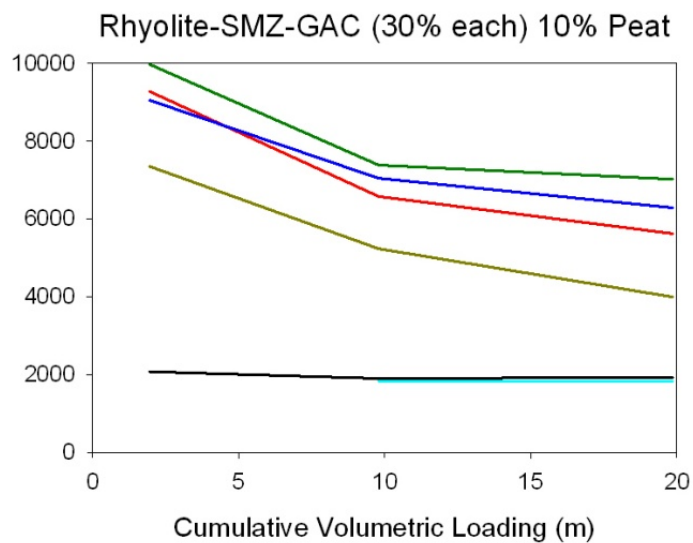
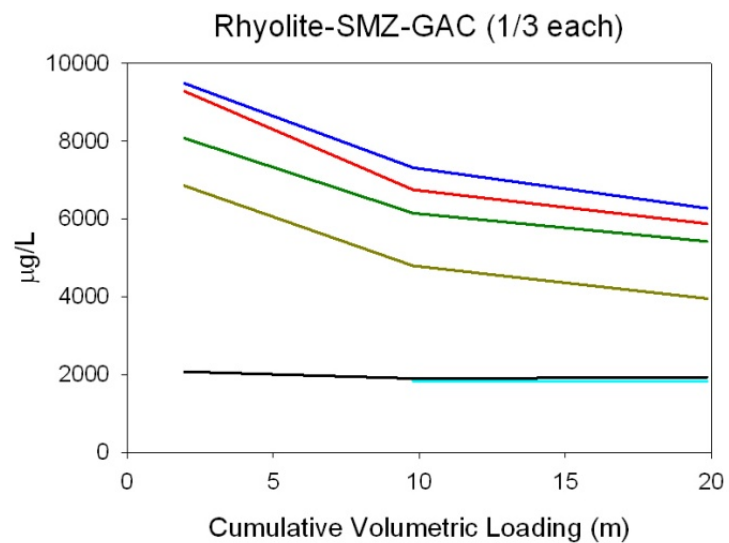
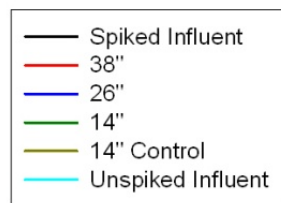
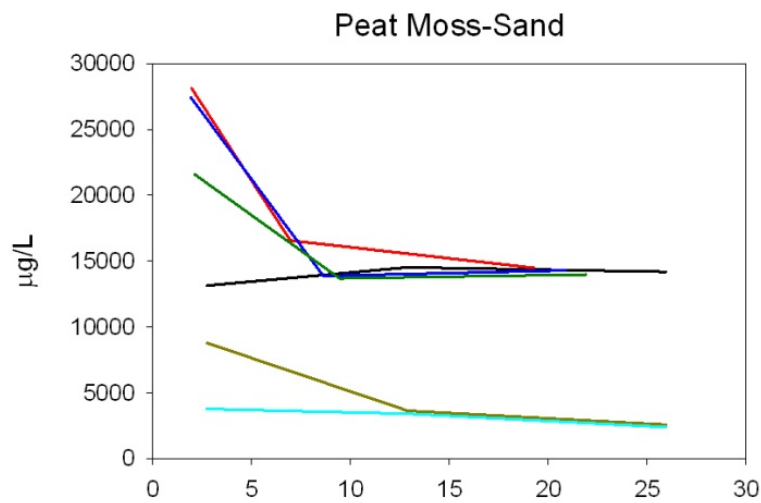


Figure B-87. Potassium (Filtered) Removal for Media Mixtures



Sodium, Total Media Column Depth Tests

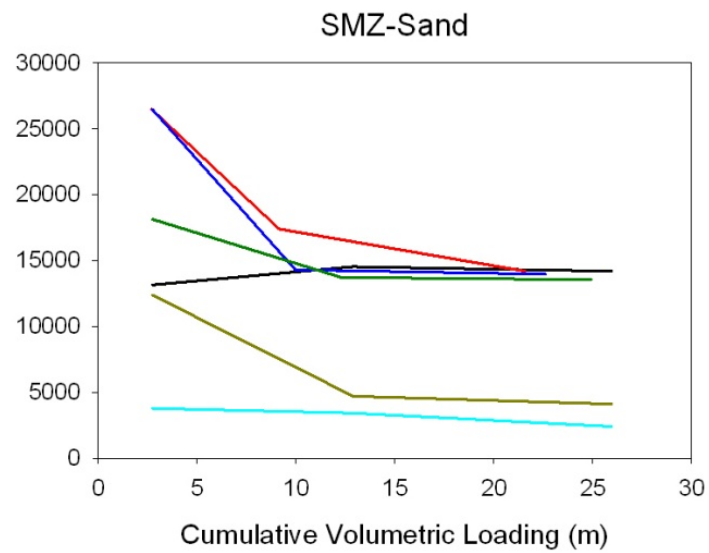
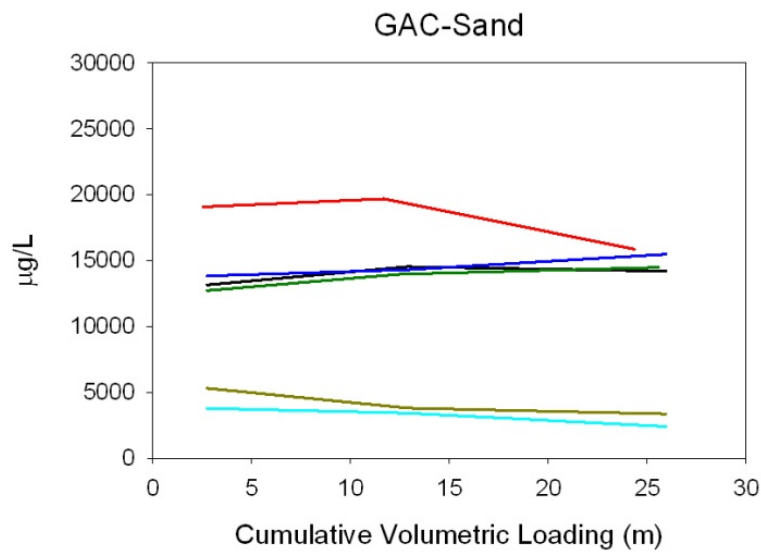
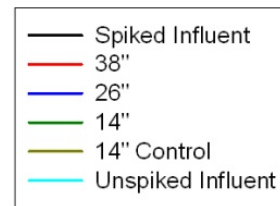
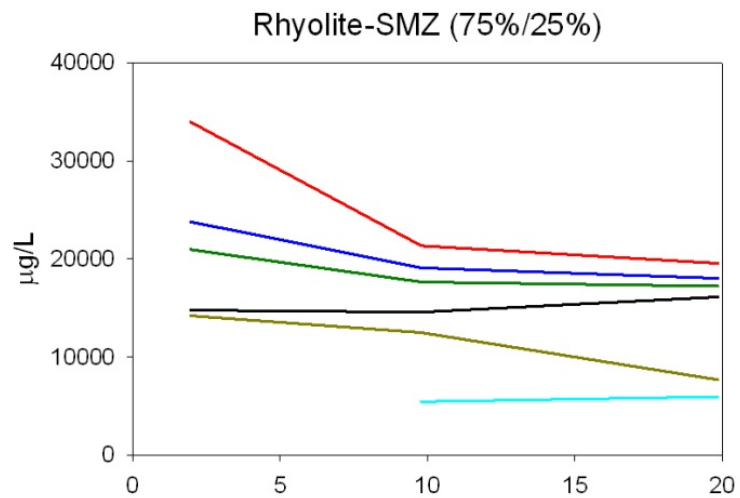


Figure B-88. Sodium (Total) Removal for Component Media



Sodium, Total Media Column Depth Tests

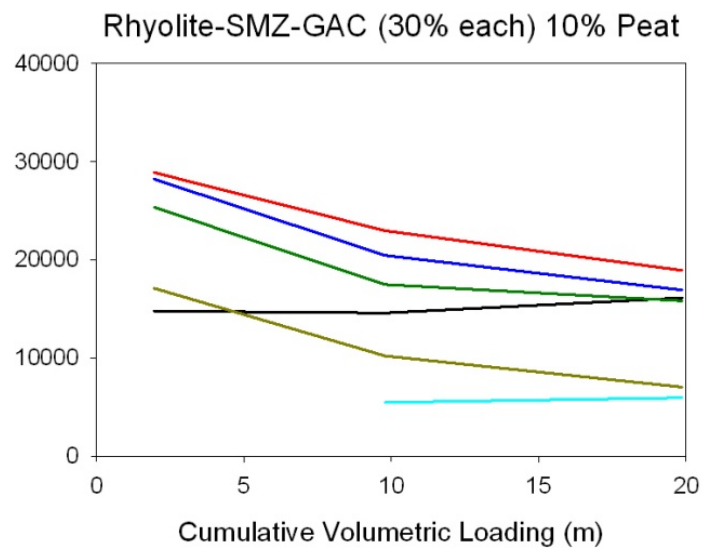
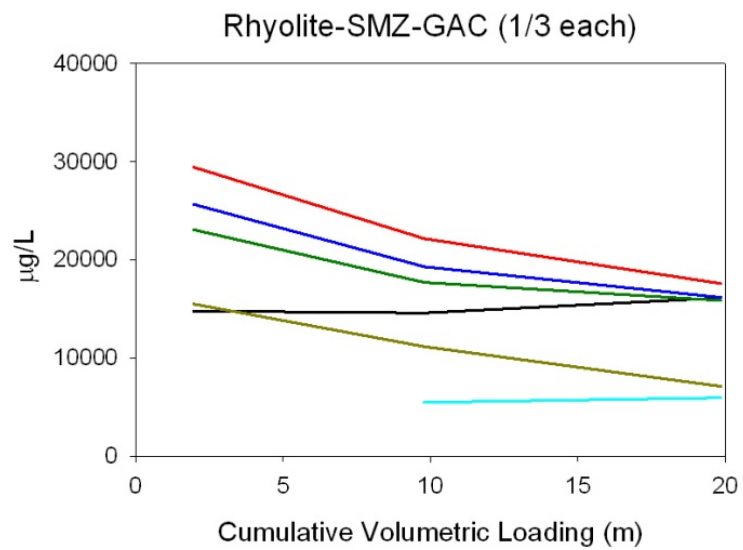
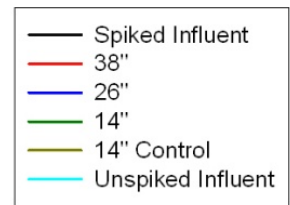


