Studying Baseline Quality of Ambient and Personal Air within the New Jersey Meadowlands District

FINAL REPORT

1. AIR POLLUTION MEASUREMENT COMPONENTS

2. MODELING COMPONENTS

Prepared for the
New Jersey Meadowlands Commission

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Table of Contents

Table of Contents....i
List of Tables....i
List of Figures....iii
Executive Summary....x
Introduction....xiii
Purpose and Specific Aims....xiii
Air Pollution Measurement Study....xiii
Modeling of Baseline Conditions throughout the Meadowlands Area of NJ....xiv
1 AIR POLLUTION MEASUREMENT COMPONENTS....1
1.1 Long Term Sampling Overview....1
1.2 Results:....2
1.3 Discussion....97
1.4 Intensive Sampling - Implementation and Results....103
1.5 Comparison of Intensive and Long Term VOC Concentrations....135
1.6 Overall Summary and Conclusions for the Field Sampling....136
2 MODELING COMPONENTS....137
2.1 Introduction – Objectives and Background....137
2.2 Approach and Methods....139
2.3 Results and Discussion....149
2.4 Summary Conclusions for Modeling Study....188
3 General Recommendations for Future Study....191
References....192
Appendix A Quality Control and Quality Assurance Results....A-1
Appendix B Detailed Description of Modeling Approach and Methods....B-1
Appendix C Results of Geodatabases Development....C-1
Appendix D Results of 2002 NEI emission modeling and 1999 NEI landfill emission modeling....D-1
Appendix E Results of the 1st set of sensitivity runs....E-1
Appendix F Comparison of time-series profiles of the model predictions with field measurements for the ten selected air toxics....F-1

List of Tables

Table 1. Summary statistics by site for the $PM_{2.5}$ mass concentration (μg/m^3)....6
Table 2. Paired sample analysis of for the two sites for log $PM_{2.5}$ mass....6
Table 3. ANOVA of log $PM_{2.5}$ mass with season....7
Table 4. Summary statistics by site for the EC, OC and TC $PM_{2.5}$ concentration (μg/m^3)....7
Table 5. Paired sample analysis of for the two sites for log EC and OC $PM_{2.5}$ concentrations....8
Table 6a. ANOVA of log EC $PM_{2.5}$ concentration with season....9
Table 7a. Summary statistics for target trace metal air concentration (ng/m^3)....11
Table 8. Paired sample analysis of for the two sites for log metal $PM_{2.5}$ concentrations....13
Table 9. ANOVA of log metal $PM_{2.5}$ concentration with season....14
Table 10. Summary statistics by site for the VOC concentration for compounds detected (μg/m^3)....16
Table 11. Comparison of paired samples across sites (111 TRICHLOROETHANE)....19
Table 12. Comparison of paired samples across sites (CARBON TETRACHLORIDE)....19
Table 13. Comparison of paired samples across sites (BENZENE)....20
Table 14. Comparison of paired samples across sites (TRICHLOROETHYLENE)....20
Table 15. Comparison of paired samples across sites (TOLUENE)....21
Table 16. Comparison of paired samples across sites (TETRAHCLOROETHYLENE)....21
Table 17. Comparison of paired samples across sites (ETHYL BENZENE)....22
Table 18. Comparison of paired samples across sites (m/p XYLENE)....22
Table 19. Comparison of paired samples across sites (o XYLENE)....23
Table 20. Comparison of paired samples across sites (STYRENE)....23
Table 21. Comparison of paired samples across sites (PROPYLBENZENE)....24
Table 22. Comparison of paired samples across sites (1,3,5 TRIMETHLYBENZENE)....24
Table 23. Comparison of paired samples across sites (1,2,4 TRIMETHLYBENZENE)....25
Table 24. Comparison of paired samples across sites (p-ISOPROPLYBENZENE)....25

Table 25. Comparison of paired samples across sites (1,4 DICHLOROBENZENE) 26
Table 26. Comparison of paired samples across sites (BUTLYBENZENE) 26
Table 27. Comparison of paired samples across sites (NAPHTHALENE) 27
Table 28. Paired t-test – post hoc analysis (BENZENE) 27
Table 29. One way ANOVA of VOCs with season, all sites combined 28
Table 30. Paired t-test – post hoc analysis (*m/p* XYLENE) 33
Table 31. Paired t-test – post hoc analysis (*o* XYLENE) 34
Table 32. Paired t-test – post hoc analysis (1,2,4 TRIMETHLYBENZENE) 35
Table 33. Summary statistics of all air concentrations (μg/m^3) combined from all personal samples for VOCs measured in the Meadowlands and comparison values 107
Table 34. Comparison of the VOC air concentrations for personal samples across the three different sampling periods by one-way ANOVA and the log transformed air concentrations 108
Table 35. Comparison of the VOC air concentrations for personal samples across the four different sampling trails by one-way ANOVA and the log transformed air concentrations 109
Table 36. Air quality monitoring and emissions estimation combined with air dispersion modeling (these are complementary approaches) (adapted from Vanderbilt & Lowe, 2003) 139
Table 37. Final set of air toxics considered in this study 143
Table 38. Background concentrations (ug/m3) of the ten selected air toxics at the four receptor locations obtained from the 1999 NATA study (USEPA, 2006a). 145
Table 39. The 1st set of sensitivity simulations with 8 different combinations of dispersion models, emissions inputs, and meteorology inputs. 145
Table 40. The 2nd set of sensitivity simulations for testing the sensitivity of using the mobile on-road emissions processed by different spatial allocation factors (Emission inputs: NEI-2002, Meteorology inputs: Newark Airport) 145
Table 41. Comparison of the model performance metrics (mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error (MFE)) of the 6 modeling scenarios in the 2nd set of sensitivity runs for the BTEX chemicals using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at all of the 4 receptor locations. 154
Table 42. Comparison of the model performance metrics (mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error (MFE)) of the 6 modeling scenarios in the 2nd set of sensitivity runs for Benzene using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the 4 receptor locations. 155
Table 43. Comparison of the model performance metrics (mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error (MFE)) of the 6 modeling scenarios in the 2nd set of sensitivity runs for Toluene using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the 4 receptor locations. 156
Table 44. Comparison of the model performance metrics (mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error (MFE)) of the 6 modeling scenarios in the 2nd set of sensitivity runs for Ethylbenzene using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the 4 receptor locations. 157
Table 45. Comparison of the model performance metrics (mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error (MFE)) of the 6 modeling scenarios in the 2nd set of sensitivity runs for Xylenes using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the 4 receptor locations. 158
Table 46. Comparison of the model performance metrics (mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error (MFE)) of the two dispersion model predictions (ISCST3 vs. AERMOD) for the 3 chlorinated chemicals (Tetrachloroethene (PERC), Trichloroethene (TCE), and p-Dichlorobenzene (PDB)) and 3 metals (As, Pb, and Hg) using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at all of the receptor locations. 159
Table 47. Comparison of the model performance metrics (mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error

(MFE)) of the two dispersion model predictions (ISCST3 vs. AERMOD) for the 3 chlorinated chemicals (Tetrachloroethene (PERC), Trichloroethene (TCE), and p-Dichlorobenzene (PDB)) using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the receptor locations....160
Table 48. Comparison of the model performance metrics (mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error (MFE)) of the two dispersion model predictions (ISCST3 vs. AERMOD) for 3 metals (As, Pb, and Hg) using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the receptor locations. 161
Table 49. Comparison of the model performance metrics (mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error (MFE)) of the ISCST3 model predictions with the two different meteorology inputs (Newark Airport vs. MERI) for BTEX using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at all of the receptor locations....162
Table 50. Percentage contributions from ambient sources categorized by five emission groups (i.e. point, non-point (area), mobile non-road, mobile on-road, and background) to the predicted 48-hr averages of the ISCST3 predictions for the BTEX chemicals at each of the 4 receptor locations. 162

List of Figures

Figure 1. Map showing land use that were considered in sampling site considerations....36
Figure 2. (a) Distribution of $PM_{2.5}$ mass concentration (μg/m^3); (b) Distribution of log $PM_{2.5}$ mass concentration (μg/m^3)....37
Figure 3. $PM_{2.5}$ mass concentration by site with date (μg/m^3). Site 1 NJMC Headquarters; Site 2 Sports Complex 38
Figure 4. Box and whisker plot of PM2.5 mass by site and season. Site 1 NJMC Headquarters; Site 2 Sports Complex....38
Figure 5. (a) Distribution of elemental carbon $PM_{2.5}$ concentration; (b) Distribution of elemental carbon $PM_{2.5}$ log concentration 39
Figure 6. (a) Distribution of organic carbon $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of organic carbon $PM_{2.5}$ log concentration (μg/m^3) 40
Figure 7. (a). Temporal elemental carbon concentration (μg/m^3) by site and; (b) Temporal organic carbon concentration (μg/m^3) by Site. Site 1 NJMS Headquarters; Site 2 Sports Complex....41
Figure 8. (a) Box and whisker plot of organic carbon concentration (μg/m^3) by site and season; (b) Box and whisker plot of elemental carbon concentration (μg/m^3) by site and season. Site 1 NJMC Headquarters; Site 2 Sports Complex....42
Figure 9. (a) Distribution of arsenic $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of arsenic $PM_{2.5}$ log concentration (μg/m^3) 43
Figure 10. (a) Distribution of cadmium $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of cadmium $PM_{2.5}$ log concentration (μg/m^3) 44
Figure 11. (a) Distribution of cobalt $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of cobalt PM2.5 log concentration (μg/m^3) 45
Figure 12. (a) Distribution of copper $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of copper $PM_{2.5}$ log concentration (μg/m^3) 46
Figure 13. (a) Distribution of lead $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of lead $PM_{2.5}$ log concentration (μg/m^3)....47
Figure 14. (a) Distribution of magnesium $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of magnesium $PM_{2.5}$ log concentration (μg/m^3) 48
Figure 15. (a) Distribution of manganese $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of manganese $PM_{2.5}$ log concentration (μg/m^3) 49
Figure 16. (a) Distribution of nickel $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of nickel $PM_{2.5}$ log concentration (μg/m^3) 50
Figure 17. (a) Distribution of selenium $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of selenium $PM_{2.5}$ log concentration (μg/m^3) 51
Figure 18. (a) Distribution of vanadium $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of vanadium $PM_{2.5}$ log concentration (μg/m^3) 52
Figure 19. Temporal change in arsenic concentration (μg/m^3) by site 53

Figure 20. Temporal change in cadmium concentration (μg/m^3) by site....53
Figure 21. Temporal change in cobalt concentration (μg/m^3) by site....54
Figure 22. Temporal change in copper concentration (μg/m^3) by site....54
Figure 23. Temporal change in lead concentration (μg/m^3) by site....55
Figure 24. Temporal change in magnesium concentration (μg/m^3) by site....55
Figure 25. Temporal change in manganese concentration (μg/m^3) by site....56
Figure 26. Temporal change in nickel concentration (μg/m^3) by site....56
Figure 27. Temporal change in selenium concentration (μg/m^3) by site....57
Figure 28. Temporal change in vanadium concentration (μg/m^3) by site....57
Figure 29. Box and whisker plot of arsenic concentration (μg/m^3) by site and season....58
Figure 30. box and whisker plot of cadmium concentration (μg/m^3) by site and season....58
Figure 31. Box and whisker plot of cobalt concentration (μg/m^3) by site and season....59
Figure 32. Box and whisker plot of copper concentration (μg/m^3) by site and season....59
Figure 33. Box and whisker plot of lead concentration (μg/m^3) by site and season....60
Figure 34. Box and whisker plot of magnesium concentration (μg/m^3) by site and season....60
Figure 35. Box and whisker plot of manganese concentration (μg/m^3) by site and season....61
Figure 36. Box and whisker plot of nickel concentration (μg/m^3) by site and season....61
Figure 37. Box and whisker plot of selenium concentration (μg/m^3)) by site and season....62
Figure 38. Box and whisker plot of vanadium concentration (μg/m^3) by site and season....62
Figure 39. (a) Distribution of 111 trichloroethane concentration (μg/m^3) with normal curve; and (b) Distribution of 111 trichloroethane log concentration (μg/m^3) with normal curve....63
Figure 40. (a) Distribution of carbon tetrachloride concentration (μg/m^3) with normal curve; and (b) Distribution of carbon tetrachloride log concentration (μg/m^3) with normal curve....64
Figure 41. (a) Distribution of benzene concentration (μg/m^3) with normal curve; and (b) Distribution of benzene log concentration (μg/m^3) with normal curve....65
Figure 42. (a) Distribution of trichloroethene concentration (μg/m^3) with normal curve; and (b) Distribution of trichloroethene log concentration (μg/m^3) with normal curve....66
Figure 43. (a) Distribution of toluene concentration (μg/m^3) with normal curve; and (b) Distribution of toluene log concentration (μg/m^3) with normal curve....67
Figure 44. (a) Distribution of tetrachloroethene concentration (μg/m^3) with normal curve; and (b) distribution of tetrchloroethene log concentration (μg/m^3) with normal curve....68
Figure 45. (a) Distribution of ethyl benzene concentration (μg/m^3) with normal curve; and (b) Distribution of ethyl benzene log concentration (μg/m^3) with normal curve....69
Figure 46. (a) Distribution of *m/p* xylene concentration (μg/m^3) with normal curve; and (b) Distribution of *m/p* xylene log concentration (μg/m^3) with normal curve....70
Figure 47. (a) Distribution of *o* xylene concentration (μg/m^3) with normal curve; and (b) Distribution of *o* xylene log concentration (μg/m^3) with normal curve....71
Figure 48. (a) Distribution of styrene concentration (μg/m^3) with normal curve; and (b) Distribution of styrene log concentration (μg/m^3) with normal curve....72
Figure 49. (a) Distribution of propyl benzene concentration (μg/m^3) with normal curve; and (b) Distribution of propyl benzene log concentration (μg/m^3) with normal curve....73
Figure 50. (a) Distribution of 1,3,5 trimethylbenzene concentration (μg/m^3) with normal curve; and (b) Distribution of 1,3,5 trimethylbenzene log concentration (μg/m^3) with normal curve....74
Figure 51. (a) Distribution of 1,2,4 trimethylbenzene concentration (μg/m^3) with normal curve; and (b) Distribution of 1,2,4 trimethylbenzene log concentration (μg/m^3) with normal curve....75
Figure 52. (a) Distribution of *p* Isopropylbenzene Concentration (μg/m^3) with Normal Curve; and (b) Distribution of *p* isopropylbenzene log concentration (μg/m^3) with normal curve....76
Figure 53. (a) Distribution of *p* dichlorobenzene concentration (μg/m^3) with normal curve; and (b) Distribution of *p* dichlorobenzene log concentration (μg/m^3) with normal curve....77
Figure 54. (a) Distribution of butylbenzene concentration (μg/m^3) with normal curve; and (b) Distribution of butylbenzene log concentration (μg/m^3) with normal curve....78
Figure 55. (a) Distribution of naphthalene concentration (μg/m^3) with normal curve; and (b) Distribution of naphthalene log concentration (μg/m^3) with normal curve....79
Figure 56. Temporal change in 1,1,1 trichloroethane concentration (μg/m^3) by site....80
Figure 57. Temporal change in carbon tetrachloride concentration (μg/m^3) by site....80
Figure 58. Temporal change in benzene concentration (μg/m^3) by site....81
Figure 59. Temporal change in trichloroethene concentration (μg/m^3) by site....81

Figure 60. Temporal change in toluene concentration (μg/m^3) by site 82
Figure 61. Temporal change in tetrachloroethene concentration (μg/m^3) by site 82
Figure 62. Temporal change in ethyl benzene concentration (μg/m^3) by site 83
Figure 63. Temporal change in *m/p* xylene concentration (μg/m^3) by site 83
Figure 64. Temporal change in *o* xylene concentration (μg/m^3) by site 84
Figure 65. Temporal change in propylbenzene concentration (μg/m^3) by site 84
Figure 66. Temporal change in n-butylbenzene concentration (μg/m^3) by site 85
Figure 67. Temporal change in 1,3,5 trimethylbenzene concentration (μg/m^3) by site 85
Figure 68. Temporal change in 1,2,4 trimethylbenzene concentration (μg/m^3) by site 86
Figure 69. Temporal change in 1,4 dichlorobenzene concentration (μg/m^3) by site 86
Figure 70. Temporal change in naphthalene concentration (μg/m^3) by site 87
Figure 71. Box and whisker plot of 1,1,1-trichloroethane concentration (μg/m^3) by site and season 87
Figure 72. Box and whisker plot of carbon tetrachloride concentration (μg/m^3) by site and season 88
Figure 73. Box and whisker plot of benzene concentration (μg/m^3) by site and season 88
Figure 74. Box and whisker plot of trichloroethene concentration (μg/m^3) by site and season 89
Figure 75. Box and whisker plot of toluene concentration (μg/m^3) by site and season 89
Figure 76. Box and whisker plot of tetrachloroethene concentration (μg/m^3) by site and season 90
Figure 77. Box and whisker plot of ethylbenzene concentration (μg/m^3) by site and season 90
Figure 78. Box and whisker plot of *m,p* xylene concentration (μg/m^3) by site and season 91
Figure 79. Box and whisker plot of *o* xylene concentration (μg/m^3) by site and season 92
Figure 80. Temporal box and whisker plot of styrene concentration (μg/m^3) by site and season 93
Figure 81. Box and whisker plot of propylbenzene concentration (μg/m^3) by site and season 93
Figure 82. Box and whisker plot of 1,3,5 trimethylbenzene concentration (μg/m^3) by site and season 94
Figure 83. Box and whisker plot of 1,2,4 trimethylbenzene concentration (μg/m^3) by site and season 94
Figure 84. Box and whisker plot of p-Isopropylbenzene concentration (μg/m^3) by site and season 95
Figure 85. Box and whisker plot of 1,4 dichlorobenzene concentration (μg/m^3) by site and season 95
Figure 86. Box and whisker plot of n-butylbenzene concentration (μg/m^3) by site and season 96
Figure 87. Box and whisker plot of napththalene concentration (μg/m^3) by site and season 96
Figure 88. Artifact corrected particulate organic carbon (OC, μgC/m^3) and elemental carbon (EC, μgC/m^3), all days 101
Figure 89. Artifact corrected particulate organic carbon (OC, μgC/m^3) and elemental carbon (EC, μgC/m^3), November - April. 101
Figure 90. Artifact corrected particulate organic carbon (OC, μgC/m^3) and elemental carbon (EC, μgC/m^3), measurements with the lowest 20th percentile OC/EC 101
Figure 91. Location of NJDEP monitoring sites used for comparison to concentrations measured in the Meadowlands (Source NJ DEP web site on air toxics in New Jersey) 102
Figure 92. Locations of trails followed for intensive sampling 110
Figure 93. Air concentration (μg/m^3) (a) and log air concentration (b) of Toluene with wind speed (m/s) during Intensive sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted. 111
Figure 94. Air concentration (μg/m^3) (a) and log air concentration (b) of Benzene with wind speed (m/s) during Intensive sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted. 112
Figure 95. Air concentration (μg/m^3) (a) and log air concentration (b) of Ethyl benzene with wind speed (m/s) during Intensive sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted 113
Figure 96. Air concentration (μg/m^3) (a) and log air concentration (b) of *m/*p Xylene with wind speed (m/s) during Intensive sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted 114
Figure 97. Air concentration (μg/m^3) (a) and log air concentration (b) of o Xylene with wind speed (m/s) during Intensive ampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted. 115
Figure 98. Air concentration (μg/m^3) (a) and log air concentration (b) of Tetrachloroethene with wind speed (m/s) during Intensive Sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted. 116