Figure B-89. Sodium (Total) Removal for Media Mixtures

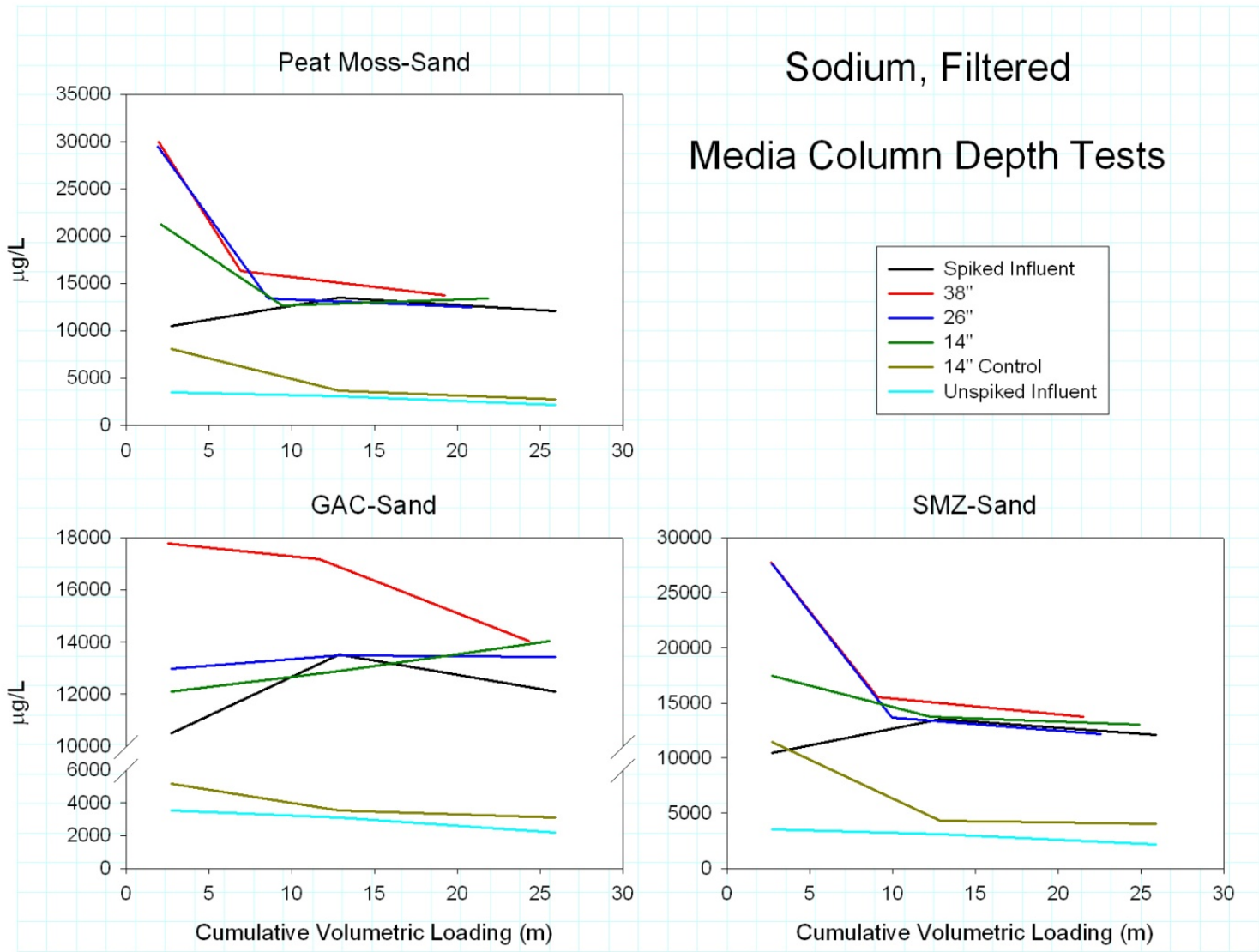
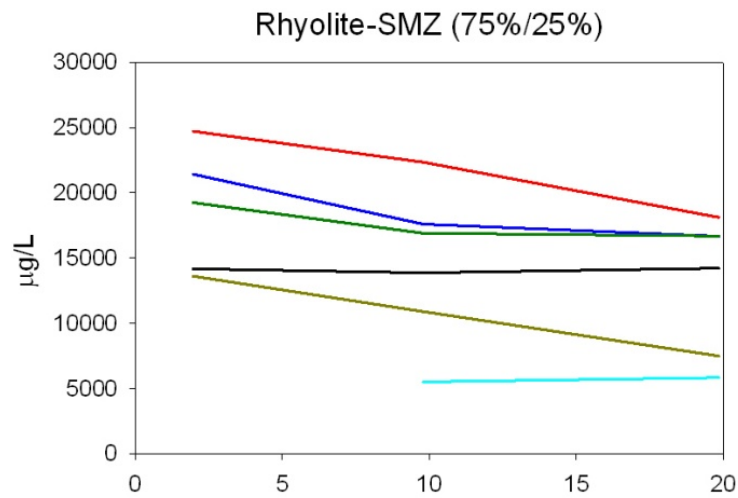


Figure B-90. Sodium (Filtered) Removal for Component Media



Sodium, Filtered Media Column Depth Tests

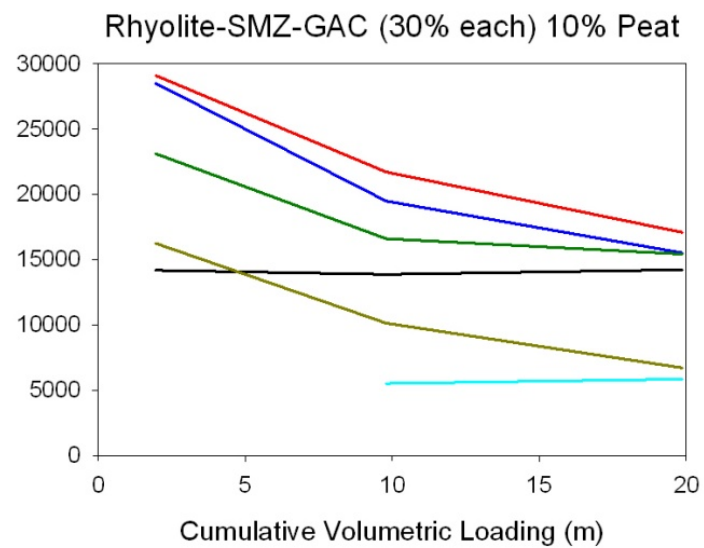
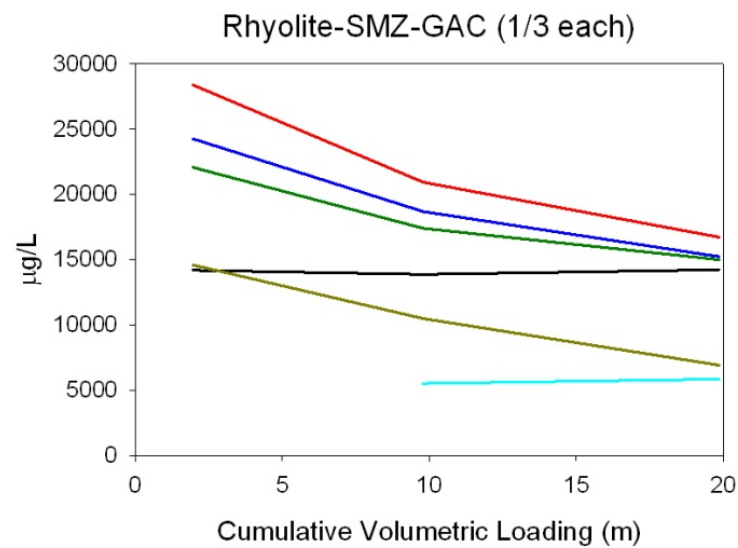
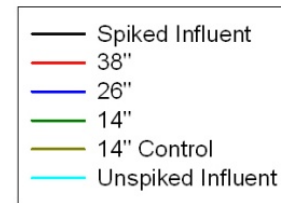
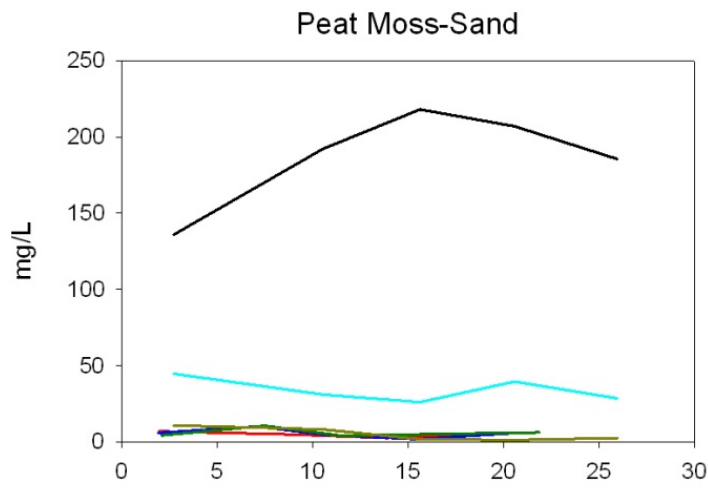