Figure 99. Air concentration (μg/m^3) (a) and log air concentration (b) of 2-chloroetoluene with wind speed (m/s) during Intensive Sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted....117
Figure 100. Air concentration (μg/m^3) (a) and log air concentration (b) of 1,2,4-trimethylbenzene with wind speed (m/s) during Intensive Sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted....118
Figure 101. Air concentration (μg/m^3) (a) and log air concentration (b) of trichlorofluoromethane (Freon) with wind speed (m/s) during Intensive Sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted....119
Figure 102. Air concentration (μg/m^3) (a) and log air concentration (b) of Methylene Chloroide with wind speed (m/s) during Intensive Sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted....120
Figure 103. Air concentration (μg/m^3) (a) and log air concentration (b) of Carbon Tetrachloroide with wind speed (m/s) during Intensive Sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted....121
Figure 104. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of Chloroform by Sampling Time and Trail Location during Intensive Sampling Program....122
Figure 105. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of Bromovhloromethane by Sampling Time and Trail Location during Intensive Sampling Program....122
Figure 106. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of Toluene by Sampling Time and Trail Location during Intensive Sampling Program....123
Figure 107. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of Benzene by Sampling Time and Trail Location during Intensive Sampling Program....123
Figure 108. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of Ethybenzene by Sampling Time and Trail Location during Intensive Sampling Program....124
Figure 109. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of *m*/p Xylene by Sampling Time and Trail Location during Intensive Sampling Program....124
Figure 110. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of Styrene by Sampling Time and Trail Location during Intensive Sampling Program....125
Figure 111. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of o-Xylene by Sampling Time and Trail Location during Intensive Sampling Program....125
Figure 112. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of iso-Propylbenzene by Sampling Time and Trail Location during Intensive Sampling Program....126
Figure 113. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of n-Propylbenzene by Sampling Time and Trail Location during Intensive Sampling Program....126
Figure 114. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of Tetrachloroethene by Sampling Time and Trail Location during Intensive Sampling Program....127
Figure 115. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of 2-Chlorotoluene by Sampling Time and Trail Location during Intensive Sampling Program....127
Figure 116. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of 1,2,4-Trimethylbenzene by Sampling Time and Trail Location during Intensive Sampling Program....128
Figure 117. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of tert-Butylbenzene by Sampling Time and Trail Location during Intensive Sampling Program....128
Figure 118. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of n-Butylbenzene by Sampling Time and Trail Location during Intensive Sampling Program....129
Figure 119. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of sec-Butylbenzene by Sampling Time and Trail Location during Intensive Sampling Program....129
Figure 120. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of Trichloroflouromethane (Freon) by Sampling Time and Trail Location during Intensive Sampling Program....130
Figure 121. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of Methylene Chloride by Sampling Time and Trail Location during Intensive Sampling Program....130
Figure 122. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of Carbon Tetrachloride by Sampling Time and Trail Location during Intensive Sampling Program....131
Figure 123. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of Bromochloromethane by Sampling Time and Trail Location during Intensive Sampling Program....131
Figure 124. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of Trichloroethene by Sampling Time and Trail Location during Intensive Sampling Program....132

Figure 125. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of Chlorobenzene by Sampling Time and Trail Location during Intensive Sampling Program. 132
Figure 126. Box and Whisker Plot of the Mean Air concentration (μg/m^3) of Bromobenzene by Sampling Time and Trail Location during Intensive Sampling Program. 133
Figure 127. Box and Whisker Plot of the Mean Air concentration (μg/m3) of Naphthalene by Sampling Time and Trail Location during Intensive Sampling Program. 133
Figure 128. Mercury concentrations (ng/m3) in breathing zone measured on the Berry's Creek boat trail on July 21, 2005, 10:50 - 13:00. Blue numbers are Hg readings of trip from marina to tide gate, and purple numbers are readings of return trip from tide gate to marina; bottom image shows same concentrations overlaid on an aerial image of the location (aerial data from NJDEP) 134
Figure 129. Area considered for emissions and dispersion modeling in assessing air toxics contamination in Meadowlands District 144
Figure 130. Geographic distributions of roadways within the 10km radius of the Meadowlands District used for developing the new spatial allocation factors (SAFs) based on the NJ-DOT 2007 FCC database (NJDOT, 2007). 146
Figure 131. Geographic distributions of roadways within the 10km radius of the Meadowlands District used for developing the default spatial allocation factors (SAFs) based on the TIGER 2000 CFCC database (USCB, 2004). 147
Figure 132. Wind rose plot for the modeling period from March 17th, 2005 to March 13th, 2007 based on the meteorological data from Newark Airport (WBAN: 14734). The direction of winds shown is the direction from which the wind is blowing. 148
Figure 133. 2002 annual Benzene emissions (short tons/year) from mobile on-road sources of interstate highways and expressways allocated to the census tracts within a 10km radius of the Meadowlands District using (a) the default spatial allocation factors (SAFs) and (b) the new SAFs. 163
Figure 134. 2002 annual Benzene emissions (short tons/year) from mobile on-road sources of principal arterials allocated to the census tracts within a 10km radius of the Meadowlands District using (a) the default spatial allocation factors (SAFs) and (b) the new SAFs. 164
Figure 135. 2002 annual Benzene emissions (short tons/year) from mobile on-road sources of minor arterials allocated to the census tracts within a 10km radius of the Meadowlands District using (a) the default spatial allocation factors (SAFs) and (b) the new SAFs. 165
Figure 136. 2002 annual Benzene emissions (short tons/year) from mobile on-road sources of local roads allocated to the census tracts within a 10km radius of the Meadowlands District using (a) the default spatial allocation factors (SAFs) and (b) the new SAFs. 166
Figure 137. Differences between the 2002 annual Benzene mobile on-road emissions (short tons/year) allocated by the new SAFs and the default SAFs for the census tracts within a 10km radius of the Meadowlands District. 167
Figure 138. Differences between the 2002 annual Toluene mobile on-road emissions (short tons/year) allocated by the new SAFs and the default SAFs for the census tracts within a 10km radius of the Meadowlands District. 168
Figure 139. Differences between the 2002 annual Ethylbenzene mobile on-road emissions (short tons/year) allocated by the new SAFs and the default SAFs for the census tracts within a 10km radius of the Meadowlands District. 169
Figure 140. Differences between the 2002 annual Xylenes mobile on-road emissions (short tons/year) allocated by the new SAFs and the default SAFs for the census tracts within a 10km radius of the Meadowlands District. 170
Figure 141. Comparisons of mean normalized bias (MNB) of the model predictions obtained from the 6 modeling scenarios (listed in Table 40) of the 2nd set of sensitivity runs for the BTEX chemicals. The MNB metrics were calculated using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at all of the receptor locations. Note: three options (TR, LKTR, LKRD) of spatial allocation factors were available for processing mobile on-road emissions, where TR is the default census tract-based approach, LKTR is the improved link-based approach for adjusting the source strengths of mobile on-road emissions but still allocating to census tracts, and LKRD is the improved link-based approach for adjusting both source strengths and locations of mobile on-road emissions. 171
Figure 142. Comparisons of mean normalized error (MNE) of the model predictions obtained from the 6 modeling scenarios (listed in Table 40) of the 2nd set of sensitivity runs for the BTEX chemicals. The MNE metrics were calculated using model predictions matched with field measurements for the time

period of March 17, 2005 to March 13, 2007 at all of the receptor locations. Note: three options (TR, LKTR, LKRD) of spatial allocation factors were available for processing mobile on-road emissions, where TR is the default census tract-based approach, LKTR is the improved link-based approach for adjusting the source strengths of mobile on-road emissions but still allocating to census tracts, and LKRD is the improved link-based approach for adjusting both source strengths and locations of mobile on-road emissions. 172

Figure 143. Comparisons of mean fractional bias (MFB) of the model predictions obtained from the 6 modeling scenarios (listed in Table 40) of the 2nd set of sensitivity runs for the BTEX chemicals. The MFB metrics were calculated using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at all of the receptor locations. Note: three options (TR, LKTR, LKRD) of spatial allocation factors were available for processing mobile on-road emissions, where TR is the default census tract-based approach, LKTR is the improved link-based approach for adjusting the source strengths of mobile on-road emissions but still allocating to census tracts, and LKRD is the improved link-based approach for adjusting both source strengths and locations of mobile on-road emissions.....173

Figure 144. Comparisons of mean fractional error (MFE) of the model predictions obtained from the 6 modeling scenarios (listed in Table 40) of the 2nd set of sensitivity runs for the BTEX chemicals. The MFE metrics were calculated using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at all of the receptor locations. Note: three options (TR, LKTR, LKRD) of spatial allocation factors were available for processing mobile on-road emissions, where TR is the default census tract-based approach, LKTR is the improved link-based approach for adjusting the source strengths of mobile on-road emissions but still allocating to census tracts, and LKRD is the improved link-based approach for adjusting both source strengths and locations of mobile on-road emissions.....174

Figure 145. Comparisons of mean normalized bias (MNB) of the model predictions obtained from the 6 modeling scenarios (listed in Table 40) of the 2nd set of sensitivity runs for the BTEX chemicals. The MNB metrics were calculated using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the receptor locations. Note: three options (TR, LKTR, LKRD) of spatial allocation factors were available for processing mobile on-road emissions, where TR is the default census tract-based approach, LKTR is the improved link-based approach for adjusting the source strengths of mobile on-road emissions but still allocating to census tracts, and LKRD is the improved link-based approach for adjusting both source strengths and locations of mobile on-road emissions. 175

Figure 146. Comparisons of mean normalized error (MNE) of the model predictions obtained from the 6 modeling scenarios (listed in Table 40) of the 2nd set of sensitivity runs for the BTEX chemicals. The MNE metrics were calculated using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the receptor locations. Note: three options (TR, LKTR, LKRD) of spatial allocation factors were available for processing mobile on-road emissions, where TR is the default census tract-based approach, LKTR is the improved link-based approach for adjusting the source strengths of mobile on-road emissions but still allocating to census tracts, and LKRD is the improved link-based approach for adjusting both source strengths and locations of mobile on-road emissions. 176

Figure 147. Comparisons of mean fractional bias (MFB) of the model predictions obtained from the 6 modeling scenarios (listed in Table 40) of the 2nd set of sensitivity runs for the BTEX chemicals. The MFB metrics were calculated using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the receptor locations. Note: three options (TR, LKTR, LKRD) of spatial allocation factors were available for processing mobile on-road emissions, where TR is the default census tract-based approach, LKTR is the improved link-based approach for adjusting the source strengths of mobile on-road emissions but still allocating to census tracts, and LKRD is the improved link-based approach for adjusting both source strengths and locations of mobile on-road emissions.....177

Figure 148. Comparisons of mean fractional error (MFE) of the model predictions obtained from the 6 modeling scenarios (listed in Table 40) of the 2nd set of sensitivity runs for the BTEX chemicals. The MFE metrics were calculated using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the receptor locations. Note: three options (TR, LKTR, LKRD) of spatial allocation factors were available for processing mobile on-road emissions, where TR is the default census tract-based approach, LKTR is the improved link-based approach for adjusting

the source strengths of mobile on-road emissions but still allocating to census tracts, and LKRD is the improved link-based approach for adjusting both source strengths and locations of mobile on-road emissions.....178
Figure 149. Comparisons of mean normalized bias (MNB) and mean normalized error (MNE) of the ISCST3 and AERMOD model predictions for the three chlorinated chemicals (PERC, TCE, and PDB) and the three metals (As, Pb, and Hg) with the inputs of NEI-2002 emissions and Newark Airport meteorology. The MNB and MNE metrics were calculated using all of the model predictions matched with field measurements for the period of March 17th, 2005 to March 13th, 2007 at all of the receptor locations. 179
Figure 150. Comparisons of mean fractional bias (MFB) and mean fractional error (MFE) of the ISCST3 and AERMOD model predictions for the three chlorinated chemicals (PERC, TCE, and PDB) and the three metals (As, Pb, and Hg) with the inputs of NEI-2002 emissions and Newark Airport meteorology. The MFB and MFE metrics were calculated using all of the model predictions matched with field measurements for the period of March 17th, 2005 to March 13th, 2007 at all of the receptor locations. 180
Figure 151. Comparisons of mean normalized bias (MNB) and mean normalized error (MNE) of the ISCST3 and AERMOD model predictions for the three chlorinated chemicals (PERC, TCE, and PDB) with the inputs of NEI-2002 emissions and Newark Airport meteorology. The MNB and MNE metrics were calculated using the model predictions matched with field measurements at each of the field sampling sites for the period of March 17th, 2005 to March 13th, 2007.....181
Figure 152. Comparisons of mean fractional bias (MFB) and mean fractional error (MFE) of the ISCST3 and AERMOD model predictions for the three chlorinated chemicals (PERC, TCE, and PDB) with the inputs of NEI-2002 emissions and Newark Airport meteorology. The MFB and MFE metrics were calculated using the model predictions matched with field measurements at each of the field sampling sites for the period of March 17th, 2005 to March 13th, 2007.....182
Figure 153. Comparisons of mean normalized bias (MNB) and mean normalized error (MNE) of the ISCST3 and AERMOD model predictions for the three metals (As, Pb, and Hg) with the inputs of NEI-2002 emissions and Newark Airport meteorology. The MNB and MNE metrics were calculated using the model predictions matched with field measurements at each of the field sampling sites for the period of March 17th, 2005 to March 13th, 2007.....183
Figure 154. Comparisons of mean fractional bias (MFB) and mean fractional error (MFE) of the ISCST3 and AERMOD model predictions for the three metals (As, Pb, and Hg) with the inputs of NEI-2002 emissions and Newark Airport meteorology. The MNB and MNE metrics were calculated using the model predictions matched with field measurements at each of the field sampling sites for the period of March 17th, 2005 to March 13th, 2007.....184
Figure 155. Comparisons of mean normalized bias (MNB) and mean normalized error (MNE) of the ISCST3 model predictions for BTEX with the two different meteorology inputs (Newark Airport data vs. MERI data). The MNB and MNE metrics were calculated using the model predictions matched with field measurements at all of the field sampling sites for the period of June 10, 2006 to March 13, 2007.185
Figure 156. Comparisons of mean fractional bias (MFB) and mean fractional error (MFE) of the ISCST3 model predictions for BTEX with the two different meteorology inputs (Newark Airport data vs. MERI data). The MFB and MFE metrics were calculated using the model predictions matched with field measurements at all of the field sampling sites for the period of June 10, 2006 to March 13, 2007.186
Figure 157. Contributions of ambient sources categorized by five emission groups (i.e. point, non-point (area), mobile non-road, mobile on-road, and background) to the predicted 48-hr averages of the ISCST3 predictions for the BTEX chemicals at each of the 4 receptor locations in the Meadowlands District. Note: The results presented are obtained by averaging the outputs of the source contribution analyses conducted on the 5 selected sampled dates (9/7/2005, 1/11/2006, 2/16/2006, 3/12/2006, and 10/20/2006), which are typical for other sampled dates. 187

Executive Summary

In order to 1) establish the air pollution levels currently affecting the Meadowlands District, 2) assess the impact on individuals using sections of the district for recreational purposes, and 3) provide the foundation for the potential air pollution impact after specific planned land development, a comprehensive and systematic air pollution study was conducted within the Meadowlands District. As with most baseline studies for an area that has mixed use, there was a need to have a balance between measurements and modeling activities. The air quality measurement program established the concentrations at a number of strategic locations and for specific types of activities completed in the District. The air quality measurements included both a long term and a short term (intensive) component. In parallel we completed air quality modeling applications to estimate ambient air contaminant concentrations and potential corresponding population exposures for the entire district, and the comparative model performance with the actual air quality measurements.

The primary objective of the measurements were to quantify the current baseline ambient air quality throughout the vicinity of the Meadowlands. The long term air pollution sampling included 48 hour samples collected every sixth day over a period of two years. Data was collected for specific Volatile Organic Compounds (VOCs) at four sites, and elemental species and particles at two sites. Short term (2-3 hours) air pollution sampling was completed on ten days during three different time periods. The short term studies consisted of *personal monitoring* while staff hiked along designated trails in the Meadowlands to focus on activities participated in by individuals that can lead to location or time specific exposures associated with individual or population based air pollution issues. The modeling was completed to quantify baseline ambient air quality in the vicinity of the Meadowlands, using various available emissions, land-use, meteorological, etc. databases and the results of the field measurement study, and to demonstrate how modeling can provide a prospective for assessing future contributions to air pollution based upon the projected plans for the District.

For long term measurements the fixed monitoring stations measured $PM_{2.5}$ mass, organic carbon, elemental carbon, a suite of metals and a suite of aromatic and chlorinated hydrocarbons that are hazardous air pollutants to provide baseline air concentrations for future comparison as development of the Meadowlands proceeds. The sample to sample temporal variability in air concentrations spanned more than an order of magnitude for individual elements and compounds while only some of these air pollutants showed average seasonal differences. The results were indicative of the effect of meteorological conditions on the daily air concentration for pollutants with sources in a region and potential variability in their emission rates. Seasonal differences were more limited in magnitude than the day-to-day changes, within a factor of two. Not all air pollutants showed temporal variations. The seasonal differences likely reflect variations in source emissions over the course of a year. Such variations are not captured in current emission inventories and would increase the uncertainty in the modeling results.

Overall the spatial differences in concentration were smaller than the temporal differences, though some significant differences were identified for individual metals and VOCs. These spatial differences were likely due to variability in the proximity of sources to the different sites. For example, the sites closest to the Jersey Turnpike were impacted more by mobile source emissions of aromatic hydrocarbons resulting in higher air concentrations at those specific sites. Local activities observed associated with construction could resuspend dust containing individual metals, and these would lead to some of the spatial and seasonal differences. For the intensive sampling studies, the aromatic hydrocarbon air concentrations measured along the trails in the Meadowlands generally were two or more times the concentrations measured at the stationary long term monitoring while were closer in concentration for the halogenated compounds. The exposure of individuals to VOCs using these trails would be similar to exposures that occur in typical urban settings for volatile

organic compounds from mobile sources. Some chlorinated compounds yielded exposures that were lower than occur in typical urban settings. For the aromatic hydrocarbons the emissions from mobile sources from the surrounding major roadways in the region appear to be the major source to the exposures that occurred on the trails. The chlorinated compounds do not show a strong increase in concentration during the summer as might have been expected if they were emitted from prior spills in the area nor do they have as strong a relationship with wind speed as observed for the aromatic hydrocarbons. The results suggest that chlorinated compounds are not emitted locally with values below those measured in urban centers, similar to background levels measured in other parts of the state of NJ. These results implied that the current use of the trails within the Meadowlands do not present elevated VOC exposure to residents of NJ compared to exposure they may already received elsewhere in the state. However, further evaluation of exposure along trails should be completed as the development of the Meadowlands District continues to assure that the exposure levels determined in this study are maintained at these levels or are reduced by new control strategies.

For those pollutants for which comparison data are available, the air concentrations at the ambient sites were consistently lower than levels measured outside homes in Elizabeth, NJ and were within the upper portion of the range measured at NJDEP monitoring sites at different locations across the state. This suggests that for most air pollutants the current air quality in the Meadowlands reflects the general background for northern/central eastern NJ, though some individual exceptions were identified.

The modeling component of the Meadowlands study simulated and estimated the baseline ambient air quality in the vicinity of the Meadowlands District. This was accomplished using various available emissions, land-use, and meteorological, etc. databases, along with performance tests completed using the results of the field measurement study. Further, efforts were made to demonstrate how the modeling analysis can be employed prospectively to assess future contributions based upon the anticipated “end-states”, i.e. conditions corresponding to implementation of development plans, projected for the District. Air toxics considered in the modeling study were Benzene, Toluene, Ethylbenzene, Xylenes, Trichloroethylene (TCE), Tetrachloroethylene (PERC), 1,4-Dichlorobenzene (PDB), Arsenic, Lead, and Mercury. The background levels of the ten air toxics were estimated for the Meadowlands using the simulation results from the 1999 NATA study for the census tracts associated with our four field sampling sites. There is no information available on the background values for six of the selected air toxics, i.e. Toluene, Ethylbenzene, 1,4-Dichlorobenzene, As, Pb, and Hg, in the 1999 NATA study.

Both the ISCST3 (USEPA, 1995) and AERMOD models were used to calculate ambient concentrations of the ten selected air toxics at four receptor locations. These locations corresponded to the four Meadowlands field sampling sites. Modeling analyses were completed for the time period of March 17th, 2005 to March 13th, 2007 which matched with the time span of the entire field measurement collection. Model predictions were generally in agreement with the field measurements for 7 air toxics (benzene, toluene, ethylbenzene, xylenes, PERC, TCE, PDB, and Pb) and were within the factor of 2 acceptance criterion recommended by U.S. EPA. The model predictions were significantly under-estimated and as the emission inventory appears to “miss” major As sources. For Hg, the majority of field measurements were below the detection limits and the corresponding model predictions were also below the detection limits. Therefore, the model predictions were qualitatively in agreement with the field measurements.

The refinement of mobile on-road emissions through the link-based spatial allocation significantly improved the model performances for the benzene, toluene, ethylbenzene, and xylenes. The improvement over the default spatial allocation approach (i.e. census tract-based) generally resulted in 15% to 25% decreases of the mean normalized errors in the comparison with field measurements. Further, the model predictions based on the Newark Airport meteorological data had

better model performance than those based on the MERI meteorological data, but either are acceptable for future modeling analyses. The two standard atmospheric dispersion models (ISCST3 and AERMOD) had similar model performances for the ambient data comparisons. However, AERMOD showed marginally better model performance than ISCST3 due to its improved incorporation of local meteorology. Source contribution analysis results indicated that the local mobile on-road, mobile non-road, and non-point (area) sources were significant contributors to the ambient levels of benzene, toluene, ethylbenzene, and xylene in the Meadowland District. Further, the contributions from mobile non-road sources were relatively larger than the other two source categories (mobile on-road and non-point) for benzene and ethylbenzene. The contributions from non-point (area) sources were relatively larger than mobile non-road and on-road sources for toluene and xylenes. Based upon the comparability between the ambient measurements and the detailed emissions and dispersion modeling results, a firm baseline of the air quality modeling system has been developed for the Meadowlands. This modeling system can be used to assess future states of air quality reflecting impact of specific (and alternative) planned development for the Meadowlands District. Specifically, the emission growth from the current base year of 2002 to future years can be projected after considering specific economic and population growth, fuel consumption, vehicle miles traveled etc. impacted by the development plan for the Meadowlands District. In addition, regulations and policies on emission reductions mandated by various agencies will need to be taken into account for the projection of future year emissions. Embedded within the air quality modeling system is the “Growth and Control” module of the EMS-HAP program can be used to compute future or projected emissions as a result of projected economic growth and/or emission reduction strategy scenarios. For the application to the Meadowlands District, the source specific growth factors and control strategies for emission reduction will need to be developed by incorporating the impacts estimated for specific features of the development plan for the Meadowlands District.

General Recommendations for Future Study

1. The Modeling and Measurement results provide a wealth of baseline information, and the modeling tools applied by EOHSI can be used in a prognostic manner as part of future implementation plans to examine the impact of major new sources or land developments in the Meadowlands during the design phases of development, i.e. housing, commercial facilities, sports and entertainment projects. This could help guide the development of more efficient energy technologies, and transportation plans.
2. Exposure monitoring can be incorporated in development projects that include major construction activities or changes in traffic patterns to evaluate changes in personnel exposure during the implementation of the projects and confirm the assumptions underlying the emission projections.
3. To better understand spatial variability in this area, the new sampling strategy called “Saturation” recently implemented by EOHSI could provide a better picture of the spatial variation of VOCs and aldehyde,s thereby improving the knowledge base on spatial variability across various sections of the Meadowlands. It involves placement of passive 24 to 48 hour samplers within a grid associated with strategic locations for examining potentially significant human or ecological exposures. This was employed successfully in a recent study completed in Camden, NJ.

Introduction

The NJ Meadowlands Commission has provided a vision for the development and re-development of the almost 20,000 acres of land that comprise the Meadowland District. Currently, it is a mixed-use district that includes land-use categories that span from wetlands, commercial, industrial, residential, to transportation uses. In reviewing the master plan little information was available on the baseline air quality within the Meadowlands District. This was especially true for organic and inorganic air toxics, and fine particulate matter ($PM_{2.5}$). In order to establish any degree of concern for air pollution levels currently affecting the district, to assess the impact on individuals using sections of the district for recreational purposes, and to provide the foundation for the potential air pollution impact after specific planned land development, a comprehensive and systematic air pollution study was conducted within the area. The study was needed to address questions and concerns that will arise during planning phases of various sections of the Meadowlands District. Included are environmental impact from such a large new development, the decisions about how to develop or not to develop specific portions of the District, and the maintenance or improvement of local air quality. As with most baseline studies for an area that has mixed use, there was a need to have a balance between measurements and modeling activities. The air quality measurement program was used to establish the concentrations at a number of strategic locations and for specific types of activities to be completed in the District. As discussed below, there were long term and short-term intensive components to the study. The results provide a basis for understanding current ambient levels and human exposure issues. In parallel to the measurement program, we developed and implemented air quality modeling applications to provide estimates of ambient air contaminant concentrations and of potential corresponding population exposures for the entire district.

Purpose and Specific Aims

1. An air pollution measurement study was conducted to examine the current air quality in the Meadowlands District for air toxics and pollutants and provide baseline measurements of exposure for specific activities conducted in the Meadowlands.
2. An air pollution modeling study was conducted to provide quantitative estimates of the emissions from various pollutant source categories within and around the Meadowlands District, and then apply this information to air quality models for estimation of the contributions from individual source categories to current pollutant levels.
3. An integration of measurement and modeling activities was completed to test the overall performance of the Meadowlands District air quality model for its ability to represent current air pollution and as a resource for future planning analyses.

Air Pollution Measurement Study

Objectives: The primary objective of the measurement components of the project was to quantify the current baseline ambient air quality throughout the Meadowlands vicinity. This was to be done by completing both a long term and a short-term air pollution study at key locations and times over the course of multiple years.

Approach Summary: Two air sampling strategies were used to assess the background concentration of selected volatile organic compounds, particulate mass ($PM_{2.5}$), trace metals and elemental carbon.

1. ***Long term air pollution sampling***. 48 hour air pollution samples were collected every sixth day for a period of two years for specific Volatile Organic Compounds (VOCs) at four sites, and elemental species and particles at two sites. This schedule was used to take advantage of the statewide DEP monitoring network that obtains 24 hour data starting on the same

schedule for some key indicator pollutants, such extant data can be used in comparisons with the levels measured in the Meadowlands District.

2. ***Short Term air pollution sampling.*** These sets of samples were collected daily for 10 days during three time periods over the course of the study. The *intensive monitoring* provides daily variability and peak concentrations, in New Jersey, the peaks primarily occur during the summer, e.g. July. This was accomplished by *personal monitoring* which focused on activities participated in by individuals that can lead to location or time specific exposures associated with individual or population based air pollution issues (e.g. residential exposures to diesels).

Modeling of Baseline Conditions throughout the Meadowlands Area of NJ

Objective: The primary objectives of the modeling components of the project were:

a. to investigate, and quantify, baseline ambient air quality in the vicinity of the Meadowlands, using various available emissions, land-use, meteorological, etc. databases and the results of the field measurement study;

b. to demonstrate of how modeling results can provide a prospective for assessing future contributions to air pollution based upon the projected plans for the District

1 AIR POLLUTION MEASUREMENT COMPONENTS

C. Weisel, Team Leader

1.1 Long Term Sampling Overview

The general character of the land use in the Hackensack Meadowlands District is open water surrounded by wetlands criss-crossed by rail and highway transportation networks. Industrial activity is dominated by warehouses and intra-modal transfer stations. Major construction activity that was concurrent with the project time frame included site preparation for golf courses on closed landfills and a sports and entertainment themed shopping center (Xanadu) within the footprint of the New Jersey Sports Complex. Some landfilling was also taking place. Air samples were collected to address emissions from these sites and scheduled for collection every sixth day from two sites for particulate matter and from four sites for the volatile organic compounds (VOCs). Sampling was conducted for 48 hours using passive samplers (3M-OVM badges) for the VOC samples, and active pump samplers (MSP-Model 400 MEM™- Micro-Environmental Monitor) for collecting $PM_{2.5}$ (particles less than 2.5 µm in diameter). The latter were used for mass, trace elemental and elemental/organic carbon analyses (EC/OC). The four sites (Figure 1) selected in the Meadowlands for the long term sampling were:

- Site 1 NJMC Headquarters (Particulates and VOCs): Situated at the rear of a storage building adjacent to offices; the western spur of the New Jersey turnpike is approximately one kilometer to the east. The road to an active landfill one kilometer to the west, which accepted construction debris, was adjacent to this site. Site preparation for golf courses that included movement and storage of large quantities of soil was taking place on inactive landfills immediately to the north.
- Site 2 Sports Complex (Particulates and VOCs): Referred to as Xanadu in the report, the actual construction was taking place almost 2 kilometers to the east. Located on a concrete slab between two large storm water storage lagoons; a well trafficked state highway was 300 meters to the south. This site is also within 200 meters of a major tributary of the Hackensack River. Parking lots servicing sports facilities were utilized during periodic events at the Sports Complex. A turnpike interchange is located approximately two kilometers southeast.
- Site 3 Laurel Hill (VOCs): This site was within a county park adjacent to the Hackensack River. The eastern spur of the New Jersey Turnpike is 600 meters to the east. Site preparation and construction of a large residential complex was taking place on a lot to the northeast.
- Site 4 1A Landfill (VOCs): Located at the base of a closed landfill less then 200 meters north of a county road with high truck traffic servicing nearby warehouses. The New Jersey turnpike is 350 meters west. The Amtrak corridor passes within 150 meters; a large rail yard is less then one kilometer to the south.

The samples were collected by the staff of MERI using the SOPs prepared by and procedures demonstrated by personnel from EOHSI.

The Teflon Filters (37 mm PFTE membrane filters) were weighed using a Sartorius Research Grade Balance Model RC210P which has a readability of 10µg. The filters were placed in a controlled temperature (20-23°C) and relative humidity (30-40%) weighing room to allow the filter material and/or collected dust to equilibrate for at least 24 hours immediately prior to weighing before and after sampling. After determining the mass the Teflon filters were then analyzed for metals in the Analytical Chemistry Laboratories of EOHSI overseen by Dr. Brian Buckley. The dust collected on the air filter was digested in closed Teflon vessels (6 mL, Savillex Corp, Minnetonka MN). The vessel was cleaned in a microwave with 0.5 mL Optima HNO_3 (Thermo-Fisher Scientific, Waltham MA) followed by 0.5 mL deionized water, in closed 50-mL

centrifuge tubes (VWR, Westchester PA) before use. The samples were placed in 1 mL Optima HNO_3 (Thermo-Fisher Scientific), and 0.5 mL Utrex II H_2O_2 (JT Baker, Phillipsburg NJ) in individual Teflon vessels. The vessel was sealed with a socket-type cap (Savillex Corp) designed for high-pressure applications. The digestion protocol had eight stages (500 watts; 5 min/stage; 10% power increments from 40% to 70% for the first four stages and 60% for the last four stages). Samples were digested in a microwave oven (MDS-2000, CEM Corporation, Matthews NC) operated under time–power control mode. In each batch blanks, one urban PM standard (NIST 1648) and a standard aqueous solution (NIST 1643), were digested. After digestion, samples were cooled and transferred to precleaned 15-mL centrifuge tubes and diluted with high purity water to a volume of 15-mL. Multi-elemental analyses of the samples and controls were done with a Thermo Elemental Plasma Quad3 ICP–MS and ASX-500 autosampler (CETAC Technologies, Omaha NE). For every six to eight samples, a 10-ppb solution made from NIST traceable SM- 1811-001 and SM-1811-002 (high-purity element solutions containing 23 elements) was run as a quality control sample. If the quality control sample was not within ± 20% of the certified value for target elements, the instrument was recalibrated and the batch was reanalyzed. Accuracy was determined by comparisons with results from a certified standard solution (NIST 1643) and from a urban PM standard (NIST 1648) to reflect digestion and matrix-extraction recoveries, respectively. Recoveries for most "extractable" elements were between 91% and 103% with ICP–MS.

The Organic Carbon (OC) and Elemental Carbon (EC) were measured by thermal-optical transmittance using a Sunset Laboratory Carbon Analyzer overseen by Dr. Barbara Turpin, Department of Environmental Sciences, Rutgers University. A 1.0 cm^2 punch of the Quartz Fiber Filter (QFF) is placed in the analyzer with air above it purged. The QFF punch is then heated in a stepwise manner in a helium environment to 820°C to volatilize the OC. After removing the OC, EC was removed by combustion in 2% oxygen in helium while heated in a stepwise manner to 910°C. All evolved carbon is converted to methane and measured in a flame ionization detector for quantification. Calibration of the instrument was done with methane gas standards.

The volatile organic compounds (VOCs) were analyzed by Gas Chromatography/Mass Spectrometry. The charcoal pads were first removed from the 3M 3500 VOC Monitors then the VOCs were extracted in 1.0 mL of carbon disulfide and acetone mixture (1:2 by volume) facilitated by ultrasonication. Internal standards were added to the solvent for QC validation and blanks and laboratory control run. The samples were analyzed by Dr. Jin-Young Shin initially at the laboratories at EOHSI and subsequently at MERI.

- Quality Control and Quality Assurance results are in Appendix A.
- Complete copies of all data are provided in Excel files.

1.2 Results:

The summary statistics for the $PM_{2.5}$ mass are given in Table 1. The $PM_{2.5}$ mass concentrations were consistent with a log normal distribution (Figure 2), as is typical of ambient air concentration data. The temporal variations in the air concentrations at the two sampling locations indicate that overall the concentrations track one another (Figure 3) with little difference evident in the mean concentrations between the two sites by season (Figure 4). A t-test of the log transformed data (mean concentrations 11.3±5.6 and 11.4±7.0 $\mu g/m^3$) showed no statistical significant difference (Table 2). The seasonal variations in $PM_{2.5}$ mass concentration were not significantly different across the seasons based on an One-way ANOVA statistical test of the actual or the log-transformed data (Table 3).

1.2.1 Elemental and Organic Carbon $PM_{2.5}$

The summary statistics for the elemental (EC), organic carbon (OC) and total carbon (TC) $PM_{2.5}$ are given in Table 4. The EC and OC concentrations were consistent with a log normal distribution (Figure 5 and Figure 6 respectively), as is typical of ambient air concentration data. The temporal variations in the air concentrations at the two sampling locations indicate that overall the concentrations of the two sites track one another for both EC and OC (Figure 7), however, for EC Site 2 (Sports Complex) tended to have higher values than site 1 (NJMC Headquarters), while for OC there are some individual days that exhibit large differences but overall no site differences are evident. Valid data were obtained only at site 2 during the last three months of the study, so no data is available for site 1 during that time period. Little difference is evident in the mean concentrations between the two sites by season. However OC appears to have higher levels during the summer while EC appears higher in the winter (Figure 8). A t-test of the log transformed EC concentrations showed a statistically significant difference between the two sites (mean concentrations 0.498±0.289 and 0.578±0.421 $\mu g/m^3$, sites 1 and 2 respectively), while no statistical differences were found between the sites for OC (mean concentrations 2.24±1.47 and 2.42±1.28 $\mu g/m^3$, sites 1 and 2 respectively) (
Table 5). The seasonal variations in EC concentration were not statistically different across the seasons based on an One-way ANOVA of the log-transformed data, though higher values were present in the winter. The summer concentrations of OC were statistically higher at site 2 than during other times of the year. While the same trend was observed at site 1, the difference did not reach statistical significance (Table 6).

1.2.2 Trace Elements in $PM_{2.5}$

The target metals in the $PM_{2.5}$ were arsenic, cadmium, chromium cobalt, copper, lead, magnesium, manganese, mercury, nickel, selenium and vanadium. As discussed in Appendix A there were blank contamination problems with chromium so those values are not reported. Particulate mercury was above the detection limit (<0.2ng/m^3) in less than 5% of the samples so it is not possible to calculate any summary values for mercury. This is not unusual for mercury since only a small portion of atmospheric mercury is in the particulate phase. Table 7 provides the summary statistics for the remaining ten metals and some additional elements that were routinely detected in the air samples by the ICP/MS method used. The target compounds were all consistent with a log normal distribution, though magnesium had about 30% of the samples below detection which resulted in some skewness of the distribution (Figure 9 - Figure 18).

The temporal variations in the air concentrations of metals measured at the two sites (Figure 19 - Figure 28) show the same large day to day variation in air concentration observed for $PM_{2.5}$ mass and EC/OC. The metals concentrations however, were several orders of magnitude lower than $PM_{2.5}$ mass and EC/OC, as is typical of ambient samples. The two sites do not appear to track each other well for several of the metals. For most of the metals, the concentration profile at site 1 (NJMC Headquarters) appears to be elevated compared to site 2 (Sports Complex). However, individual days show spikes in the concentration at site 2 that are not present at site 1, particularly for cadmium, cobalt, copper and nickel. The paired samples (Table 8) showed statistical differences between the mean concentrations present at the two sites for arsenic (0.94±0.54 vs. 0.76±0.55ng/m^3), cadmium (0.17±0.11 vs. 0.14±0.09 ng/m^3), cobalt (0.28±0.25 vs. 0.24±0.22 ng/m^3), lead (4.2±3.5 vs. 3.4±2.3 ng/m^3), manganese (2.9±2.1 vs. 2.4±1.7 ng/m^3) and vanadium (3.7±3.8 vs. 2.8±2.7 ng/m^3) (site 1 and 2 respectively). Seasonal variations were identified for only cadmium, cobalt and magnesium, with the summer being statistically different from the other seasons based on a one-way ANOVA of the log-transformed data (Table 9, Figure 29 - Figure 38). The differences for magnesium across the season are suspect because of the large number of samples below detection and a few days with very high concentrations that affected the differences.