Figure B-91. Sodium (Filtered) Removal for Media Mixtures



Suspended Sediment Concentration Media Column Depth Tests

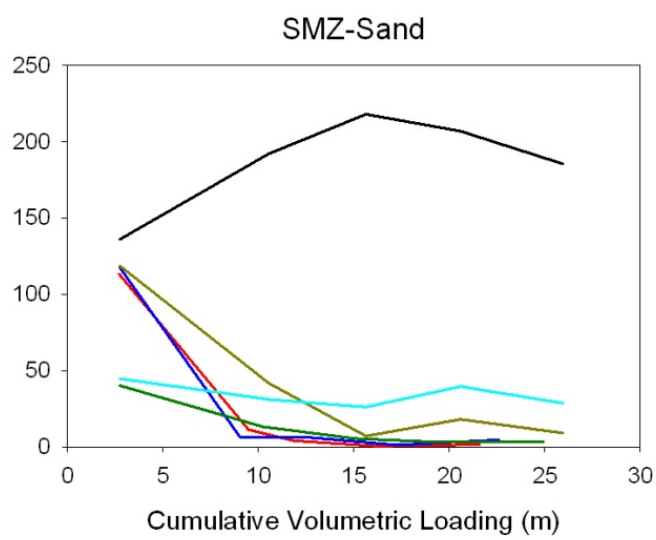
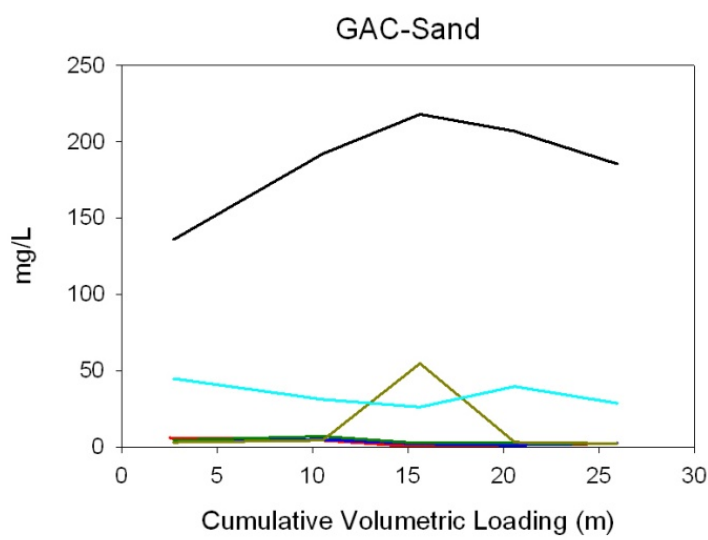
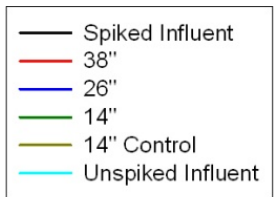


Figure B-92. Suspended Sediment Concentration (SSC) Removal for Component Media

Suspended Sediment Concentration Media Column Depth Tests

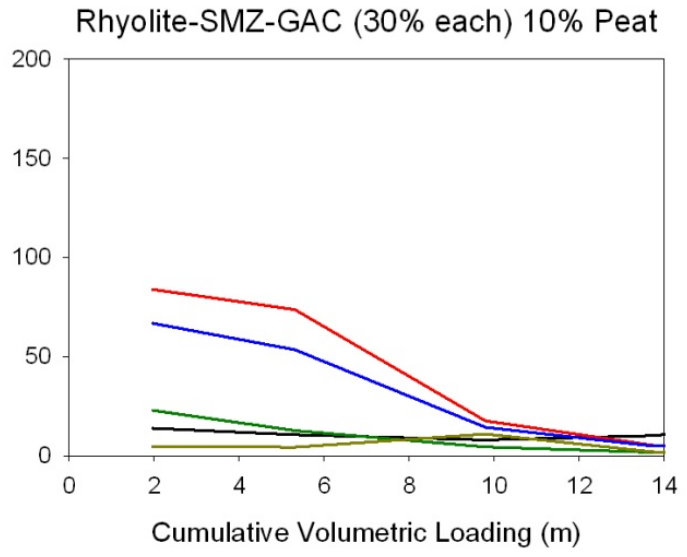
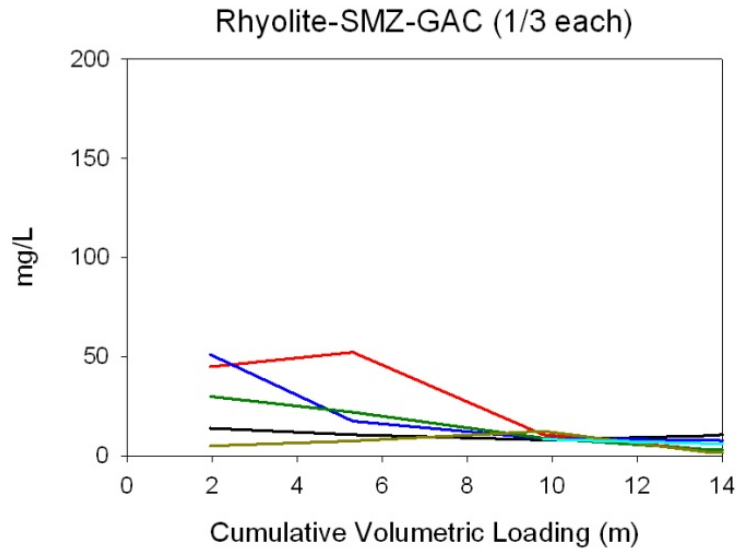
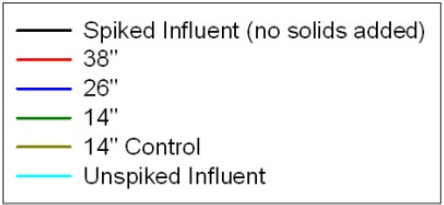
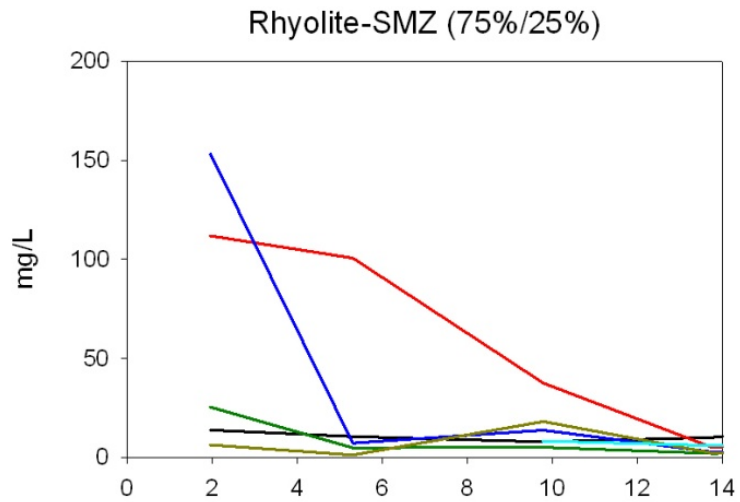
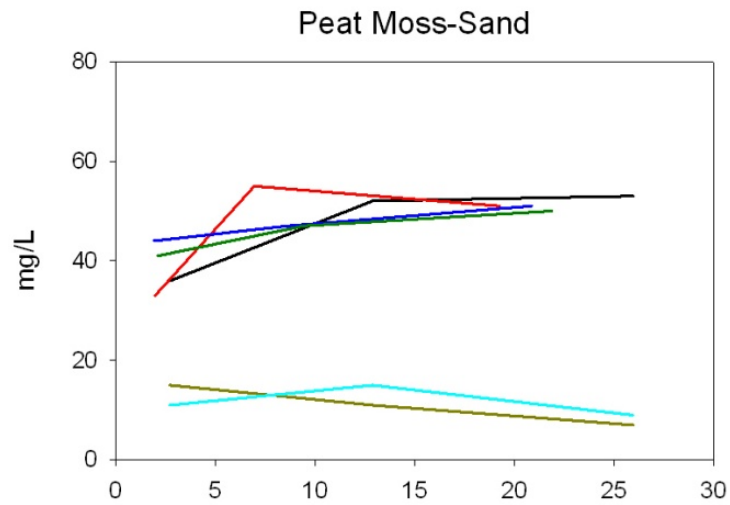


Figure B-93. Suspended Sediment Concentration (SSC) Removal for Media Mixtures



Sulfate Media Column Depth Tests

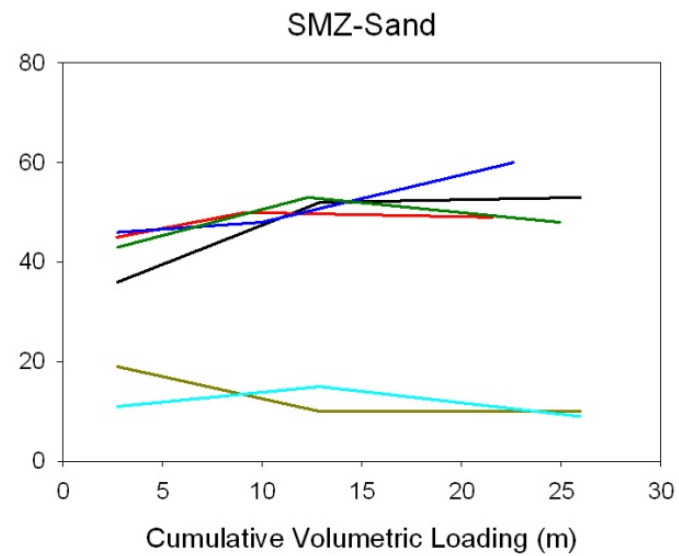
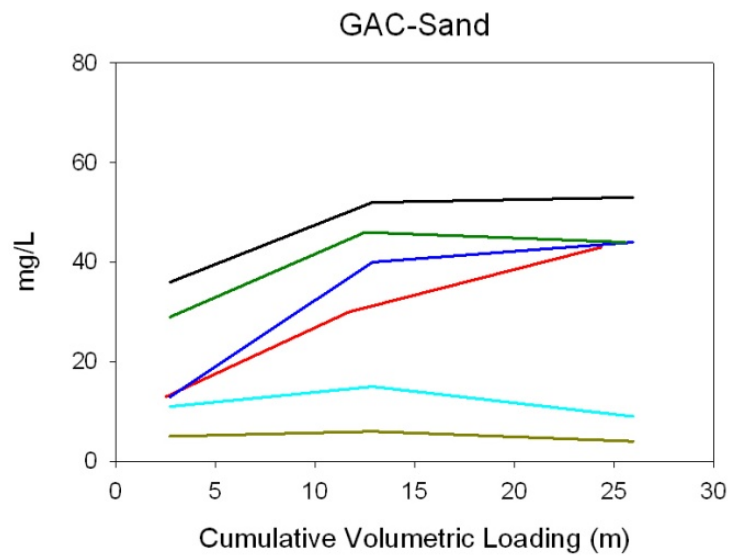
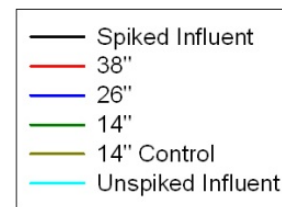
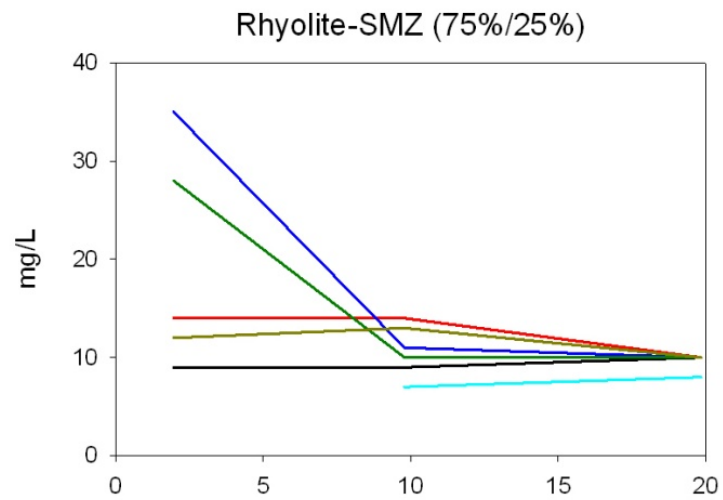