1.2.3 Volatile Organic Compounds (VOCs)

Sixty VOCs were present in the analytical standards used for analysis and these compounds were scanned for in the air samples. Seventeen VOCs were detected in the samples (benzene, toluene, ethylbenzene, *m*,p xylene, o xylene, 1,3,5 trimethylbenzene, 1,2,4-trimethylbenzene, styrene, propylbenzene, p-isoproplybenzene, *n*-butylbenzene, naphthalene, 1,1,1-trichloroethane, carbon tetrachloride, tetrachloroethylene, 1,4-dichlorobenzene) with the summary statistics for those compounds presented in Table 10. Compounds which are not reported because of the QC problems (as discussed in Appendix A) include: chlormethane, vinyl chloride, bromomethane, trichlorofluormethane, methylene chloride, 1,1-dichloroethene, *t*-1,2-dichloroethene, 1,1-dichloroethane, 2,2-dichloropropane, and chlorobenzene. In addition, the compounds that were not detected in any of the samples included: chloroform, 1,2 dichloropropene, 1,2-dichloroethane, 1,2-dichloropropane, dibromoethane, bromodichloromethane, *cis*-1,2-dichloropropene, *trans*-1,3-dichloropropene, 1,1,2-trichloroethane, 1,3-dichloropropane, dibromochloromethane, 1,2-dibromoethane, 1,1,2,2-tetrachloroethane, bromoform, 1,1,2,2-tetrachloroethane, bromobenzene, 4-chlorotoluene, 1,2-dibromo-3-chloropropane, 1,2,4-trichlorobenzene, hexachloro-1,3-butadiene and 1,2,3-trichlorobenzene. The compounds present in the standard are part of a commercial mixture used for evaluating contaminated environmental samples by GC/MS analysis, and all are not necessarily expected to be in ambient air. Thus, for majority of these compounds it is not surprising that they were not detected at the Meadowland Sites.

The compounds with concentrations above the detection limits had distributions consistent with a log normal distribution, (Figure 39 – Figure 55). The temporal changes for each compound detected at the four sites (Figure 56 - Figure 70) showed the same large day to day variations in air concentrations, and the overall tracking of the concentrations across the sites as observed for the $PM_{2.5}$ mass and species. This was consistent with the source of a major component of both the VOC and PM being a combination of transport of air pollutants from outside and in the immediate area of the Meadowland. Other contributors affecting the variation is alterations by meteorology on the build up of emissions from local sources. Excursions for individual compounds on some days at one of the sites would occur occasionally. No single site was uniquely identified containing these excursions. For example, in 2005 several aromatic compounds had very high concentration at site 4 on October 13-15, 2005, while in 2006 the highest concentrations for many of the same compounds were at Site 3 in the October 2-4, 2006 sample. These results are consistent with an upwind emission source near a site on those specific sampling days.

To determine if the mean concentrations for any site was elevated compared to the other locations, the collected samples were analyzed using a General Linear Model (GLM) Repeated Measures analysis in SPSS. The log transformed data was used in the model and the site was used as the repeated variable. These analyses only examined days when valid samples were available from all sites. The results of GLM analyses are given in Table 11 - Table 27, along with the actual mean concentrations for each site from the subset of data when all samples had valid results above the minimum detection limit. No statistical differences among the sites were identified for toluene, 1,3,5-trimethylbenzene, styrene, propylbenzene, p-isoproplybenzene, *n*-butylbenzene, naphthalene, 1,1,1-trichloroethane, carbon tetrachloride, tetrachloroethylene, or 1,4-dichlorobenzene. For the compounds that had a statistical difference, paired t-tests were run as the Post-Hoc evaluation to identify which sites were statistically different. The benzene concentrations at site 1 were statistically higher than site 2, which were statistically higher than sites 3 and 4. The ethyl benzene (Table 29), *m,p*-xylene (Table 30), and *o*-xylene (Table 31) concentrations at site 4 were statistically higher than the other three sites. The 2,3,4 trimethylbenzene concentrations (Table 32) at site 3 were statistically higher than site 2 with the concentrations at the other two sites being in between them and not statistically different. Thus, even though these compounds al have mobile sources, no consistent trend was observed.

Statistical differences in concentrations associated with season were evaluated using a One-way ANOVA on the log-transformed data. Seasonal differences were identified for all compounds except for m/p xylene and some of the heavier aromatic compounds (propylbenzene, 1,2,4 trimethylbenzene, p isopropylbenzene, m/p xylene, butylbenzene and styrene) (Table 9, Figure 71 – Figure 87). No season appeared to be consistently higher for the lighter aromatic compounds: benzene decreased from fall to summer (Figure 73), toluene decreased from spring to winter (Figure 75), ethyl benzene decreased from spring to winter (Figure 77) and *o* xylene had no consistent pattern (Figure 79). This lack of consistent seasonal pattern likely reflects the changing composition of gasoline fuel through the year coupled with differences in evaporation rates. The seasonal variation rate for 111 trichloroethane showed the highest concentrations in the summer and lowest in the winter suggesting evaporation from fugitive emissions (Figure 71). However, this pattern was not present for trichloroethylene which had peak values in the winter (Figure 74) which suggested different source strengths or pattern of use at different times during the year. Tetrachloroethylene had the highest concentrations in the fall (Figure 76); however, the peak fall values were only present during 2005 and not 2006 (Figure 61). Carbon tetrachloride also appears to have some seasonal differences (Figure 72). However the temporal variation and the day to day changes for carbon tetrachloride were small, which is expected since carbon tetrachloride has few local sources (Figure 57). One explanation for the temporal profile suggesting a seasoned effect when new calibration curves were periodically developed may be small shifts in the laboratory analyses equivalent to a 0.2$\mu g/m^3$ air concentration bias rather than actual changes in atmospheric concentration. The magnitude of the change is within the QC criteria. The seasonality of styrene and naphthalene were due to the few samples that were actually above the detection limit for those compounds on a limited number of days rather than an actual seasonal trend (Figure 80 and Figure 87). The concentration of 1,4 dichlorobenzene was lowest in the winter and higher toward the spring and summer, consistent with this compounds low volatility (Figure 85).

Table 1. Summary statistics by site for the $PM_{2.5}$ mass concentration ($\mu g/m^3$)

PM2.5 Air Concentration ($\mu g/m^3$)		Site 1	Site 2
N		84	98
Mean		12.0	10.7
Median		11.0	9.5
Std. Deviation		6.5	6.1
Percentiles	25	6.8	6.3
	50	11.0	9.5
	75	16.1	13.8
Elizabeth RIOPA		20±10	
NJDEP 2006		12 to 14	

Table 2. Paired sample analysis of for the two sites for log $PM_{2.5}$ mass

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	LogSite1	.9862	79	.36779	.04138
	LogSite2paired	.9612	79	.24602	.02768

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	LogSite1 & LogSite2paired	79	.542	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		Mean	Std. Deviation	Std. Error Mean
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Pair 1	LogSite1 - LogSite2paired	.02499	.31250	.03516	-.04500	.09499	.711	78	.479

Table 3. ANOVA of log $PM_{2.5}$ mass with season

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
LogSite1	Between Groups	.223	3	.074	.566	.639
	Within Groups	10.514	80	.131		
	Total	10.737	83			
LogSite2	Between Groups	.284	3	.095	1.541	.209
	Within Groups	5.774	94	.061		
	Total	6.058	97			

Table 4. Summary statistics by site for the EC, OC and TC $PM_{2.5}$ concentration (µg/m^3)

		OC conc. (µg/m3)	EC conc. (µg/m3)	TC conc. (µg/m3)
N	Valid	121	121	121
Mean		2.35	.546	2.90
Median		2.24	.491	2.75
Std. Deviation		1.36	.374	1.58
Percentiles	25	1.28	.291	1.68
	50	2.24	.491	2.75
	75	3.11	.689	3.75
Elizabeth RIOPA		3.2	0.7	3.9
NJ DEP 2006		Not available		

		Site1EC	Site2EC	Site1OC	Site2OC	Site1TC	Site2TC
N	Valid	49	72	49	72	49	72
Mean		.498	.578	2.24	2.42	2.74	3.00
Median		.477	.493	2.20	2.35	2.50	2.78
Std. Deviation		.289	.421	1.47	1.28	1.655	1.53
Percentiles	25	.280	.294	1.18	1.32	1.45	1.76
	50	.477	.493	2.20	2.35	2.50	2.78
	75	.636	.706	2.95	3.22	3.45	4.03

Table 5. Paired sample analysis of for the two sites for log EC and OC $PM_{2.5}$ concentrations

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	logSite1EC	-.3763	44	.24749	.03731
	logSite2EC	-.3358	44	.28780	.04339
Pair 2	logSite1OC	.2244	42	.35029	.05405
	logSite2OC	.2671	42	.30911	.04770

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	logSite1EC & logSite2EC	44	.929	.000
Pair 2	logSite1OC & logSite2OC	42	.870	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		Mean	Std. Deviation	Std. Error Mean
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Pair 1	logSite1EC - logSite2EC	-.04054	.10854	.01636	-.07354	-.00754	-2.478	43	.017
Pair 2	logSite1OC - logSite2OC	-.04271	.17301	.02670	-.09662	.01121	-1.600	41	.117

Table 6a. ANOVA of log EC $PM_{2.5}$ concentration with season

		Sum of Squares	Df	Mean Square	F	Sig.
Site1EC	Between Groups	.161	3	.054	.629	.600
	Within Groups	3.843	45	.085		
	Total	4.004	48			
Site2EC	Between Groups	.679	3	.226	1.292	.284
	Within Groups	11.919	68	.175		
	Total	12.598	71			

Multiple Comparisons Tukey HSD

Dependent Variable	(I) Season	(J) Season	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound
Site1EC	1	2	-0.14	0.12	0.67	-0.45	0.18
		3	-0.09	0.11	0.85	-0.40	0.21
		4	0.00	0.12	1.00	-0.33	0.32
	2	1	0.14	0.12	0.67	-0.18	0.45
		3	0.04	0.11	0.98	-0.26	0.35
		4	0.13	0.12	0.70	-0.19	0.46
	3	1	0.09	0.11	0.85	-0.21	0.40
		2	-0.04	0.11	0.98	-0.35	0.26
		4	0.09	0.12	0.88	-0.23	0.40
	4	1	0.00	0.12	1.00	-0.32	0.33
		2	-0.13	0.12	0.70	-0.46	0.19
		3	-0.09	0.12	0.88	-0.40	0.23
Site2EC	1	2	0.07	0.13	0.96	-0.28	0.41
		3	0.16	0.15	0.72	-0.24	0.57
		4	0.25	0.14	0.26	-0.11	0.61
	2	1	-0.07	0.13	0.96	-0.41	0.28
		3	0.10	0.15	0.92	-0.30	0.49
		4	0.18	0.13	0.50	-0.16	0.53
	3	1	-0.16	0.15	0.72	-0.57	0.24
		2	-0.10	0.15	0.92	-0.49	0.30
		4	0.09	0.15	0.94	-0.32	0.50
	4	1	-0.25	0.14	0.26	-0.61	0.11
		2	-0.18	0.13	0.50	-0.53	0.16
		3	-0.09	0.15	0.94	-0.50	0.32

* The mean difference is significant at the .05 level.

Table 6b. ANOVA of log OC $PM_{2.5}$ concentration with season

		Sum of Squares	df	Mean Square	F	Sig.
Site1OC	Between Groups	9.919	3	3.306	1.586	.206
	Within Groups	93.806	45	2.085		
	Total	103.725	48			
Site2OC	Between Groups	15.262	3	5.087	3.411	.022
	Within Groups	101.433	68	1.492		
	Total	116.695	71			

Multiple Comparisons Tukey HSD

Dependent Variable	(I) Season	(J) Season	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound
Site1OC	1	2	-0.74	0.59	0.60	-2.31	0.83
		3	-0.32	0.57	0.94	-1.83	1.20
		4	-1.23	0.60	0.19	-2.84	0.38
	2	1	0.74	0.59	0.60	-0.83	2.31
		3	0.42	0.57	0.88	-1.09	1.94
		4	-0.49	0.60	0.85	-2.10	1.12
	3	1	0.32	0.57	0.94	-1.20	1.83
		2	-0.42	0.57	0.88	-1.94	1.09
		4	-0.91	0.58	0.41	-2.47	0.64
	4	1	1.23	0.60	0.19	-0.38	2.84
		2	0.49	0.60	0.85	-1.12	2.10
		3	0.91	0.58	0.41	-0.64	2.47
Site2OC	1	2	-0.28	0.38	0.89	-1.28	0.73
		3	0.24	0.45	0.95	-0.94	1.43
		4	-1.03	0.40	0.06	-2.07	0.02
	2	1	0.28	0.38	0.89	-0.73	1.28
		3	0.52	0.44	0.64	-0.64	1.67
		4	-0.75	0.38	0.21	-1.76	0.26
	3	1	-0.24	0.45	0.95	-1.43	0.94
		2	-0.52	0.44	0.64	-1.67	0.64
		4	-1.27 (*)	0.45	0.03	-2.46	-0.08
	4	1	1.03	0.40	0.06	-0.02	2.07
		2	0.75	0.38	0.21	-0.26	1.76
		3	1.27(*)	0.45	0.03	0.08	2.46

* The mean difference is significant at the .05 level.

Table 7a. Summary statistics for target trace metal air concentration (ng/m^3)

All Data Combined		As	Cd	Co	Cu	Pb	Mg	Mn	Ni	Se	V
# Above MDL n=174		174	174	174	174	174	100	174	174	174	174
Mean		.820	.155	.253	5.57	3.67	29.0	2.58	7.19	1.41	3.15
Median		.693	.140	.178	4.43	3.20	20.2	2.16	4.52	.937	2.24
Std. Deviation		.537	.111	.223	4.68	2.78	44.9	1.84	10.1	1.45	3.22
Percentiles	25	.433	.0732	.083	2.71	1.96	11.3	1.43	2.28	.472	.979
	50	.693	.140	.178	4.43	3.20	20.2	2.16	4.52	.937	2.24
	75	1.03	.183	.305	6.79	4.70	37.7	3.39	7.53	1.74	4.03
Elizabeth RIOPA		1.2	0.6	0.1	11	7.5		5.6	5.3	1.5	6.6
NJ DEP 2006		1.1-1.3	7.3-7.6			3.6-6.0		1.4-2.9	2.3-4.9		

Site 1		As	Cd	Co	Cu	Pb	Mg	Mn	Ni	Se	V
# Above MDL n=94		80	80	80	80	80	44	80	80	80	80
Mean		.914	.164	.279	5.38	4.04	29.2	2.77	6.40	1.53	3.76
Median		.798	.155	.197	4.48	3.36	22.0	2.27	5.46	1.070	2.60
Std. Deviation		.533	.105	.240	4.09	3.34	30.7	2.05	5.27	1.52	3.83
Percentiles	25	.531	.0772	.0880	2.74	2.00	13.6	1.48	2.82	.524	1.17
	50	.798	.155	.197	4.48	3.36	22.0	2.27	5.46	1.07	2.60
	75	1.18	.197	.422	6.63	5.12	40.4	3.47	7.42	1.93	4.33

Site 2		As	Cd	Co	Cu	Pb	Mg	Mn	Ni	Se	V
# Above MDL n=94		94	94	94	94	94	56	94	94	94	94
Mean		.739	.146	.232	5.74	3.35	28.8	2.42	7.87	1.30	2.64
Median		.606	.129	.164	4.42	3.09	17.9	2.118	3.35	.880	1.95
Std. Deviation		.529	.116	.206	5.15	2.18	53.7	1.64	12.9	1.38	2.50
Percentiles	25	.385	.069	.0784	2.69	1.80	8.00	1.37	2.09	.404	.698
	50	.606	.129	.164	4.42	3.09	17.9	2.12	3.35	.880	1.95
	75	.932	.173	.292	7.36	4.17	35.8	3.39	7.66	1.47	3.63

Table 7b. Summary statistics for trace metal air concentration (ng/m3) - Non-target elements

All Data Combined		Li	Ti	Rb	Sr	Ag	Ba
# Above MDL n=174		174	174	174	154	174	174
Mean		.156	5.94	.202	1.52	.145	6.84
Median		.103	3.48	.173	.70	.161	5.31
Std. Deviation		.299	11.1	.174	7.14	.102	5.51
Percentiles	25	.0701	2.19	.133	.44	.0709	3.03
	50	.103	3.48	.173	.70	.161	5.31
	75	.174	5.75	.211	1.00	.177	9.20
Elizabeth RIOPA			10.4	0.1	1.8	0.5	22.9
NJ DEP 2006		Not Available					

Site 1		Li	Ti	Rb	Sr	Ag	Ba
# Above MDL n=94		80	80	80	71	80	80
Mean		.148	4.84	.229	1.12	.152	6.83
Median		.116	3.46	.189	.77	.161	5.21
Std. Deviation		.125	5.12	.227	1.58	.111	5.97
Percentiles	25	.0733	2.10	.147	.48	.0721	2.68
	50	.116	3.46	.189	.77	.161	5.21
	75	.181	5.69	.237	1.18	.183	7.99

Site 2		Li	Ti	Rb	Sr	Ag	Ba
# Above MDL n=94		94	94	94	83	94	94
Mean		.166	6.88	.180	1.86	.139	6.86
Median		.0797	3.50	.166	.65	.162	5.96
Std. Deviation		.391	14.3	.106	9.62	.094	5.13
Percentiles	25	.0665	2.22	.113	.35	.0684	3.25
	50	.0797	3.50	.166	.65	.162	5.96
	75	.172	6.55	.190	.87	.175	9.72

Table 8. Paired sample analysis of for the two sites for log metal $PM_{2.5}$ concentrations

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	logAs1	-.11656	70	.301584	.036046
	logAs2	-.21477	70	.300002	.035857
Pair 2	logCd1	-.85744	70	.258873	.030941
	logCd2	-.92665	70	.233637	.027925
Pair 3	logCo1	-.69621	70	.350646	.041910
	logCo2	-.77612	70	.354117	.042325
Pair 4	logCu1	.63522	70	.333840	.039901
	logCu2	.61540	70	.393888	.047079
Pair 5	logMg1	1.05044	33	.924174	.160878
	logMg2	.99851	33	.930347	.161953
Pair 6	logMn1	.35204	70	.335646	.040117
	logMn2	.27075	70	.327707	.039168
Pair 7	logNi1	.67357	70	.390476	.046671
	logNi2	.63279	70	.514487	.061493
Pair 8	logSe1	.01029	70	.410652	.049082
	logSe2	-.04796	70	.405680	.048488
Pair 9	logPb1	.50858	70	.344417	.041166
	logPb2	.42040	70	.349492	.041772
Pair	logV1	.33574	70	.534778	.063918
10	logV2	.20186	70	.525858	.062852

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	logAs1 & logAs2	70	.520	.000
Pair 2	logCd1 & logCd2	70	.775	.000
Pair 3	logCo1 & logCo2	70	.703	.000
Pair 4	logCu1 & logCu2	70	.449	.000
Pair 5	logMg1 & logMg2	33	.952	.000
Pair 6	logMn1 & logMn2	70	.549	.000
Pair 7	logNi1 & logNi2	70	.528	.000
Pair 8	logSe1 & logSe2	70	.726	.000
Pair 9	logPb1 & logPb2	70	.531	.000
Pair 10	logV1 & logV2	70	.813	.000

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	logAs1 - logAs2	.0982	.295	.0350	.0280	.168	2.79	69	.007
Pair 2	logCd1 - logCd2	.0692	.167	.0200	.0294	.109	3.47	69	.001
Pair 3	logCo1 - logCo2	.0799	.271	.0324	.0152	.145	2.46	69	.016
Pair 4	logCu1 - logCu2	.0198	.385	.0461	-.0720	.112	.430	69	.668
Pair 5	logPb1 – LogPb2	.0882	.336	.0402	.00802	.168	2.19	69	.032
Pair 6	logMg1 - logMg2	.0519	.287	.0500	-.0499	.153	1.04	32	.307
Pair 7	logMn1 - logMn2	.0813	.315	.0377	.0061	.156	2.16	69	.034
Pair 8	logNi1 - logNi2	.0408	.453	.0541	-.0671	.149	.754	69	.453
Pair 9	logSe1 - logSe2	.0582	.302	.0361	-.0138	.130	1.61	69	.111
Pair 10	logV1 – LogV2	.134	.324	.0388	.0566	.211	3.45	69	.001

Table 9. ANOVA of log metal $PM_{2.5}$ concentration with season

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
LogAs	Between Groups	.340	3	.113	1.250	.293
	Within Groups	15.426	170	.091		
	Total	15.766	173			
LogCd	Between Groups	.763	3	.254	4.277	.006
	Within Groups	10.103	170	.059		
	Total	10.865	173			
LogCo	Between Groups	1.209	3	.403	3.553	.016
	Within Groups	19.275	170	.113		
	Total	20.484	173			
LogCu	Between Groups	.051	3	.017	.121	.948
	Within Groups	24.070	170	.142		
	Total	24.121	173			
LogPb	Between Groups	.022	3	.007	.060	.981
	Within Groups	20.927	170	.123		
	Total	20.949	173			
LogMg	Between Groups	26.982	3	8.994	18.256	.000
	Within Groups	47.295	96	.493		
	Total	74.277	99			
LogMn	Between Groups	.239	3	.080	.675	.568
	Within Groups	20.099	170	.118		
	Total	20.338	173			
LogNi	Between Groups	.302	3	.101	.495	.686
	Within Groups	34.606	170	.204		
	Total	34.908	173			
LogSe	Between Groups	.625	3	.208	1.317	.271
	Within Groups	26.893	170	.158		
	Total	27.518	173			
LogV	Between Groups	.358	3	.119	.448	.719
	Within Groups	45.252	170	.266		
	Total	45.610	173			

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Season	(J) Season	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound
LogCd	1	2	.06548	.05195	.589	-.0693	.2003
		3	.11521	.04977	.099	-.0139	.2444
		4	.18103(*)	.05269	.004	.0443	.3178
	2	1	-.06548	.05195	.589	-.2003	.0693
		3	.04974	.05244	.779	-.0863	.1858
		4	.11555	.05522	.160	-.0277	.2588
	3	1	-.11521	.04977	.099	-.2444	.0139
		2	-.04974	.05244	.779	-.1858	.0863
		4	.06582	.05318	.604	-.0722	.2038
	4	1	-.18103(*)	.05269	.004	-.3178	-.0443
		2	-.11555	.05522	.160	-.2588	.0277
		3	-.06582	.05318	.604	-.2038	.0722
LogCo	1	2	.04595	.07175	.919	-.1402	.2321
		3	.05865	.06875	.829	-.1197	.2370
		4	.22777(*)	.07278	.011	.0389	.4166
	2	1	-.04595	.07175	.919	-.2321	.1402
		3	.01270	.07244	.998	-.1752	.2006
		4	.18182	.07628	.084	-.0161	.3797
	3	1	-.05865	.06875	.829	-.2370	.1197
		2	-.01270	.07244	.998	-.2006	.1752
		4	.16912	.07346	.102	-.0215	.3597
	4	1	-.22777(*)	.07278	.011	-.4166	-.0389
		2	-.18182	.07628	.084	-.3797	.0161
		3	-.16912	.07346	.102	-.3597	.0215
LogMg	1	2	.24760	.18957	.561	-.2481	.7432
		3	.85688(*)	.18065	.000	.3846	1.3292
		4	1.75593(*)	.27146	.000	1.0462	2.4657
	2	1	-.24760	.18957	.561	-.7432	.2481
		3	.60929(*)	.17514	.004	.1514	1.0672
		4	1.50834(*)	.26782	.000	.8081	2.2086
	3	1	-.85688(*)	.18065	.000	-1.3292	-.3846
		2	-.60929(*)	.17514	.004	-1.0672	-.1514
		4	.89905(*)	.26158	.005	.2151	1.5830
	4	1	-1.75593(*)	.27146	.000	-2.4657	-1.0462
		2	-1.50834(*)	.26782	.000	-2.2086	-.8081
		3	-.89905(*)	.26158	.005	-1.5830	-.2151

* The mean difference is significant at the .05 level.

Table 10. Summary statistics by site for the VOC concentration for compounds detected (µg/m³)

All Data	Benzene	Toluene	Ethyl-benzene	m,p-Xylene	o-Xylene	1,3,5-Trimethyl-benzene	1,2,4-Trimethyl-benzene	Styrene	Propyl benzene
Number above MDL	467	466	441	467	457	400	375	82	355
Number below MDL	7	8	33	7	17	74	99	392	119
Mean	.915	2.41	.532	1.38	.520	.284	.507	.0855	.162
Median	.765	2.07	.420	1.05	.419	.210	.426	.0479	.107
Std. Deviation	.572	1.80	.511	1.26	.450	.244	.491	.132	.179
Percentiles 25	.550	1.42	.241	.703	.298	.124	.219	.0253	.0457
50	.765	2.07	.420	1.05	.419	.210	.426	.0479	.107
75	1.13	2.94	.670	1.68	.607	.370	.702	.0845	.203
Elizabeth RIOPA	1.4±1.6	6.8±5.8	1.3±2.8	3.2±4.3	1.3±2.7			0.53±3.48	
NJDEP 2006	0.6-2.4	1.3-5.8	0.2-1.0	0.5-2.8	0.2-1.0	.059-.32	.15-.99	0.1-0.7	.05-.14

ALL DATA	p-Isopropyl benzene	n-Butyl benzene	Naph -thalene	1,1,1-Trichloro-ethane	Carbon Tetra-chloride	Trichloro -ethene	Tetrachloro-ethene	1,4-Dichloro-benzene
Number above MDL	229	218	355	218	392	326	343	356
Number below MDL	245	256	119	256	82	148	131	118
Mean	.138	.316	.062	.0605	.633	.279	.660	.203
Median	.0667	.171	.0365	.0496	.592	.220	.502	.154
Std. Deviation	.177	.407	.0813	.0486	.196	.237	.660	.180
Percentiles 25	.0324	.057	.0457	.0231	.524	.128	.285	.0762
50	.0667	.171	.1066	.0496	.592	.220	.502	.154
75	.184	.349	.2025	.0800	.714	.359	.789	.267
Elizabeth RIOPA*					0.84±2.3	0.57±2.2	1.1±3.1	3.8±27
NJDEP 2006#	.051-.25			.04-.05	.09-.1	.02-.16	.04-.11	.04-.2

*Weisel et al 2002
#http://www.epa.gov/aqspubl1/annual_summary.html

Table10 (continued)

Site 1	Benzene	Toluene	Ethyl-benzene	m,p-Xylene	o-Xylene	1,3,5-Trimethyl-benzene	1,2,4-Trimethyl-benzene	Styrene	Propyl benzene
Number above MDL	121	120	114	121	116	102	92	29	92
Number below MDL	0	1	7	0	5	19	29	92	29
Mean	.966	2.39	.465	1.27	.485	.251	.498	.0896	.180
Median	.811	2.06	.384	.970	.399	.201	.417	.0463	.115
Std. Deviation	.576	1.66	.341	1.07	.385	.201	.464	.137	.194
Percentiles 25	.585	1.38	.231	.594	.259	.116	.221	.0201	.0511
50	.811	2.06	.384	.970	.399	.201	.417	.0463	.1146
75	1.169	3.04	.647	1.66	.589	.323	.653	.0961	.2278

Site 1	p-Isopropyl benzene	n-Butyl benzene	Naph -thalene	1,1,1-Trichloro-ethane	Carbon Tetra-chloride	Trichloro -ethene	Tetrachloro-ethene	1,4-Dichloro-benzene
Number above MDL	63	58	44	57	98	85	85	96
Number below MDL	245	58	63	77	64	23	36	36
Mean	.138	.154	.358	.0695	.0687	.609	.279	.758
Median	.0667	.0905	.187	.0339	.0535	.566	.221	.527
Std. Deviation	.177	.170	.446	.112	.0520	.179	.206	.910
Percentiles 25	.0323	.0608	.0163	.0319	.489	.125	.273	.072
50	.0905	.187	.0339	.0535	.566	.221	.527	.167
75	.241	.395	.0832	.0920	.687	.362	.774	.294

Site 2	Benzene	Toluene	Ethyl-benzene	m,p-Xylene	o-Xylene	1,3,5-Trimethyl-benzene	1,2,4-Trimethyl-benzene	Styrene	Propyl benzene
Number above MDL	119	119	112	119	119	98	95	14	90
Number below MDL	2	2	9	2	2	23	26	107	31
Mean	.821	2.24	.453	1.17	.427	.299	.460	.0697	.143
Median	.663	2.07	.383	.972	.380	.186	.425	.0574	.0930
Std. Deviation	.498	1.32	.300	.691	.240	.243	.374	.0680	.143
Percentiles 25	.499	1.41	.235	.717	.298	.1219	.204	.0161	.0543
50	.663	2.07	.383	.972	.380	.1860	.425	.0574	.0930
75	1.06	2.70	.630	1.43	.513	.4578	.566	.0964	.175

Site 2	p-Isopropyl benzene	n-Butyl benzene	Naph -thalene	1,1,1-Trichloro-ethane	Carbon Tetra-chloride	Trichloro -ethene	Tetrachloro-ethene	1,4-Dichloro-benzene
Number above MDL	49	55	50	53	100	84	89	89
Number below MDL	72	66	71	68	21	37	32	32
Mean	.138	.274	.06118	.0519	.617	.282	.526	.172
Median	.0599	.178	.0310	.0386	.583	.230	.445	.130
Std. Deviation	.234	.340	.0754	.0337	.194	.210	.365	.147
Percentiles 25	.0283	.0721	.0227	.0227	.504	.142	.276	.0674
50	.0599	.178	.0386	.0386	.583	.230	.445	.125
75	.168	.314	.0773	.0773	.706	.371	.720	.234

Table10 (continued)

Site 3		Benzene	Toluene	Ethyl-benzene	m,p-Xylene	o-Xylene	1,3,5-Trimethyl-benzene	1,2,4-Trimethyl-benzene	Styrene	Propyl benzene
Number above MDL		112	111	106	111	107	99	90	13	81
Number below MDL		4	5	10	5	9	17	26	103	35
Mean		.821	.941	2.44	.550	1.31	.544	.289	.129	.184
Median		.663	.749	2.06	.397	1.04	.426	.225	.0445	.121
Std. Deviation		.498	.702	2.03	.697	.972	.590	.274	.228	.230
Percentiles	25	.547	1.44	.192	.659	.283	.126	.230	.0267	.037
	50	.749	2.06	.397	1.04	.426	.225	.414	.0445	.121
	75	1.16	3.01	.676	1.68	.628	.381	.764	.104	.225

Site 3		p-Isopropyl benzene	n-Butyl benzene	Naph -thalene	1,1,1-Trichloro-ethane	Carbon Tetra-chloride	Trichloro -ethene	Tetrachloro-ethene	1,4-Dichloro-benzene
Number above MDL		49	47	42	50	97	74	80	85
Number below MDL		67	69	74	66	19	42	36	31
Mean		.146	.369	.0522	.0580	.666	.273	.690	.234
Median		.0579	.161	.0356	.0441	.615	.206	.516	.168
Std. Deviation		.186	.461	.0537	.0603	.238	.219	.632	.211
Percentiles	25	.0324	.0531	.0193	.0213	.547	.127	.266	.104
	50	.0579	.161	.0365	.0441	.615	.206	.516	.18
	75	.197	.496	.0664	.0763	.777	.374	.816	.286

Site 4		Benzene	Toluene	Ethyl-benzene	m,p-Xylene	o-Xylene	1,3,5-Trimethyl-benzene	1,2,4-Trimethyl-benzene	Styrene	Propyl benzene
Number above MDL		115	116	109	116	115	101	98	26	92
Number below MDL		1	0	7	0	1	15	18	90	24
Mean		.821	.932	2.59	.668	1.79	.630	.297	.0680	.145
Median		.663	.805	2.06	.515	1.28	.505	.222	.0547	.104
Std. Deviation		.498	.490	2.13	.591	1.89	.504	.255	.0820	.139
Percentiles	25	.599	1.39	.321	.874	.350	.128	.213	.0320	.0445
	50	.805	2.06	.515	1.278	.505	.222	.446	.0547	.104
	75	1.13	3.21	.836	1.954	.708	.387	.762	.0732	.186

Site 4		p-Isopropyl benzene	n-Butyl benzene	Naph -thalene	1,1,1-Trichloro-ethane	Carbon Tetra-chloride	Trichloro -ethene	Tetrachloro-ethene	1,4-Dichloro-benzene
Number above MDL		68	58	49	58	97	83	89	86
Number below MDL		48	58	67	58	19	33	27	30
Mean		.118	.270	.0649	.0626	.639	.283	.675	.188
Median		.0679	.168	.0425	.0548	.602	.190	.482	.154
Std. Deviation		.123	.376	.0755	.0449	.165	.303	.617	.158
Percentiles	25	.0326	.0458	.0187	.0213	.533	.125	.302	.0758
	50	.0679	.168	.0425	.0548	.602	.190	.482	.154
	75	.164	.320	.0686	.0824	.725	.353	.848	.258

Table 11. Comparison of paired samples across sites (111 TRICHLOROETHANE)

111 TRICHLOROETHANE	Mean	Std. Deviation	N
TCA-site1	.05984	.052371	18
TCA-site2	.04966	.035274	18
TCA-site3	.04345	.020518	18
TCA-site4	.05001	.037999	18

		TCA-site1	TCA-site2	TCA-site3	TCA-site4
N	Valid	28	25	26	32
	Missing	120	123	122	116
Mean		.05262	.04325	.05508	.04637
Median		.04065	.03361	.03842	.03870
Std. Deviation		.045535	.032162	.076263	.033474

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
site	Sphericity Assumed	.002	3	.001	.676	.571
	Greenhouse-Geisser	.002	2.616	.001	.676	.552
	Huynh-Feldt	.002	3.000	.001	.676	.571
	Lower-bound	.002	1.000	.002	.676	.422
Error(site)	Sphericity Assumed	.062	51	.001		
	Greenhouse-Geisser	.062	44.472	.001		
	Huynh-Feldt	.062	51.000	.001		
	Lower-bound	.062	17.000	.004		

Table 12. Comparison of paired samples across sites (CARBON TETRACHLORIDE)

CARBON TETRACHLORIDE	Mean	Std. Deviation	N
CT-site1	-.24312	.136504	69
CT-site2	-.24729	.136518	69
CT-site3	-.22309	.265527	69
CT-site4	-.21087	.112156	69

		CT-site1	CT-site2	CT-site3	CT-site4
N	Valid	103	100	97	96
	Missing	45	48	51	52
Mean		.60322	.61744	.66618	.63860
Median		.57636	.58290	.61477	.60206
Std. Deviation		.183319	.193617	.237961	.165725

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
site	Sphericity Assumed	.061	3	.020	.836	.475
	Greenhouse-Geisser	.061	1.747	.035	.836	.422
	Huynh-Feldt	.061	1.790	.034	.836	.424
	Lower-bound	.061	1.000	.061	.836	.364
Error(site)	Sphericity Assumed	4.937	204	.024		
	Greenhouse-Geisser	4.937	118.827	.042		
	Huynh-Feldt	4.937	121.702	.041		
	Lower-bound	4.937	68.000	.073		

Table 13. Comparison of paired samples across sites (BENZENE)

BENZENE	Mean	Std. Deviation	N
Benz-site1	-.07003	.225508	105
Benz-site2	-.14844	.279283	105
Benz-site3	-.11676	.274770	105
Benz-site4	-.08843	.233650	105

		Benz-site1	Benz-site2	Benz-site3	Benz-site4
N	Valid	121	119	112	114
	Missing	27	29	36	34
Mean		.96614	.82122	.94135	.93138
Median		.81148	.66255	.74888	.80311
Std. Deviation		.575505	.498254	.701619	.491581

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
site	Sphericity Assumed	.370	3	.123	3.171	.025
	Greenhouse-Geisser	.370	2.884	.128	3.171	.026
	Huynh-Feldt	.370	2.975	.124	3.171	.025
	Lower-bound	.370	1.000	.370	3.171	.078
Error(site)	Sphericity Assumed	12.123	312	.039		
	Greenhouse-Geisser	12.123	299.973	.040		
	Huynh-Feldt	12.123	309.439	.039		
	Lower-bound	12.123	104.000	.117		

Table 14. Comparison of paired samples across sites (TRICHLOROETHYLENE)

TRICHLOROETHYLENE	Mean	Std. Deviation	N
TCE-site1	-.64068	.306994	58
TCE-site2	-.68236	.517286	58
TCE-site3	-.73106	.459140	58
TCE-site4	-.66528	.291687	58

		TCE-site1	TCE-site2	TCE-site3	TCE-site4
N	Valid	85	84	74	82
	Missing	63	64	74	66
Mean		.27862	.28174	.27276	.28474
Median		.22065	.22993	.20599	.19686
Std. Deviation		.205939	.209719	.218824	.304495

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
site	Sphericity Assumed	.254	3	.085	1.152	.330
	Greenhouse-Geisser	.254	2.216	.115	1.152	.323
	Huynh-Feldt	.254	2.309	.110	1.152	.324
	Lower-bound	.254	1.000	.254	1.152	.288
Error(site)	Sphericity Assumed	12.557	171	.073		
	Greenhouse-Geisser	12.557	126.295	.099		
	Huynh-Feldt	12.557	131.628	.095		
	Lower-bound	12.557	57.000	.220		

Table 15. Comparison of paired samples across sites (TOLUENE)

TOLUENE	Mean	Std. Deviation	N
Tol-site1	.25975	.305753	104
Tol-site2	.26040	.293053	104
Tol-site3	.28887	.311728	104
Tol-site4	.27891	.302541	104

		Tol-site1	Tol-site2	Tol-site3	Tol-site4
N	Valid	120	119	111	115
	Missing	28	29	37	33
Mean		2.38905	2.23618	2.44436	2.51304
Median		2.05661	2.07343	2.06016	2.02181
Std. Deviation		1.657634	1.322651	2.024530	1.987217

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
site	Sphericity Assumed	.064	3	.021	.718	.542
	Greenhouse-Geisser	.064	2.502	.026	.718	.518
	Huynh-Feldt	.064	2.570	.025	.718	.522
	Lower-bound	.064	1.000	.064	.718	.399
Error(site)	Sphericity Assumed	9.212	309	.030		
	Greenhouse-Geisser	9.212	257.757	.036		
	Huynh-Feldt	9.212	264.691	.035		
	Lower-bound	9.212	103.000	.089		