Figure B-94. Sulfate Removal for Component Media



Sulfate Media Column Depth Tests

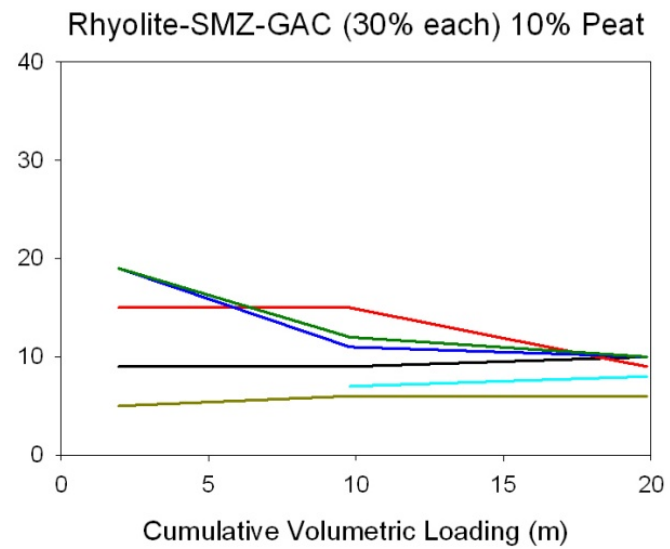
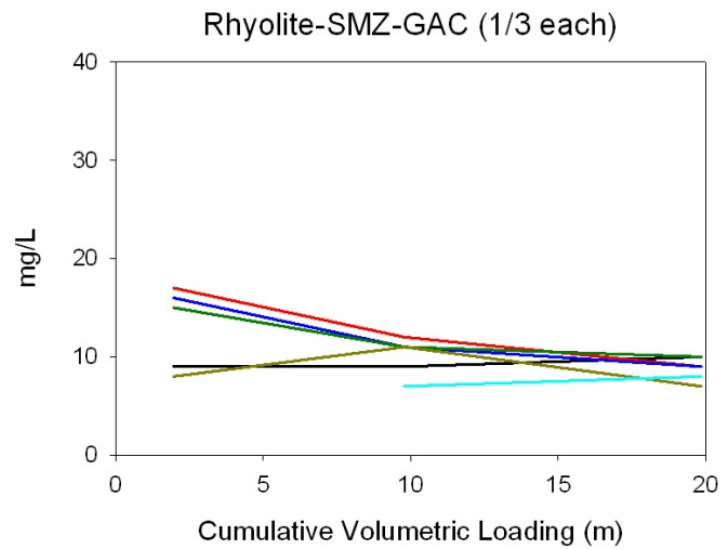
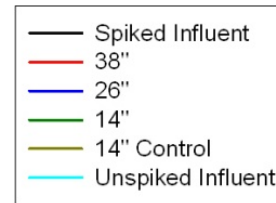


Figure B-95. Sulfate Removal for Media Mixtures

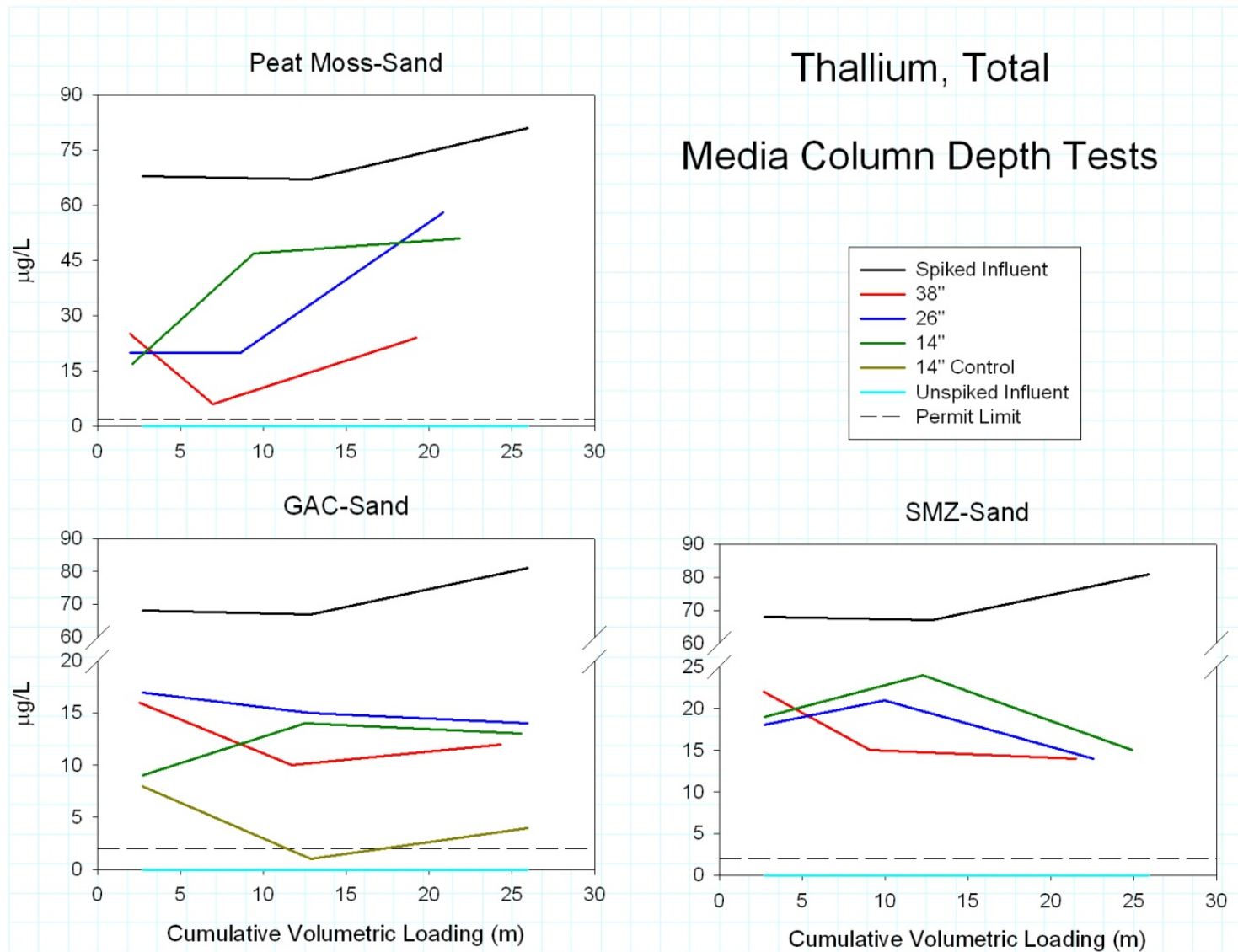


Figure B-96. Thallium (Total) Removal for Component Media

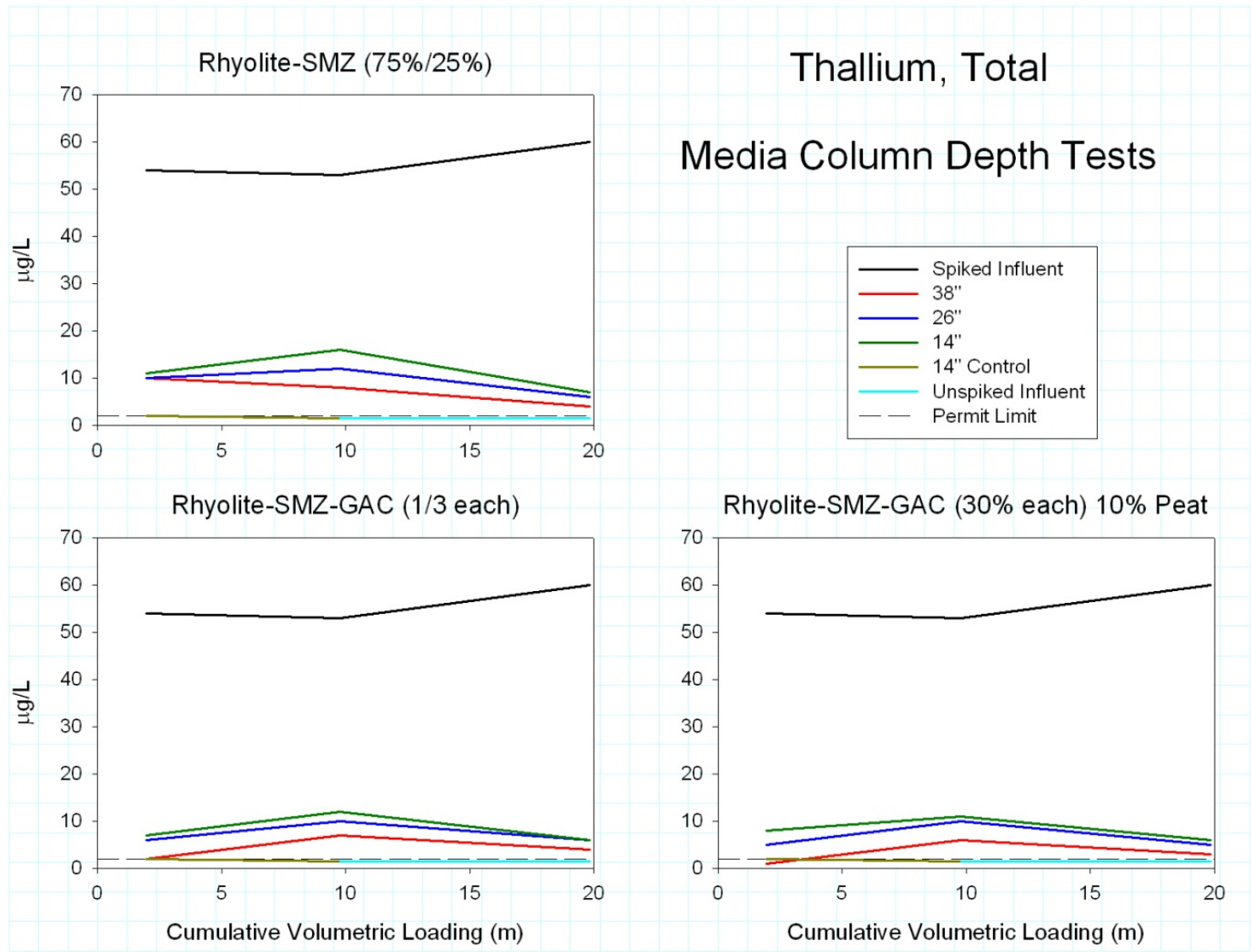


Figure B-97. Thallium (Total) Removal for Media Mixtures

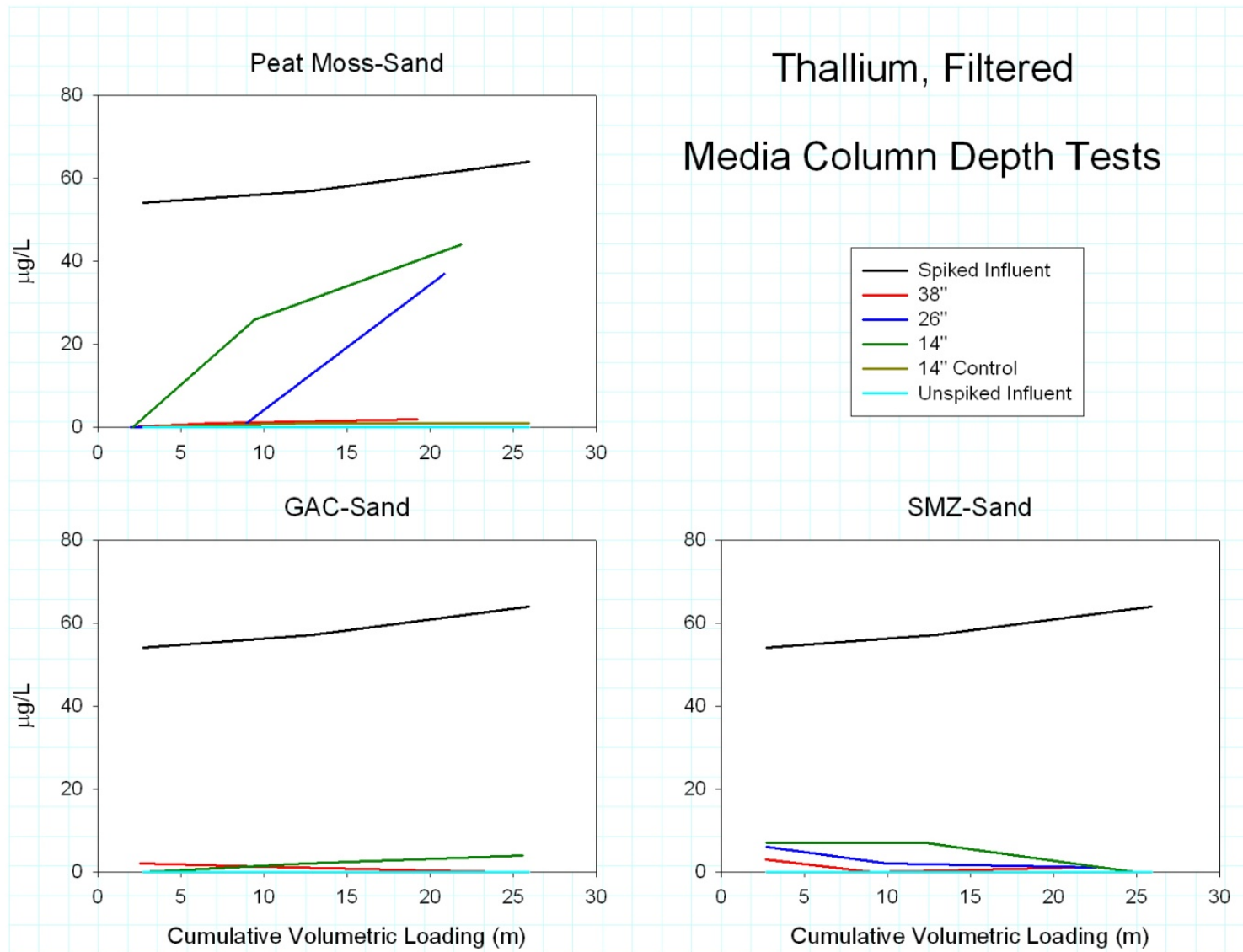


Figure B-98. Thallium (Filtered) Removal for Component Media

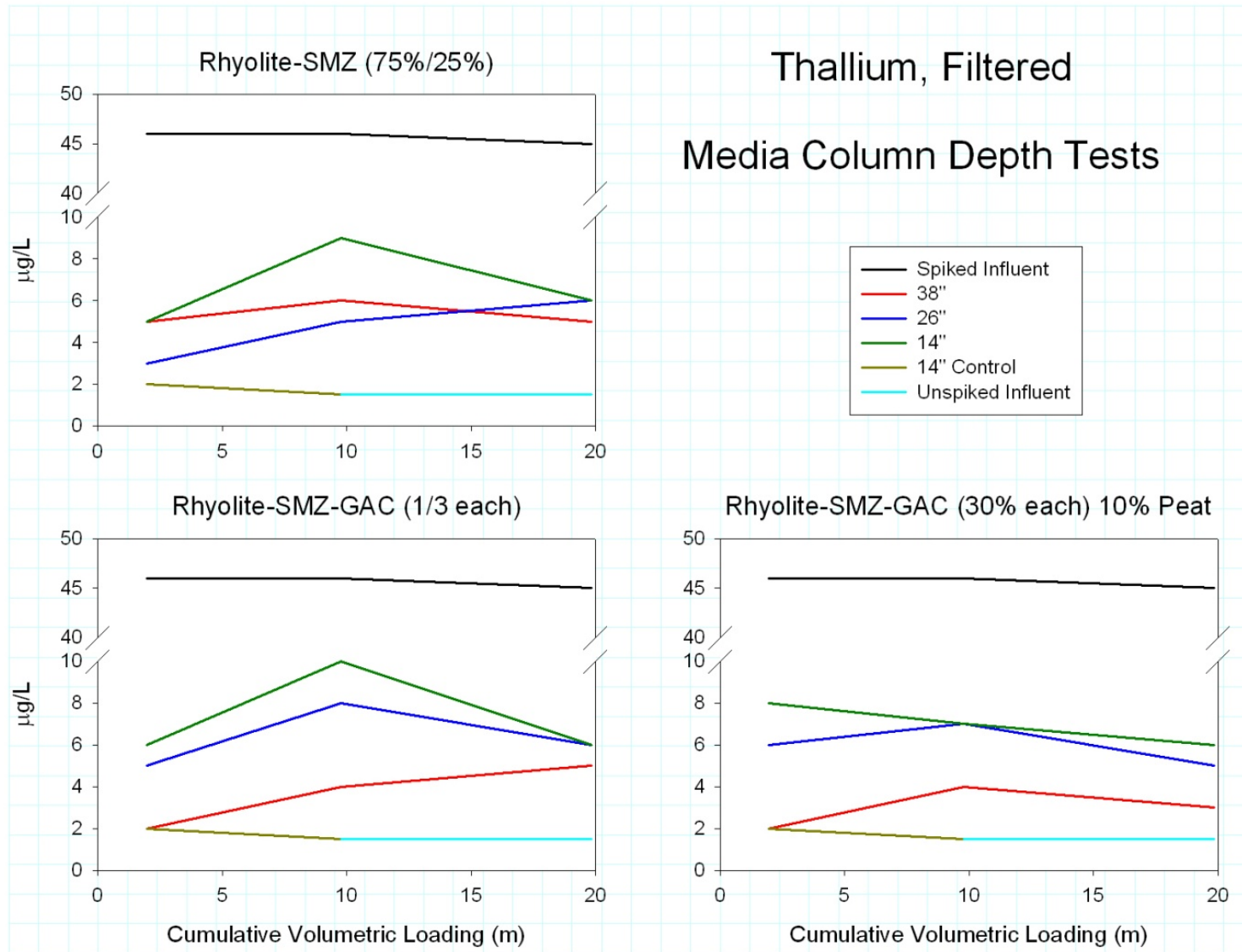
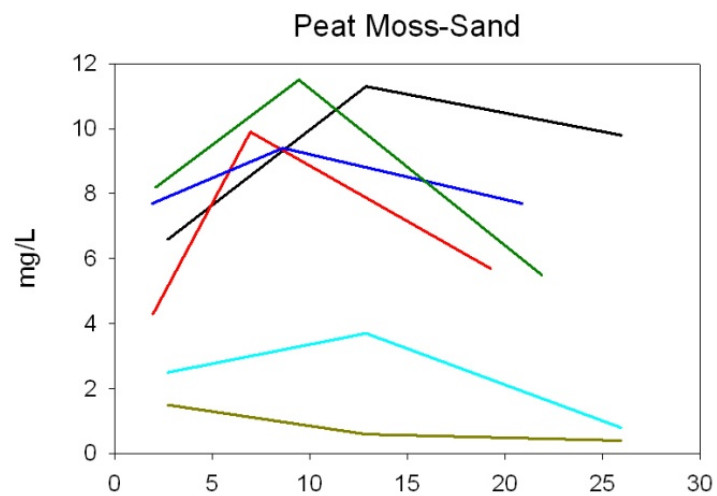