Table 16. Comparison of paired samples across sites (TETRAHCLOROETHYLENE)

TETRAHCLOROETHYLENE	Mean	Std. Deviation	N
PCE-site1	-.28156	.389892	62
PCE-site2	-.34400	.302331	62
PCE-site3	-.32635	.384796	62
PCE-site4	-.34297	.599767	62

		PCE-site1	PCE-site2	PCE-site3	PCE-site4
N	Valid	85	89	80	88
	Missing	63	59	68	60
Mean		.75823	.52555	.69033	.68133
Median		.52699	.44542	.51579	.49282
Std. Deviation		.910846	.364513	.632236	.617556

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
site	Sphericity Assumed	.064	3	.021	.718	.542
	Greenhouse-Geisser	.064	2.502	.026	.718	.518
	Huynh-Feldt	.064	2.570	.025	.718	.522
	Lower-bound	.064	1.000	.064	.718	.399
Error(site)	Sphericity Assumed	9.212	309	.030		
	Greenhouse-Geisser	9.212	257.757	.036		
	Huynh-Feldt	9.212	264.691	.035		
	Lower-bound	9.212	103.000	.089		

Table 17. Comparison of paired samples across sites (ETHYL BENZENE)

ETHYL BENZENE	Mean	Std. Deviation	N
EB-site1	-.40468	.297845	97
EB-site2	-.41896	.290606	97
EB-site3	-.41107	.383915	97
EB-site4	-.28175	.310308	97

		EB-site1	EB-site2	EB-site3	EB-site4
N	Valid	114	112	106	108
	Missing	34	36	42	40
Mean		.46495	.45253	.54968	.66930
Median		.38414	.38256	.39713	.51116
Std. Deviation		.340713	.300449	.696684	.593257

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	Df	Mean Square	F	Sig.
site	Sphericity Assumed	1.236	3	.412	9.127	.000
	Greenhouse-Geisser	1.236	2.566	.482	9.127	.000
	Huynh-Feldt	1.236	2.642	.468	9.127	.000
	Lower-bound	1.236	1.000	1.236	9.127	.003
Error(site)	Sphericity Assumed	13.000	288	.045		
	Greenhouse-Geisser	13.000	246.318	.053		
	Huynh-Feldt	13.000	253.664	.051		
	Lower-bound	13.000	96.000	.135		

Table 18. Comparison of paired samples across sites (m/p XYLENE)

m/p XYLENE	Mean	Std. Deviation	N
mpX-site1	.00262	.300809	104
mpX-site2	.00822	.243153	104
mpX-site3	.01987	.316157	104
mpX-site4	.13041	.287456	104

		mpX-site1	mpX-site2	mpX-site3	mpX-site4
N	Valid	121	119	111	115
	Missing	27	29	37	33
Mean		1.27288	1.17414	1.30803	1.78860
Median		.97035	.97180	1.03528	1.27149
Std. Deviation		1.072639	.691308	.971985	1.894754

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
site	Sphericity Assumed	1.143	3	.381	8.644	.000
	Greenhouse-Geisser	1.143	2.515	.454	8.644	.000
	Huynh-Feldt	1.143	2.583	.442	8.644	.000
	Lower-bound	1.143	1.000	1.143	8.644	.004
Error(site)	Sphericity Assumed	13.615	309	.044		
	Greenhouse-Geisser	13.615	259.063	.053		
	Huynh-Feldt	13.615	266.076	.051		
	Lower-bound	13.615	103.000	.132		

Table 19. Comparison of paired samples across sites (o XYLENE)

***o* XYLENE**	Mean	Std. Deviation	N
oX-site1	-.39777	.299339	98
oX-site2	-.40644	.248423	98
oX-site3	-.38129	.393031	98
oX-site4	-.27433	.257383	98

		oX-site1	oX-site2	oX-site3	oX-site4
N	Valid	116	119	107	114
	Missing	32	29	41	34
Mean		.48527	.42663	.54406	.63035
Median		.39888	.37957	.42565	.50185
Std. Deviation		.384946	.240397	.589801	.506008

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
site	Sphericity Assumed	1.105	3	.368	6.122	.000
	Greenhouse-Geisser	1.105	2.622	.422	6.122	.001
	Huynh-Feldt	1.105	2.702	.409	6.122	.001
	Lower-bound	1.105	1.000	1.105	6.122	.015
Error(site)	Sphericity Assumed	17.514	291	.060		
	Greenhouse-Geisser	17.514	254.358	.069		
	Huynh-Feldt	17.514	262.065	.067		
	Lower-bound	17.514	97.000	.181		

Table 20. Comparison of paired samples across sites (STYRENE)

STYRENE	Mean	Std. Deviation	N
Styr-site1	-1.28535	.317574	5
Styr-site2	-1.15740	.211125	5
Styr-site3	-1.28723	.377389	5
Styr-site4	-1.04928	.420341	5

		Styr-site1	Styr-site2	Styr-site3	Styr-site4
N	Valid	28	14	13	25
	Missing	120	134	135	123
Mean		.08926	.06973	.12849	.06697
Median		.04601	.05739	.04446	.04541
Std. Deviation		.139409	.067968	.228151	.083527

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
site	Sphericity Assumed	.197	3	.066	.611	.621
	Greenhouse-Geisser	.197	1.606	.122	.611	.538
	Huynh-Feldt	.197	2.519	.078	.611	.597
	Lower-bound	.197	1.000	.197	.611	.478
Error(site)	Sphericity Assumed	1.286	12	.107		
	Greenhouse-Geisser	1.286	6.424	.200		
	Huynh-Feldt	1.286	10.076	.128		
	Lower-bound	1.286	4.000	.322		

Table 21. Comparison of paired samples across sites (PROPYLBENZENE)

PROPYLBENZENE	Mean	Std. Deviation	N
ProBenz-site1	-1.00311	.452904	61
ProBenz-site2	-1.04337	.375106	61
ProBenz-site3	-.94916	.462393	61
ProBenz-site4	-.94842	.387682	61

		ProBenz-site1	ProBenz-site2	ProBenz-site3	ProBenz-site4
N	Valid	92	90	81	91
	Missing	56	58	67	57
Mean		.17954	.14250	.18433	.14604
Median		.11460	.09298	.12104	.10554
Std. Deviation		.193707	.143085	.230032	.139578

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
site	Sphericity Assumed	.388	3	.129	1.291	.279
	Greenhouse-Geisser	.388	2.652	.146	1.291	.280
	Huynh-Feldt	.388	2.786	.139	1.291	.280
	Lower-bound	.388	1.000	.388	1.291	.260
Error(site)	Sphericity Assumed	18.014	180	.100		
	Greenhouse-Geisser	18.014	159.128	.113		
	Huynh-Feldt	18.014	167.170	.108		
	Lower-bound	18.014	60.000	.300		

Table 22. Comparison of paired samples across sites (1,3,5 TRIMETHLYBENZENE)

1,3,5 TRIMETHLYBENZENE	Mean	Std. Deviation	N
TriBenz135-site1	-.66396	.334786	71
TriBenz135-site2	-.63512	.338802	71
TriBenz135-site3	-.60080	.343017	71
TriBenz135-site4	-.64756	.403986	71

TriBenz135-		site1	site2	site3	site4
N	Valid	102	98	99	100
	Missing	46	50	49	48
Mean		.25052	.29853	.28884	.29539
Median		.20130	.18602	.22507	.22228
Std. Deviation		.200638	.242930	.274182	.255732

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
site	Sphericity Assumed	.153	3	.051	.862	.462
	Greenhouse-Geisser	.153	2.758	.055	.862	.454
	Huynh-Feldt	.153	2.882	.053	.862	.458
	Lower-bound	.153	1.000	.153	.862	.356
Error(site)	Sphericity Assumed	12.417	210	.059		
	Greenhouse-Geisser	12.417	193.035	.064		
	Huynh-Feldt	12.417	201.741	.062		
	Lower-bound	12.417	70.000	.177		

Table 23. Comparison of paired samples across sites (1,2,4 TRIMETHLYBENZENE)

1,2,4 TRIMETHLYBENZENE	Mean	Std. Deviation	N
TriBenz-site1	-.45772	.444879	69
TriBenz-site2	-.49285	.364711	69
TriBenz-site3	-.37431	.389225	69
TriBenz-site4	-.4486	.38176	69

		TriBenz-site1	TriBenz-site2	TriBenz-site3	TriBenz-site4
N	Valid	92	95	90	97
	Missing	56	53	58	51
Mean		.49777	.46034	.58347	.48580
Median		.41718	.42537	.41438	.44547
Std. Deviation		.464298	.374317	.714466	.338558

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
site	Sphericity Assumed	.514	3	.171	3.144	.026
	Greenhouse-Geisser	.514	2.608	.197	3.144	.033
	Huynh-Feldt	.514	2.721	.189	3.144	.031
	Lower-bound	.514	1.000	.514	3.144	.081
Error(site)	Sphericity Assumed	11.119	204	.055		
	Greenhouse-Geisser	11.119	177.335	.063		
	Huynh-Feldt	11.119	185.040	.060		
	Lower-bound	11.119	68.000	.164		

Table 24. Comparison of paired samples across sites (p-ISOPROPLYBENZENE)

p-ISOPROPLYBENZENE	Mean	Std. Deviation	N
p-Isolbenz-site1	-1.22809	.754534	22
p-Isolbenz-site2	-1.30025	.538357	22
p-Isolbenz-site3	-1.22959	.562664	22
p-Isolbenz-site4	-1.2311	.48794	22

p-Isopropylbenzene		site1	site2	site3	site4
N	Valid	62	49	49	67
	Missing	86	99	99	81
Mean		.15624	.13765	.14604	.11922
Median		.09403	.05990	.05789	.06914
Std. Deviation		.170020	.234032	.185827	.123210

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
site	Sphericity Assumed	.082	3	.027	.125	.945
	Greenhouse-Geisser	.082	2.420	.034	.125	.915
	Huynh-Feldt	.082	2.758	.030	.125	.934
	Lower-bound	.082	1.000	.082	.125	.727
Error(site)	Sphericity Assumed	13.833	63	.220		
	Greenhouse-Geisser	13.833	50.817	.272		
	Huynh-Feldt	13.833	57.909	.239		
	Lower-bound	13.833	21.000	.659		

Table 25. Comparison of paired samples across sites (1,4 DICHLOROBENZENE)

1,4 DICHLOROBENZENE	Mean	Std. Deviation	N
DCB-site1	-.84076	.402349	61
DCB-site2	-.90258	.340233	61
DCB-site3	-.80261	.395707	61
DCB-site4	-.8592	.36547	61

		DCB-site1	DCB-site2	DCB-site3	DCB-site4
N	Valid	96	89	85	86
	Missing	52	59	63	62
Mean		.21788	.17168	.23382	.18827
Median		.16672	.12968	.16789	.15423
Std. Deviation		.193560	.147154	.210659	.157678

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
site	Sphericity Assumed	.316	3	.105	1.455	.228
	Greenhouse-Geisser	.316	2.846	.111	1.455	.230
	Huynh-Feldt	.316	3.000	.105	1.455	.228
	Lower-bound	.316	1.000	.316	1.455	.232
Error(site)	Sphericity Assumed	13.014	180	.072		
	Greenhouse-Geisser	13.014	170.774	.076		
	Huynh-Feldt	13.014	180.000	.072		
	Lower-bound	13.014	60.000	.217		

Table 26. Comparison of paired samples across sites (BUTLYBENZENE)

BUTLYBENZENE	Mean	Std. Deviation	N
ButlBenz-site1	-.77894	.528571	30
ButlBenz-site2	-.70359	.305414	30
ButlBenz-site3	-.79497	.470660	30
ButlBenz-site4	-.7372	.46490	30

Butyl benzene		site1	site2	site3	site4
N	Valid	58	55	47	57
	Missing	90	93	101	91
Mean		.35798	.27396	.36857	.27198
Median		.18653	.17800	.16133	.16780
Std. Deviation		.446441	.340300	.460570	.378727

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
site	Sphericity Assumed	.154	3	.051	.328	.805
	Greenhouse-Geisser	.154	2.181	.070	.328	.740
	Huynh-Feldt	.154	2.365	.065	.328	.757
	Lower-bound	.154	1.000	.154	.328	.571
Error(site)	Sphericity Assumed	13.579	87	.156		
	Greenhouse-Geisser	13.579	63.240	.215		
	Huynh-Feldt	13.579	68.578	.198		
	Lower-bound	13.579	29.000	.468		

Table 27. Comparison of paired samples across sites (NAPHTHALENE)

NAPHTHALENE	Mean	Std. Deviation	N
Naph-site1	-1.57638	.452666	21
Naph-site2	-1.52030	.374140	21
Naph-site3	-1.41237	.312215	21
Naph-site4	-1.5256	.46732	21

		Naph-site1	Naph-site2	Naph-site3	Naph-site4
N	Valid	43	50	42	48
	Missing	105	98	106	100
Mean		.07091	.06118	.05215	.06525
Median		.03602	.03097	.03651	.04214
Std. Deviation		.113008	.075417	.053651	.076303

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
site	Sphericity Assumed	.300	3	.100	.993	.402
	Greenhouse-Geisser	.300	2.354	.127	.993	.389
	Huynh-Feldt	.300	2.688	.112	.993	.396
	Lower-bound	.300	1.000	.300	.993	.331
Error(site)	Sphericity Assumed	6.040	60	.101		
	Greenhouse-Geisser	6.040	47.072	.128		
	Huynh-Feldt	6.040	53.751	.112		
	Lower-bound	6.040	20.000	.302		

Table 28. Paired t-test – post hoc analysis (BENZENE)

BENZENE		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Benz-site1	-.07358	119	.231099	.021185
	Benz-site2	-.16034	119	.271973	.024932
Pair 2	Benz-site2	-.16179	113	.274877	.025858
	Benz-site4	-.08299	113	.231581	.021785
Pair 3	Benz-site3	-.12123	106	.277298	.026934
	Benz-site4	-.09348	106	.238265	.023142
Pair 4	Benz-site1	-.07251	112	.232785	.021996
	Benz-site3	-.11378	112	.273311	.025825

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		Mean	Std. Deviation	Std. Error Mean
				Lower	Upper			
Benz-site1 - Benz-site2	.086759	.282283	.025877	.035515	.138002	3.353	118	.001
Benz-site2 - Benz-site4	-.078792	.293372	.027598	-.133474	-.024110	-2.855	112	.005
Benz-site3 - Benz-site4	-.027750	.292518	.028412	-.084086	.028585	-.977	105	.331
Benz-site1 - Benz-site3	.041264	.236722	.022368	-.003060	.085588	1.845	111	.068

Table 29. One way ANOVA of VOCs with season, all sites combined

		Sum of Squares	df	Mean Square	F	Sig.
log(1,1,1-Trichloroethane)	Between Groups	2.270	3	.757	8.698	.000
	Within Groups	18.616	214	.087		
	Total	20.886	217			
logCarbonTetrachloride	Between Groups	.442	3	.147	5.945	.001
	Within Groups	9.618	388	.025		
	Total	10.060	391			
logBenzene	Between Groups	2.136	3	.712	11.550	.000
	Within Groups	28.542	463	.062		
	Total	30.678	466			
logTrichloroethene	Between Groups	23.255	3	7.752	53.223	.000
	Within Groups	46.897	322	.146		
	Total	70.151	325			
logToluene	Between Groups	2.654	3	.885	9.875	.000
	Within Groups	41.392	462	.090		
	Total	44.047	465			
logTetrahcloroethene	Between Groups	4.103	3	1.368	7.323	.000
	Within Groups	63.314	339	.187		
	Total	67.418	342			
logEthylBenzene	Between Groups	2.872	3	.957	8.276	.000
	Within Groups	50.551	437	.116		
	Total	53.423	440			
logmpXylene	Between Groups	.271	3	.090	1.050	.370
	Within Groups	39.817	463	.086		
	Total	40.088	466			
logoXylene	Between Groups	.923	3	.308	2.859	.037
	Within Groups	48.738	453	.108		
	Total	49.661	456			
logStyrene	Between Groups	.130	3	.043	.169	.917
	Within Groups	19.956	78	.256		
	Total	20.086	81			
logPropylbenzene	Between Groups	.102	3	.034	.145	.933
	Within Groups	82.186	351	.234		
	Total	82.288	354			
Log(1,3,5 Trimethylbenzene)	Between Groups	4.920	3	1.640	12.042	.000
	Within Groups	53.934	396	.136		
	Total	58.854	399			
1,2,4 Trimethylbenzene	Between Groups	.543	3	.181	.891	.446
	Within Groups	75.396	371	.203		
	Total	75.939	374			
logpIsopropylbenzene	Between Groups	1.612	3	.537	1.533	.207
	Within Groups	78.881	225	.351		
	Total	80.493	228			
logpDichlorobenzene	Between Groups	2.380	3	.793	4.758	.003
	Within Groups	58.696	352	.167		
	Total	61.077	355			
lognButylbenzene	Between Groups	1.522	3	.507	1.152	.329
	Within Groups	94.288	214	.441		
	Total	95.810	217			
logNaphthalene	Between Groups	2.340	3	.780	3.732	.012
	Within Groups	37.829	181	.209		
	Total	40.169	184			

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Season	(J) Season	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
log(1,1,1-Trichloroethane)	1	2	.22418(*)	.05873	.001	.0721	.3762
		3	.06457	.05538	.649	-.0788	.2080
		4	-.06574	.05341	.608	-.2040	.0725
	2	1	-.22418(*)	.05873	.001	-.3762	-.0721
		3	-.15961(*)	.06053	.044	-.3164	-.0029
		4	-.28992(*)	.05873	.000	-.4420	-.1379
	3	1	-.06457	.05538	.649	-.2080	.0788
		2	.15961(*)	.06053	.044	.0029	.3164
		4	-.13031	.05538	.090	-.2737	.0131
	4	1	.06574	.05341	.608	-.0725	.2040
		2	.28992(*)	.05873	.000	.1379	.4420
		3	.13031	.05538	.090	-.0131	.2737
Log(Carbon Tetrachloride)	1	2	.07520(*)	.02264	.005	.0168	.1336
		3	.05880(*)	.02163	.034	.0030	.1146
		4	.00024	.02250	1.000	-.0578	.0583
	2	1	-.07520(*)	.02264	.005	-.1336	-.0168
		3	-.01639	.02264	.887	-.0748	.0420
		4	-.07495(*)	.02347	.008	-.1355	-.0144
	3	1	-.05880(*)	.02163	.034	-.1146	-.0030
		2	.01639	.02264	.887	-.0420	.0748
		4	-.05856(*)	.02250	.047	-.1166	-.0005
	4	1	-.00024	.02250	1.000	-.0583	.0578
		2	.07495(*)	.02347	.008	.0144	.1355
		3	.05856(*)	.02250	.047	.0005	.1166
Log(Benzene)	1	2	.03270	.03232	.743	-.0506	.1161
		3	.06905	.03192	.135	-.0133	.1514
		4	.18347(*)	.03300	.000	.0984	.2686
	2	1	-.03270	.03232	.743	-.1161	.0506
		3	.03634	.03206	.669	-.0463	.1190
		4	.15077(*)	.03313	.000	.0653	.2362
	3	1	-.06905	.03192	.135	-.1514	.0133
		2	-.03634	.03206	.669	-.1190	.0463
		4	.11443(*)	.03274	.003	.0300	.1988
	4	1	-.18347(*)	.03300	.000	-.2686	-.0984
		2	-.15077(*)	.03313	.000	-.2362	-.0653
		3	-.11443(*)	.03274	.003	-.1988	-.0300
Log(Trichloro-ethene)	1	2	-.74353(*)	.06339	.000	-.9072	-.5798
		3	-.47393(*)	.06421	.000	-.6398	-.3081
		4	-.23744(*)	.06467	.002	-.4044	-.0704
	2	1	.74353(*)	.06339	.000	.5798	.9072
		3	.26960(*)	.05661	.000	.1234	.4158
		4	.50609(*)	.05712	.000	.3586	.6536
	3	1	.47393(*)	.06421	.000	.3081	.6398
		2	-.26960(*)	.05661	.000	-.4158	-.1234
		4	.23649(*)	.05804	.000	.0866	.3864
	4	1	.23744(*)	.06467	.002	.0704	.4044
		2	-.50609(*)	.05712	.000	-.6536	-.3586
		3	-.23649(*)	.05804	.000	-.3864	-.0866
Log(Toluene)	1	2	.10134(*)	.03905	.048	.0006	.2020
		3	-.02538	.03857	.913	-.1248	.0741
		4	-.11389(*)	.03986	.023	-.2167	-.0111
	2	1	-.10134(*)	.03905	.048	-.2020	-.0006
		3	-.12672(*)	.03865	.006	-.2264	-.0270
		4	-.21523(*)	.03994	.000	-.3182	-.1122
	3	1	.02538	.03857	.913	-.0741	.1248
		2	.12672(*)	.03865	.006	.0270	.2264
		4	-.08851	.03947	.113	-.1903	.0133
	4	1	.11389(*)	.03986	.023	.0111	.2167
		2	.21523(*)	.03994	.000	.1122	.3182
		3	.08851	.03947	.113	-.0133	.1903