Figure B-99. Thallium (Filtered) Removal for Media Mixtures



Total Nitrogen Media Column Depth Tests

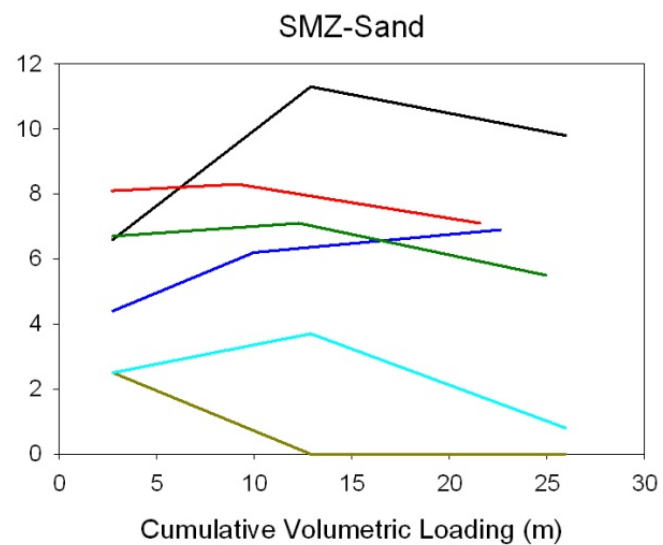
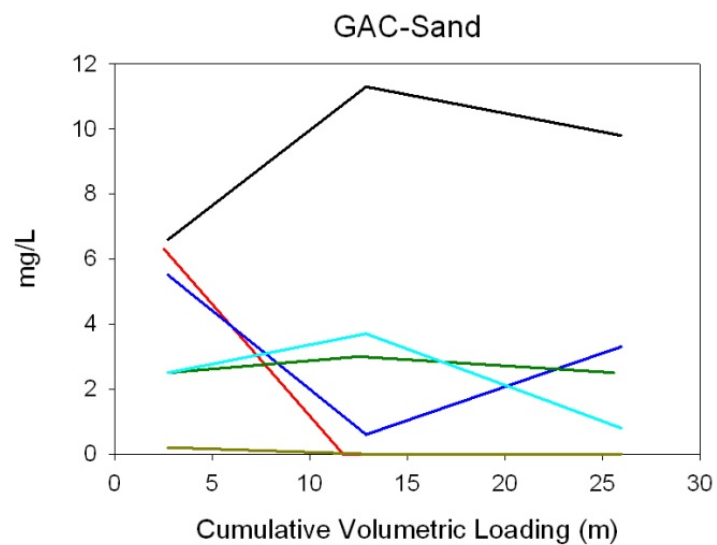
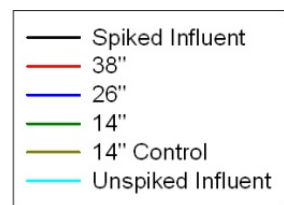


Figure B-100. Total Nitrogen Removal for Component Media

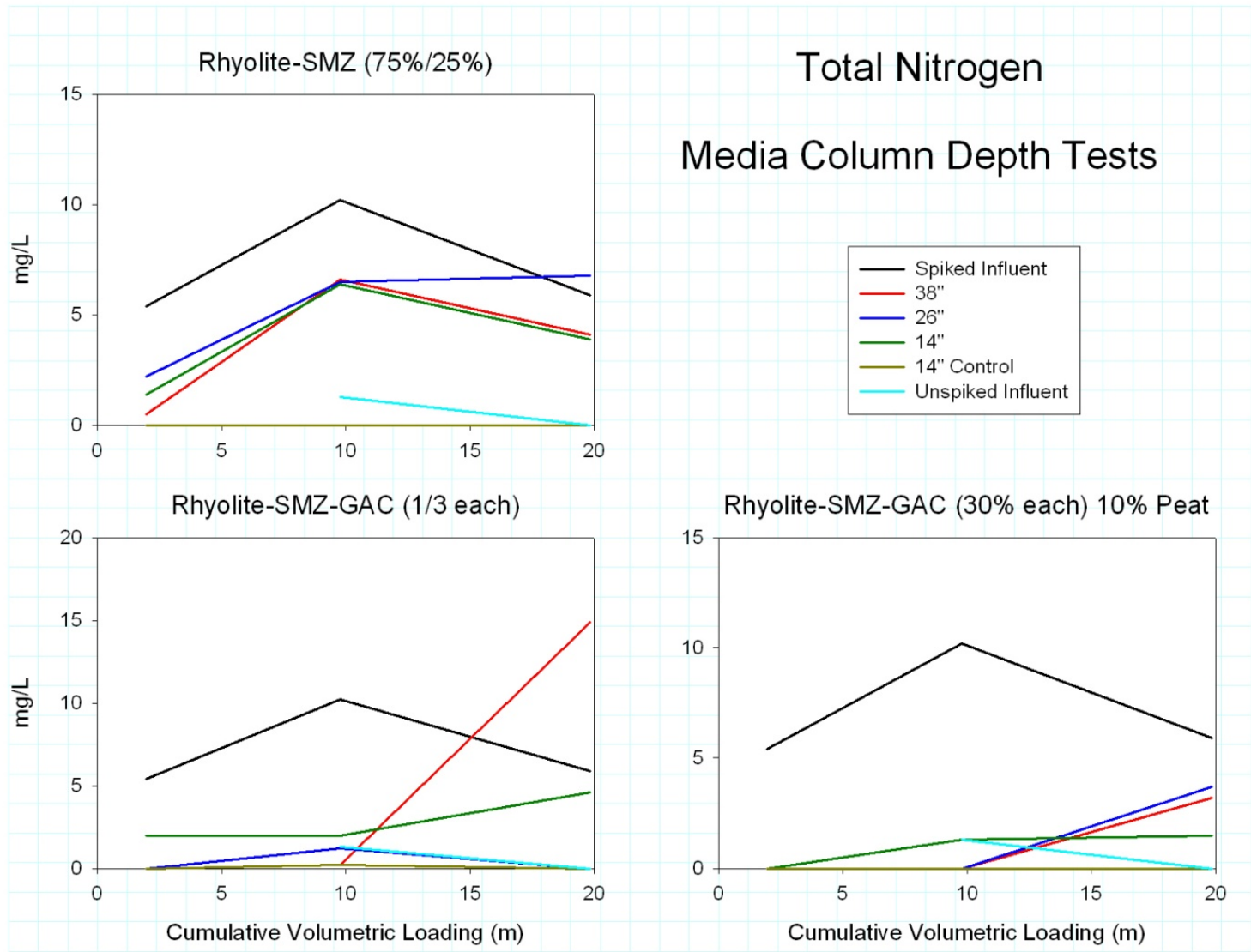
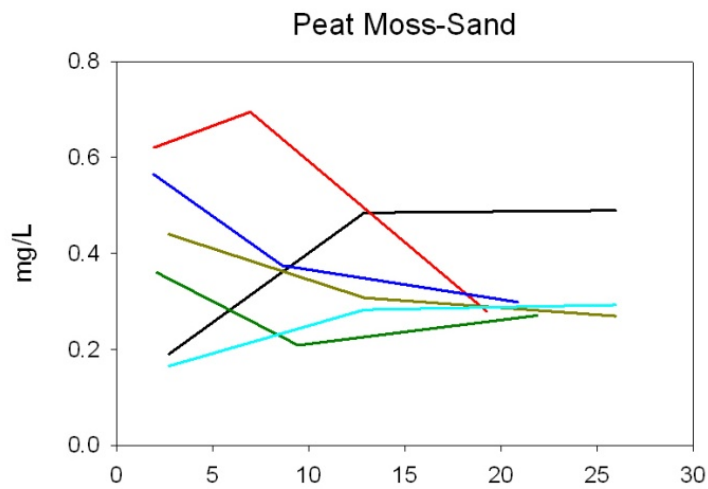


Figure B-101. Total Nitrogen Removal for Media Mixtures



UV-254 Absorbance Media Column Depth Tests

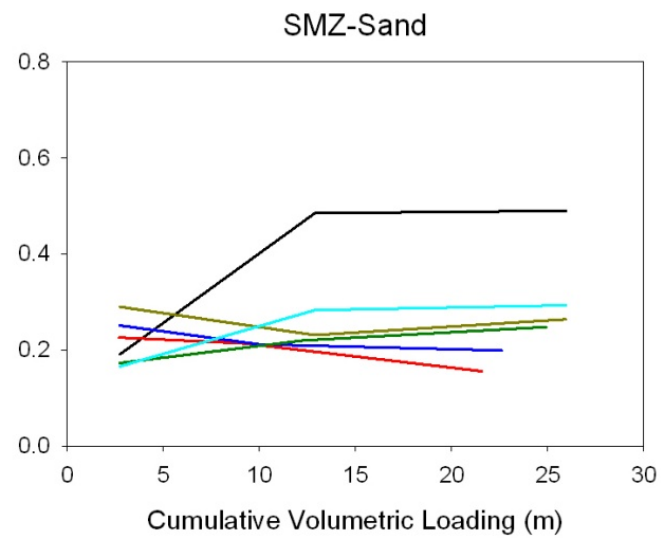
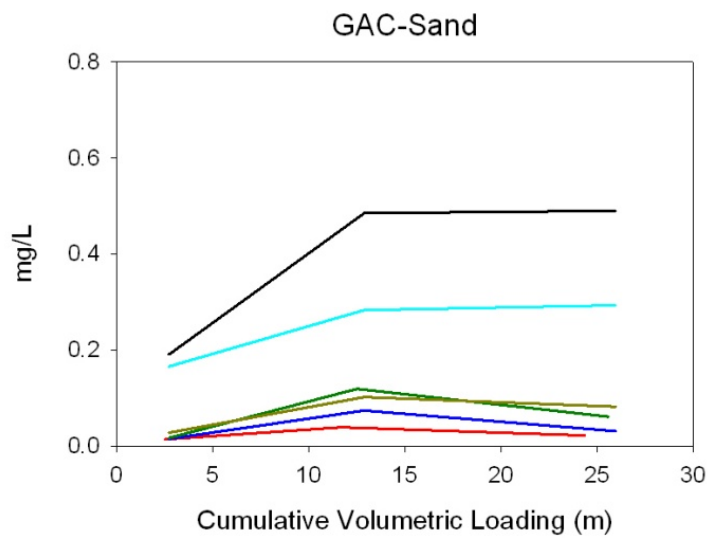
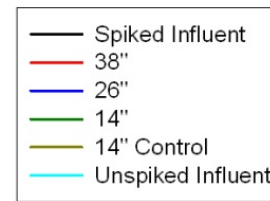
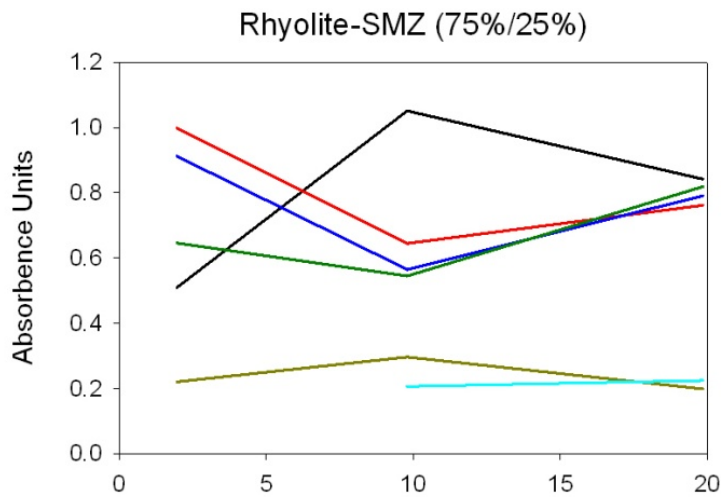


Figure B-102. UV-254 Absorbance Behavior for Component Media



UV-254 Absorbance Media Column Depth Tests

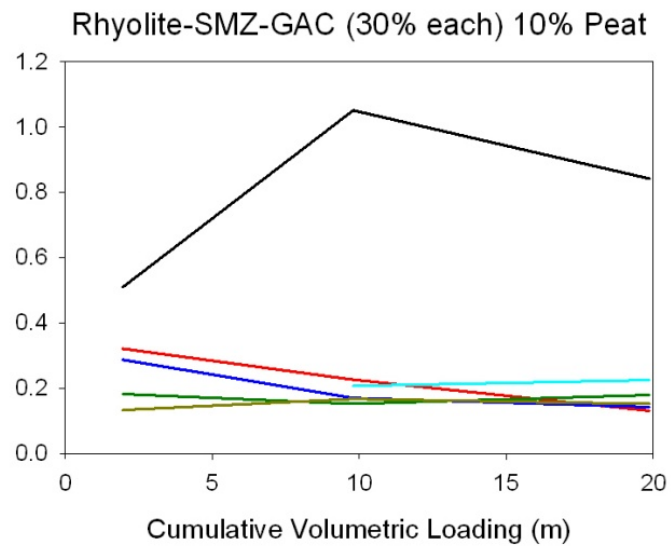
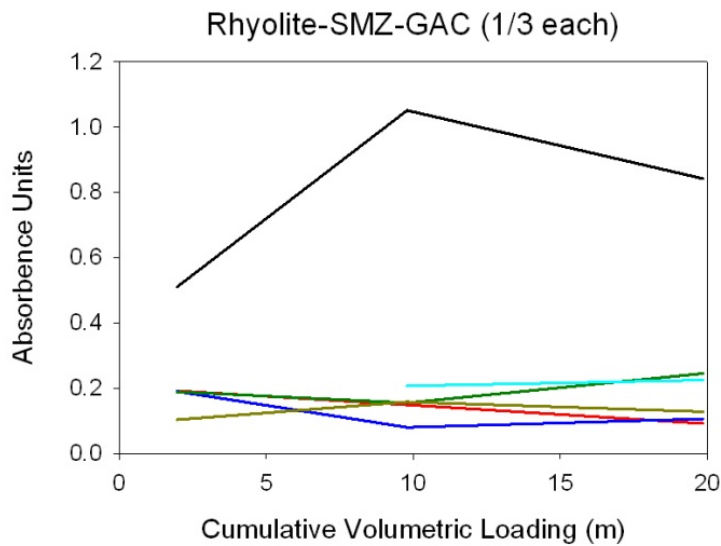
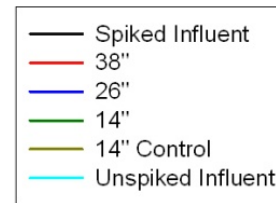
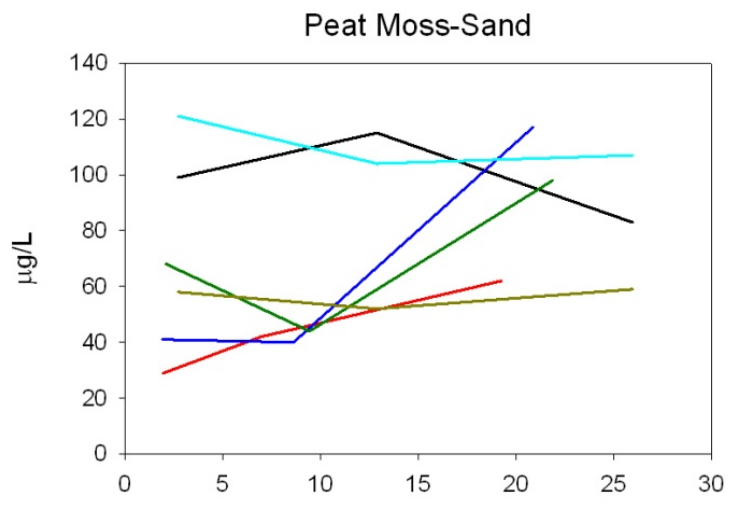


Figure B-103. UV-254 Absorbance Behavior for Media Mixtures



Zinc, Total Media Column Depth Tests

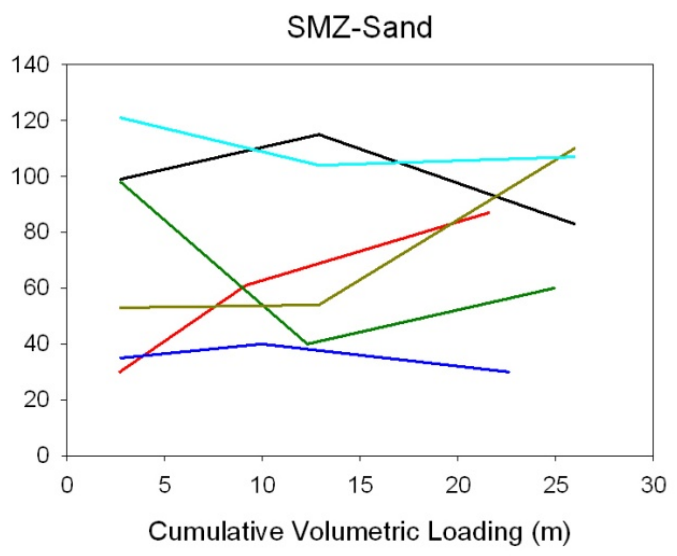
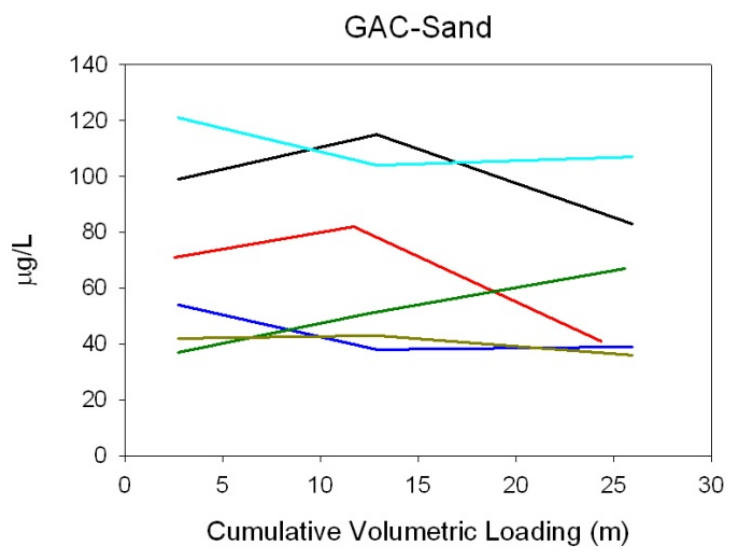
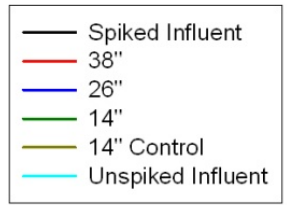
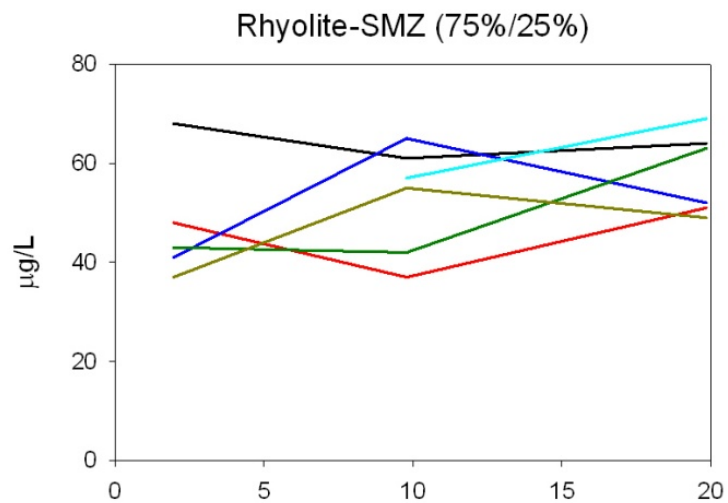