Dependent Variable	(I) Season	(J) Season	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
Log(Tetrahcloro-ethene)	1	2	.23387(*)	.07361	.009	.0438	.4239
		3	.23955(*)	.06303	.001	.0768	.4023
		4	.28388(*)	.06619	.000	.1130	.4548
	2	1	-.23387(*)	.07361	.009	-.4239	-.0438
		3	.00568	.06914	1.000	-.1728	.1842
		4	.05001	.07203	.899	-.1360	.2360
	3	1	-.23955(*)	.06303	.001	-.4023	-.0768
		2	-.00568	.06914	1.000	-.1842	.1728
		4	.04433	.06118	.887	-.1136	.2023
	4	1	-.28388(*)	.06619	.000	-.4548	-.1130
		2	-.05001	.07203	.899	-.2360	.1360
		3	-.04433	.06118	.887	-.2023	.1136
Log(Ethyl Benzene)	1	2	-.00340	.04693	1.000	-.1244	.1176
		3	-.17165(*)	.04632	.001	-.2911	-.0522
		4	.02406	.04792	.959	-.0995	.1476
	2	1	.00340	.04693	1.000	-.1176	.1244
		3	-.16825(*)	.04402	.001	-.2818	-.0547
		4	.02746	.04570	.932	-.0904	.1453
	3	1	.17165(*)	.04632	.001	.0522	.2911
		2	.16825(*)	.04402	.001	.0547	.2818
		4	.19571(*)	.04508	.000	.0795	.3120
	4	1	-.02406	.04792	.959	-.1476	.0995
		2	-.02746	.04570	.932	-.1453	.0904
		3	-.19571(*)	.04508	.000	-.3120	-.0795
Log(*mp* Xylene)	1	2	.05510	.03826	.475	-.0436	.1538
		3	.05260	.03771	.503	-.0446	.1498
		4	.01396	.03888	.984	-.0863	.1142
	2	1	-.05510	.03826	.475	-.1538	.0436
		3	-.00251	.03795	1.000	-.1004	.0954
		4	-.04115	.03912	.719	-.1420	.0597
	3	1	-.05260	.03771	.503	-.1498	.0446
		2	.00251	.03795	1.000	-.0954	.1004
		4	-.03864	.03858	.748	-.1381	.0608
	4	1	-.01396	.03888	.984	-.1142	.0863
		2	.04115	.03912	.719	-.0597	.1420
		3	.03864	.03858	.748	-.0608	.1381
Log(*o* Xylene)	1	2	.12792(*)	.04375	.019	.0151	.2407
		3	.06596	.04255	.408	-.0438	.1757
		4	.05873	.04385	.538	-.0543	.1718
	2	1	-.12792(*)	.04375	.019	-.2407	-.0151
		3	-.06196	.04304	.475	-.1730	.0490
		4	-.06918	.04433	.402	-.1835	.0451
	3	1	-.06596	.04255	.408	-.1757	.0438
		2	.06196	.04304	.475	-.0490	.1730
		4	-.00723	.04315	.998	-.1185	.1040
	4	1	-.05873	.04385	.538	-.1718	.0543
		2	.06918	.04433	.402	-.0451	.1835
		3	.00723	.04315	.998	-.1040	.1185
Log(Styrene)	1	2	.04175	.15918	.994	-.3761	.4596
		3	-.06727	.17379	.980	-.5235	.3890
		4	-.03365	.15636	.996	-.4441	.3768
	2	1	-.04175	.15918	.994	-.4596	.3761
		3	-.10902	.16466	.911	-.5413	.3233
		4	-.07540	.14614	.955	-.4591	.3083
	3	1	.06727	.17379	.980	-.3890	.5235
		2	.10902	.16466	.911	-.3233	.5413
		4	.03362	.16194	.997	-.3915	.4588
	4	1	.03365	.15636	.996	-.3768	.4441
		2	.07540	.14614	.955	-.3083	.4591
		3	-.03362	.16194	.997	-.4588	.3915
Log(Propyl-benzene)	1	2	.03762	.07349	.956	-.1521	.2273
		3	.02223	.07294	.990	-.1660	.2105

Dependent Variable	(I) Season	(J) Season	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		4	.04561	.07469	.929	-.1472	.2384
	2	1	-.03762	.07349	.956	-.2273	.1521
		3	-.01539	.07078	.996	-.1981	.1673
		4	.00799	.07258	1.000	-.1794	.1953
	3	1	-.02223	.07294	.990	-.2105	.1660
		2	.01539	.07078	.996	-.1673	.1981
		4	.02338	.07202	.988	-.1625	.2093
	4	1	-.04561	.07469	.929	-.2384	.1472
		2	-.00799	.07258	1.000	-.1953	.1794
		3	-.02338	.07202	.988	-.2093	.1625
Log(1,3,5 Trimethyl-	1	2	.09897	.05234	.234	-.0361	.2340
benzene)		3	.30184(*)	.05220	.000	.1672	.4365
		4	.18437(*)	.05155	.002	.0514	.3174
	2	1	-.09897	.05234	.234	-.2340	.0361
		3	.20287(*)	.05286	.001	.0665	.3392
		4	.08540	.05221	.360	-.0493	.2201
	3	1	-.30184(*)	.05220	.000	-.4365	-.1672
		2	-.20287(*)	.05286	.001	-.3392	-.0665
		4	-.11747	.05208	.110	-.2518	.0169
	4	1	-.18437(*)	.05155	.002	-.3174	-.0514
		2	-.08540	.05221	.360	-.2201	.0493
		3	.11747	.05208	.110	-.0169	.2518
Log(1,2,4	1	2	.03468	.06396	.949	-.1304	.1997
Trimethyl-		3	-.04777	.06742	.894	-.2218	.1262
benzene		4	-.05801	.06722	.824	-.2315	.1155
	2	1	-.03468	.06396	.949	-.1997	.1304
		3	-.08245	.06494	.583	-.2500	.0852
		4	-.09268	.06474	.480	-.2598	.0744
	3	1	.04777	.06742	.894	-.1262	.2218
		2	.08245	.06494	.583	-.0852	.2500
		4	-.01024	.06816	.999	-.1861	.1657
	4	1	.05801	.06722	.824	-.1155	.2315
		2	.09268	.06474	.480	-.0744	.2598
		3	.01024	.06816	.999	-.1657	.1861
Log(*p* Isopropyl-	1	2	-.24064	.11762	.174	-.5451	.0638
benzene)		3	-.11619	.10859	.708	-.3973	.1649
		4	-.16408	.10695	.419	-.4409	.1127
	2	1	.24064	.11762	.174	-.0638	.5451
		3	.12446	.11635	.708	-.1767	.4256
		4	.07657	.11482	.909	-.2206	.3738
	3	1	.11619	.10859	.708	-.1649	.3973
		2	-.12446	.11635	.708	-.4256	.1767
		4	-.04789	.10555	.969	-.3211	.2253
	4	1	.16408	.10695	.419	-.1127	.4409
		2	-.07657	.11482	.909	-.3738	.2206
		3	.04789	.10555	.969	-.2253	.3211
Log(*p* Dichloro-	1	2	.17223(*)	.05892	.019	.0201	.3243
benzene)		3	-.05064	.06152	.843	-.2094	.1082
		4	.05631	.05965	.781	-.0977	.2103
	2	1	-.17223(*)	.05892	.019	-.3243	-.0201
		3	-.22287(*)	.06339	.003	-.3865	-.0592
		4	-.11592	.06158	.237	-.2749	.0430
	3	1	.05064	.06152	.843	-.1082	.2094
		2	.22287(*)	.06339	.003	.0592	.3865
		4	.10695	.06407	.342	-.0584	.2723
	4	1	-.05631	.05965	.781	-.2103	.0977
		2	.11592	.06158	.237	-.0430	.2749
		3	-.10695	.06407	.342	-.2723	.0584
Log(n Butyl-	1	2	-.17057	.14282	.631	-.5404	.1992
benzene)		3	-.21552	.11949	.274	-.5249	.0939
		4	-.10866	.12660	.826	-.4365	.2191
	2	1	.17057	.14282	.631	-.1992	.5404

Dependent Variable	(I) Season	(J) Season	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		3	-.04495	.13549	.987	-.3958	.3059
		4	.06191	.14180	.972	-.3053	.4291
	3	1	.21552	.11949	.274	-.0939	.5249
		2	.04495	.13549	.987	-.3059	.3958
		4	.10686	.11827	.803	-.1994	.4131
	4	1	.10866	.12660	.826	-.2191	.4365
		2	-.06191	.14180	.972	-.4291	.3053
		3	-.10686	.11827	.803	-.4131	.1994
Log(Naphtha-lene)	1	2	.08614	.08682	.754	-.1390	.3113
		3	-.09382	.10681	.816	-.3708	.1831
		4	-.20707	.09007	.102	-.4406	.0265
	2	1	-.08614	.08682	.754	-.3113	.1390
		3	-.17996	.10775	.343	-.4594	.0995
		4	-.29320(*)	.09120	.008	-.5297	-.0567
	3	1	.09382	.10681	.816	-.1831	.3708
		2	.17996	.10775	.343	-.0995	.4594
		4	-.11325	.11040	.735	-.3995	.1730
	4	1	.20707	.09007	.102	-.0265	.4406
		2	.29320(*)	.09120	.008	.0567	.5297
		3	.11325	.11040	.735	-.1730	.3995

* The mean difference is significant at the .05 level.

Table 30. Paired t-test – post hoc analysis (*m/p* XYLENE)

m/p XYLENE		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	mpX-site2	-.00198	113	.251300	.023640
	mpX-site4	.13882	113	.285506	.026858
Pair 2	mpX-site1	-.00399	119	.306980	.028141
	mpX-site2	.00048	119	.249825	.022901
Pair 3	mpX-site2	.01064	109	.242957	.023271
	mpX-site3	.01567	109	.311877	.029872
Pair 4	mpX-site3	.01870	106	.313933	.030492
	mpX-site4	.12915	106	.289364	.028106
Pair 5	mpX-site1	-.00313	115	.305759	.028512
	mpX-site4	.13751	115	.287345	.026795
Pair 6	mpX-site1	-.00022	111	.296479	.028141
	mpX-site3	.01463	111	.309790	.029404

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		Mean	Std. Deviation	Std. Error Mean
				Lower	Upper			
mpX-site2 - mpX-site4	-.140806	.313265	.029469	-.199196	-.082416	-4.778	112	.000
mpX-site1 - mpX-site2	-.004463	.236217	.021654	-.047344	.038418	-.206	118	.837
mpX-site2 - mpX-site3	-.005022	.254275	.024355	-.053298	.043254	-.206	108	.837
mpX-site3 - mpX-site4	-.110445	.327405	.031800	-.173499	-.047390	-3.473	105	.001
mpX-site1 - mpX-site4	-.140638	.362505	.033804	-.207603	-.073673	-4.160	114	.000
mpX-site1 - mpX-site3	-.014851	.277882	.026375	-.067121	.037419	-.563	110	.575

Table 31. Paired t-test – post hoc analysis (*o* XYLENE)

o XYLENE		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	oX-site2	-.43469	112	.269638	.025478
	oX-site4	-.28912	112	.275043	.025989
Pair 2	oX-site1	-.41867	114	.326801	.030608
	oX-site2	-.43129	114	.265688	.024884
Pair 3	oX-site1	-.40085	104	.295361	.028963
	oX-site3	-.40204	104	.408730	.040079
Pair 4	oX-site1	-.42076	111	.326289	.030970
	oX-site4	-.28748	111	.282088	.026775
Pair 5	oX-site3	-.39026	102	.389260	.038543
	oX-site4	-.28340	102	.264552	.026195
Pair 6	oX-site2	-.41706	105	.259362	.025311
	oX-site3	-.40730	105	.413748	.040378

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		Mean	Std. Deviation	Std. Error Mean
				Lower	Upper			
oX-site2 - oX-site4	-.145567	.341325	.032252	-.209476	-.081657	-4.513	111	.000
oX-site1 - oX-site2	.012619	.258024	.024166	-.035259	.060496	.522	113	.603
oX-site1 - oX-site3	.001183	.361026	.035402	-.069028	.071393	.033	103	.973
oX-site1 - oX-site4	-.133276	.358376	.034015	-.200687	-.065865	-3.918	110	.000
oX-site3 - oX-site4	-.106855	.396243	.039234	-.184684	-.029025	-2.724	101	.008
oX-site2 - oX-site3	-.009763	.372641	.036366	-.081878	.062352	-.268	104	.789

Table 32. Paired t-test – post hoc analysis (1,2,4 TRIMETHLYBENZENE)

1,2,4 TRIMETHLYBENZENE		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	TriBenz-site2	-.50824	80	.463329	.051802
	TriBenz-site3	-.38668	80	.385262	.043074
Pair 2	TriBenz-site2	-.52744	86	.480063	.051767
	TriBenz-site4	-.4408	86	.38089	.04107
Pair 3	TriBenz-site1	-.48034	85	.460930	.049995
	TriBenz-site4	-.4514	85	.41900	.04545
Pair 4	TriBenz-site3	-.41346	80	.442578	.049482
	TriBenz-site4	-.4515	80	.40444	.04522

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		Mean	Std. Deviation	Std. Error Mean
				Lower	Upper			
TriBenz-site2 - TriBenz-site3	-.121556	.340636	.038084	-.197361	-.045751	-3.192	79	.002
TriBenz-site2 - TriBenz-site4	-.086645	.406969	.043885	-.173900	.000609	-1.974	85	.052
TriBenz-site1 - TriBenz-site4	-.028932	.371393	.040283	-.109039	.051176	-.718	84	.475
TriBenz-site3 - TriBenz-site4	.038000	.368174	.041163	-.043933	.119933	.923	79	.359

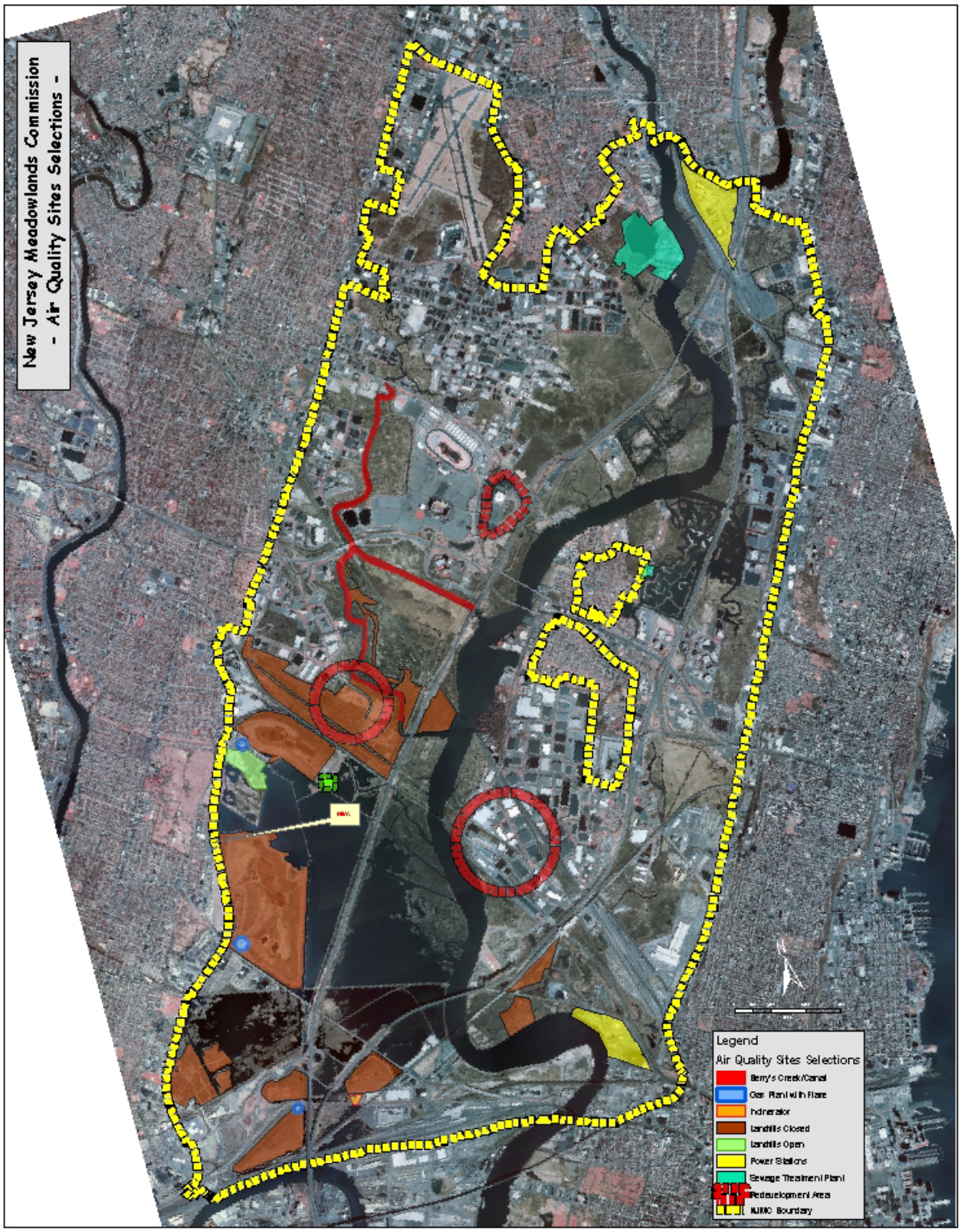
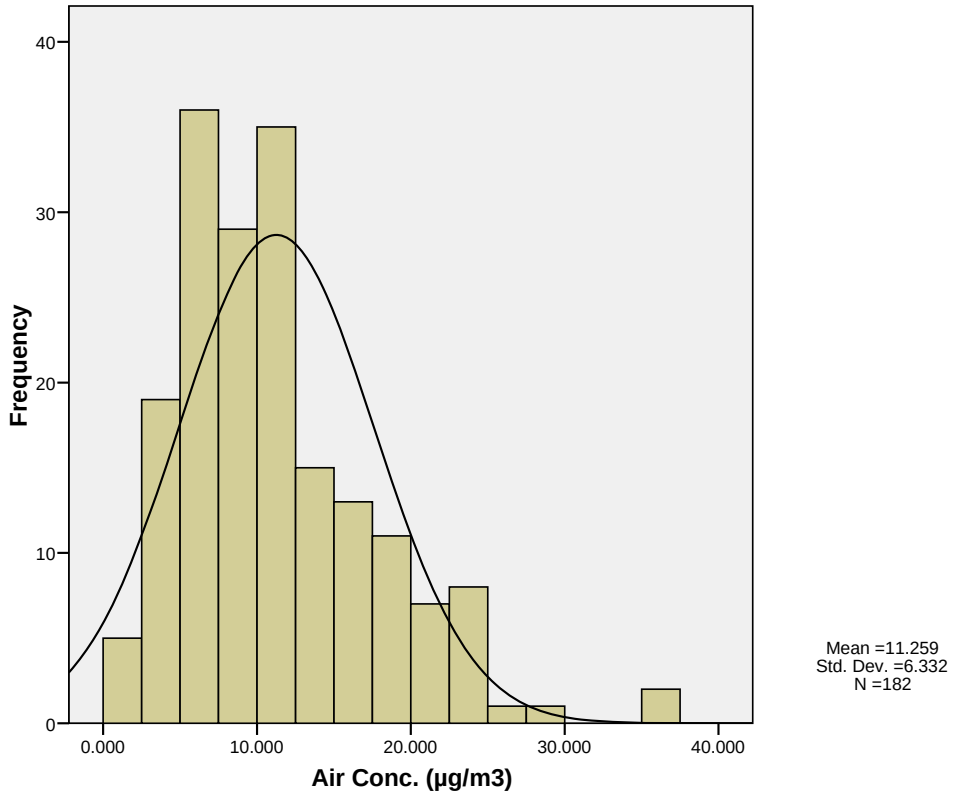