Figure B-104. Zinc (Total) Removal for Component Media



Zinc, Total Media Column Depth Tests

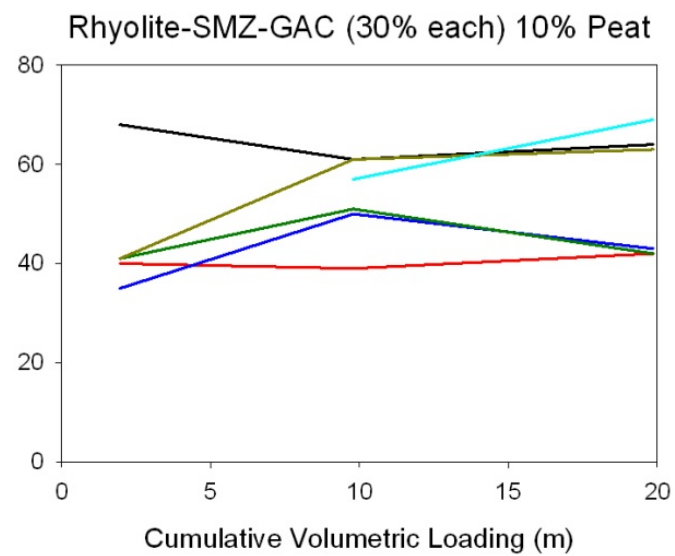
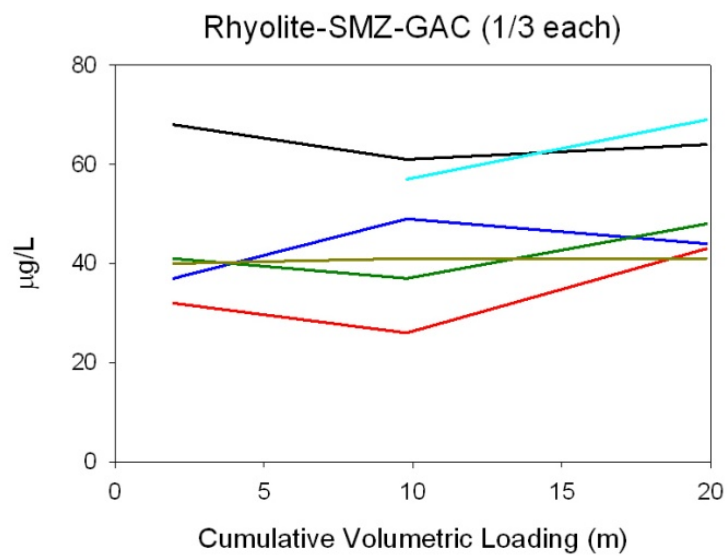
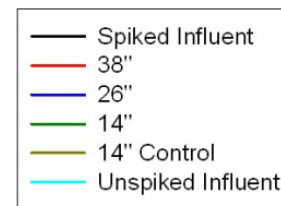
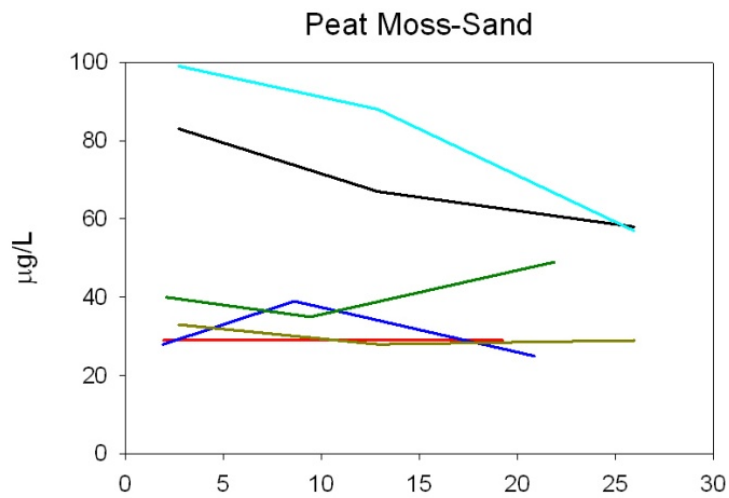


Figure B-105. Zinc (Total) Removal for Media Mixtures



Zinc, Filtered Media Column Depth Tests

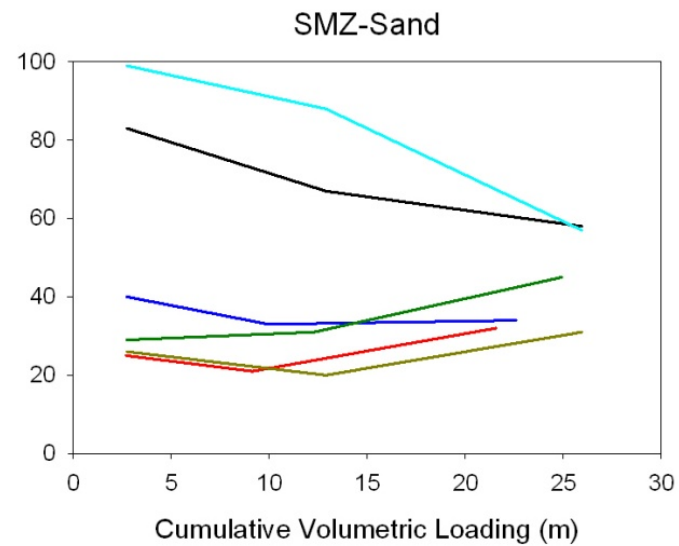
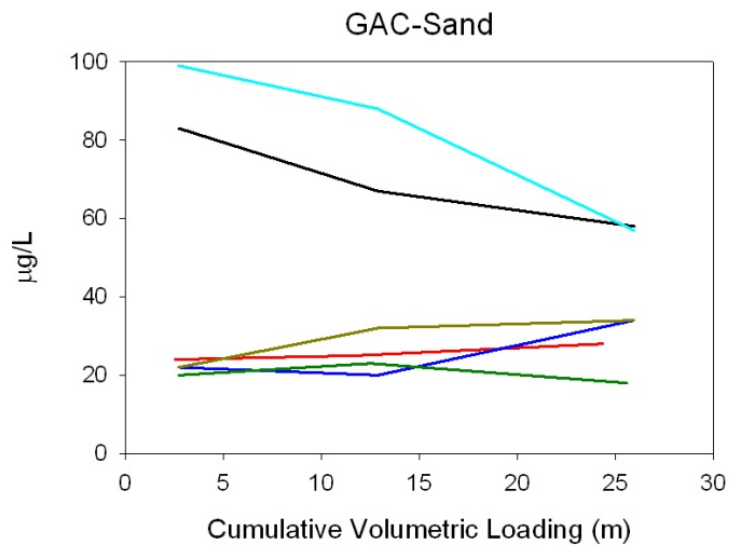
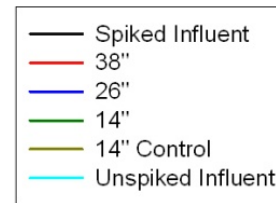
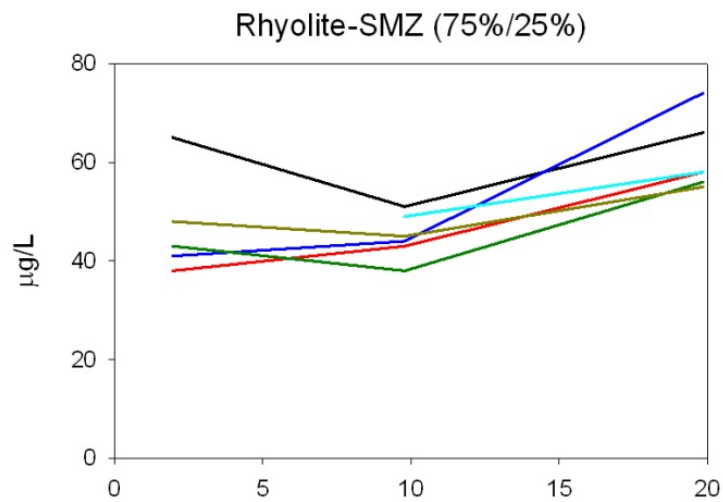


Figure B-106. Zinc (Filtered) Removal for Component Media



Zinc, Filtered Media Column Depth Tests

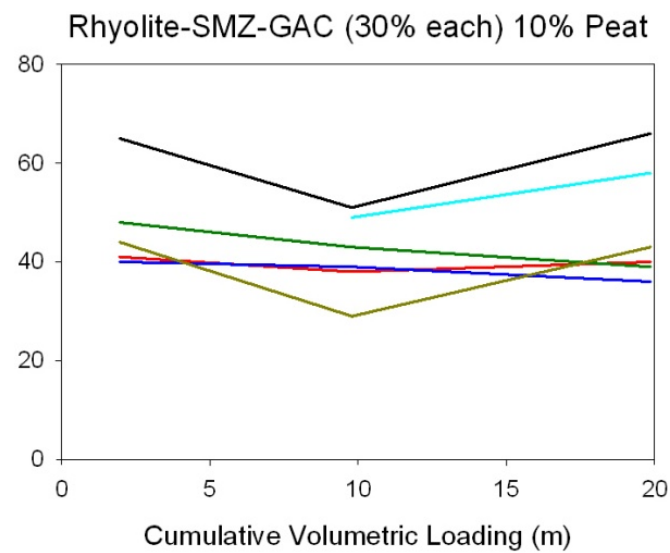
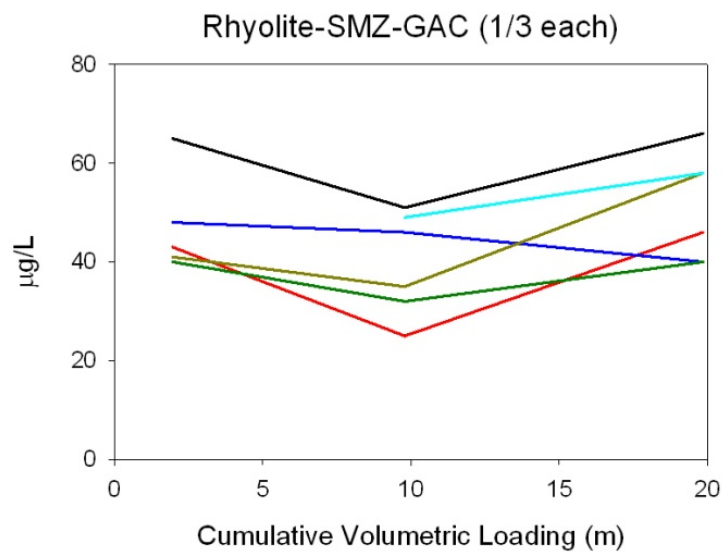
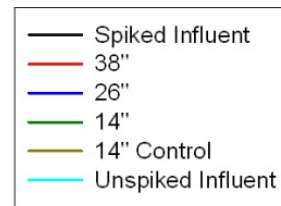


Figure B-107. Zinc (Filtered) Removal for Media Mixtures