Figure 1. Map showing land use that were considered in sampling site considerations

(a)



(b)

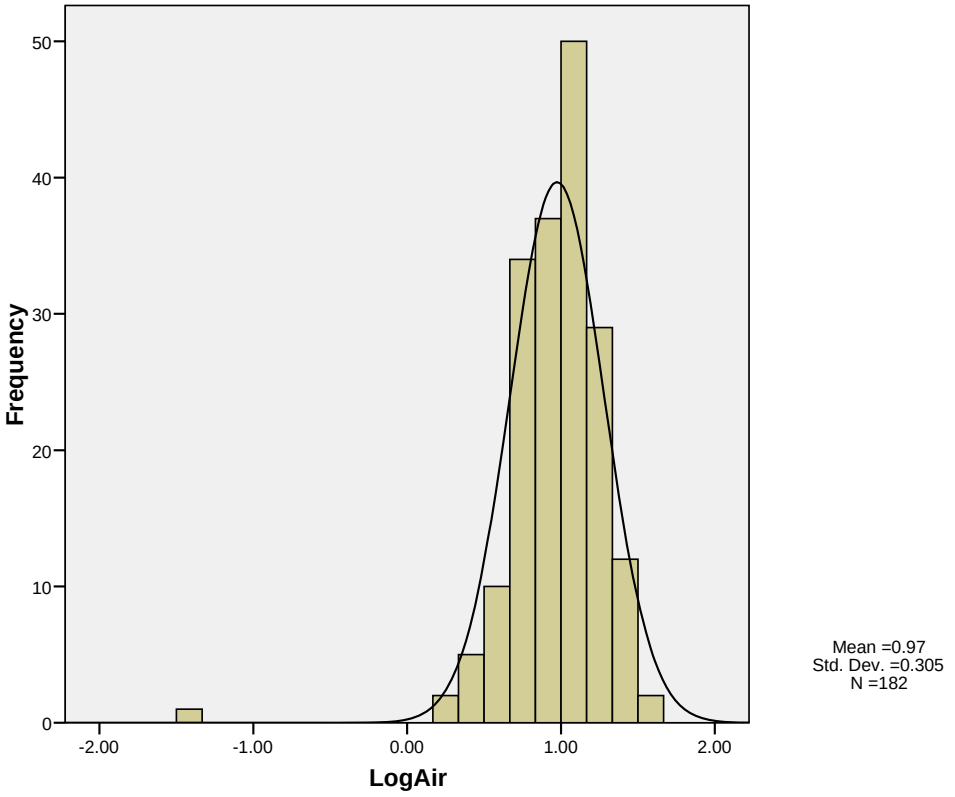


Figure 2. (a) Distribution of $PM_{2.5}$ mass concentration (µg/m^3); (b) Distribution of log $PM_{2.5}$ mass concentration (µg/m^3)

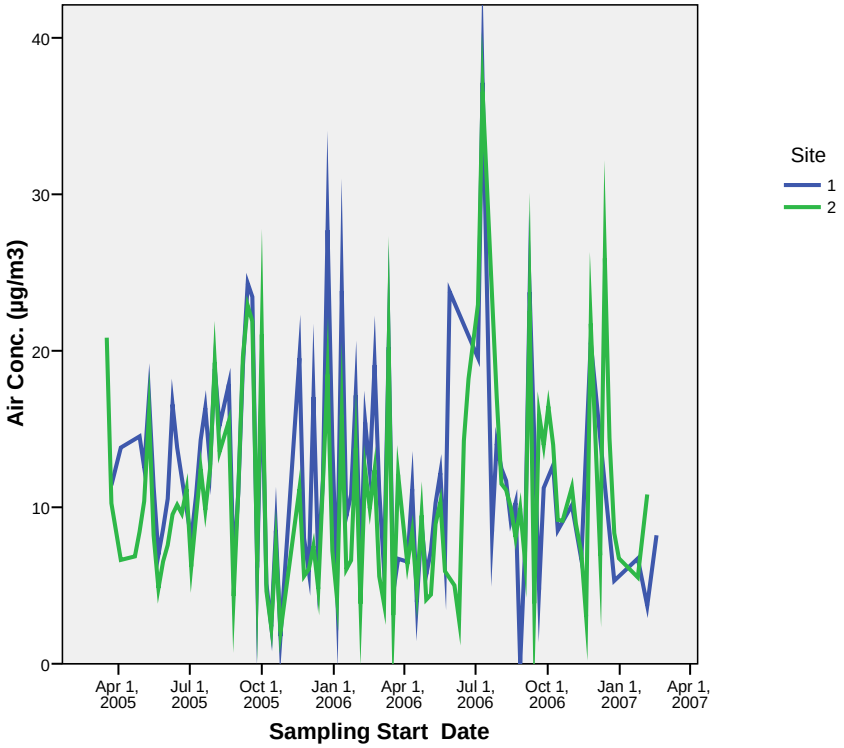


Figure 3. $PM_{2.5}$ mass concentration by site with date (µg/m^3). Site 1 NJMC Headquarters; Site 2 Sports Complex

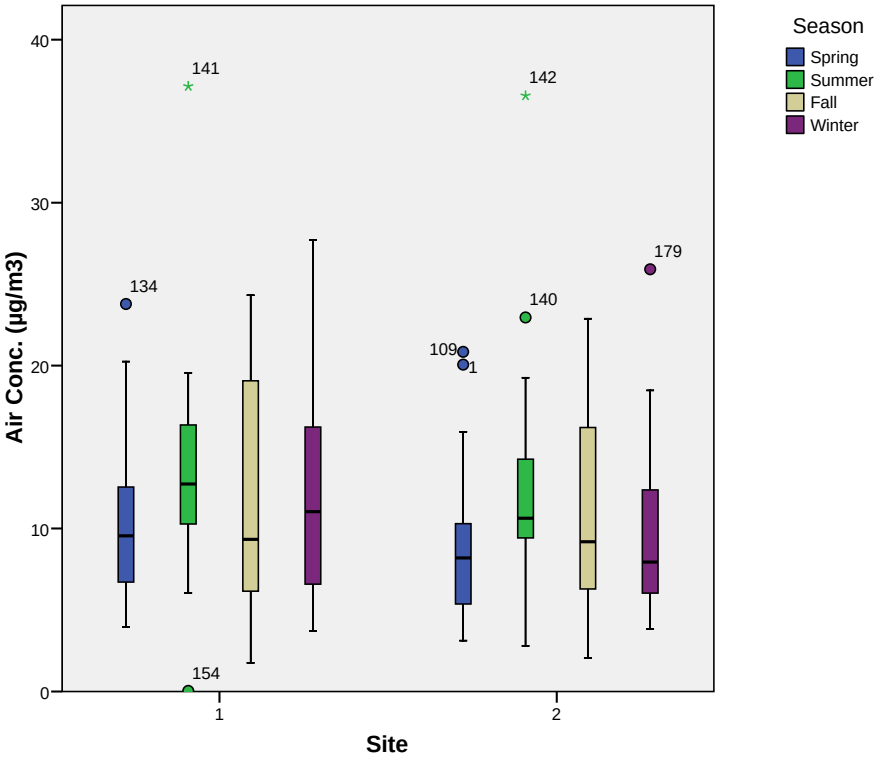
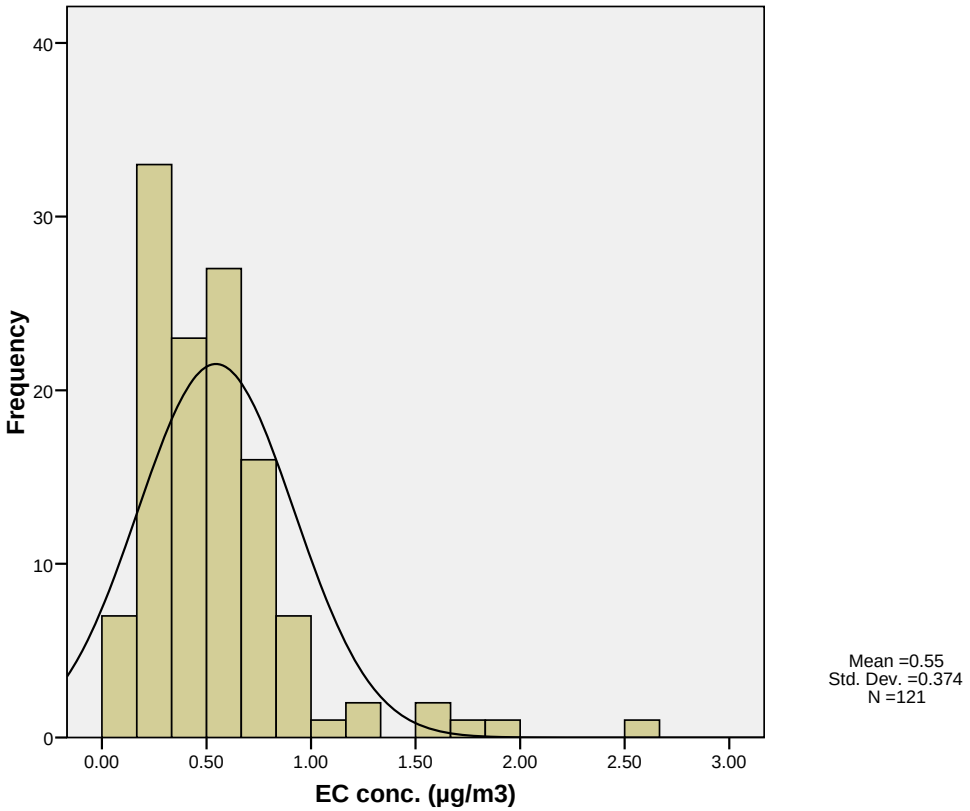


Figure 4. Box and whisker plot of PM2.5 mass by site and season. Site 1 NJMC Headquarters; Site 2 Sports Complex

(a)



(b)

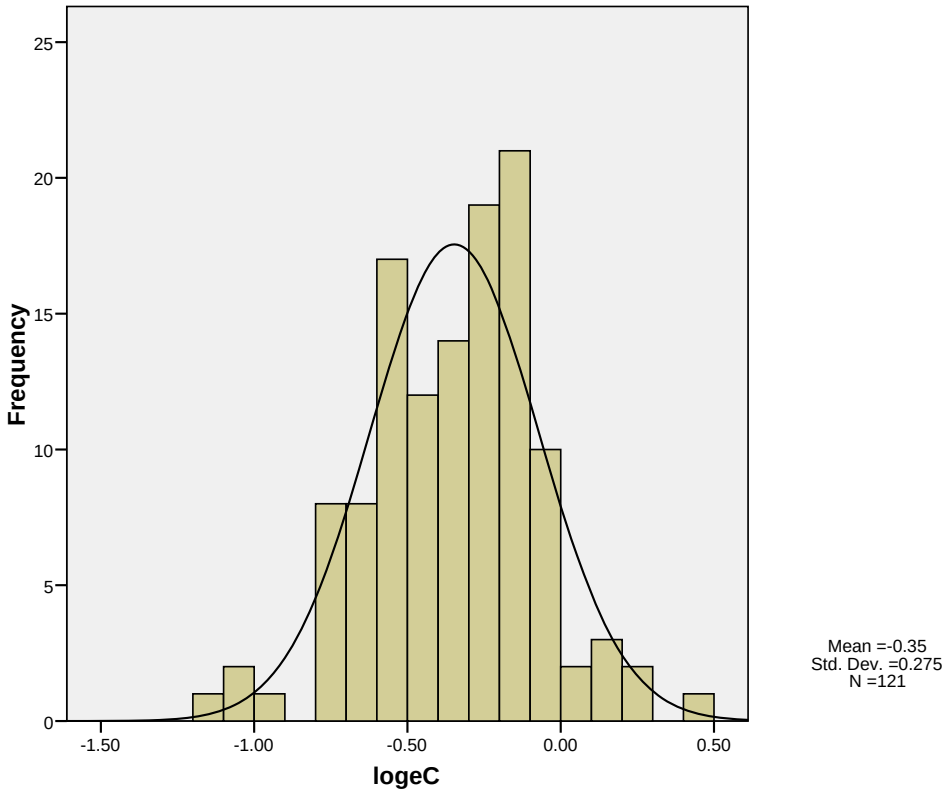
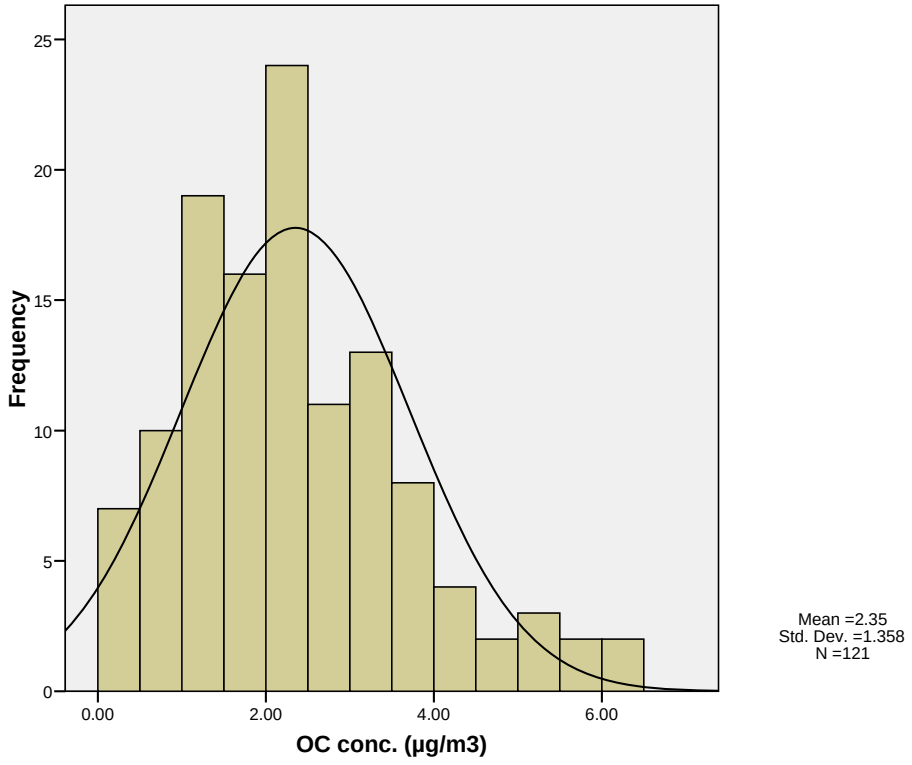


Figure 5. (a) Distribution of elemental carbon $PM_{2.5}$ concentration; (b) Distribution of elemental carbon $PM_{2.5}$ log concentration

(a)



(b)

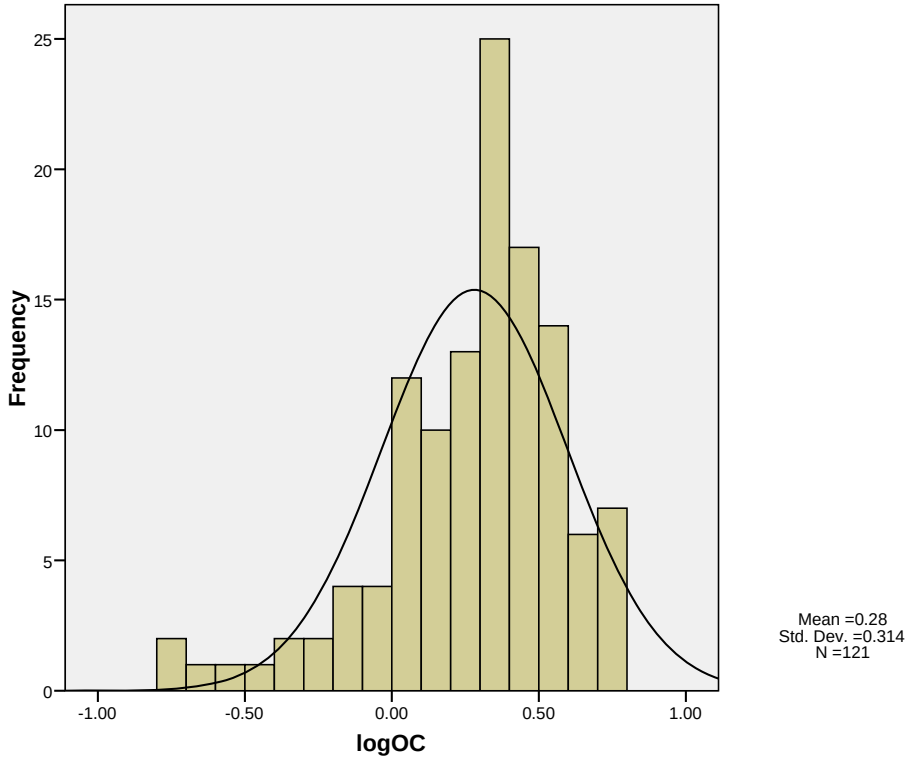
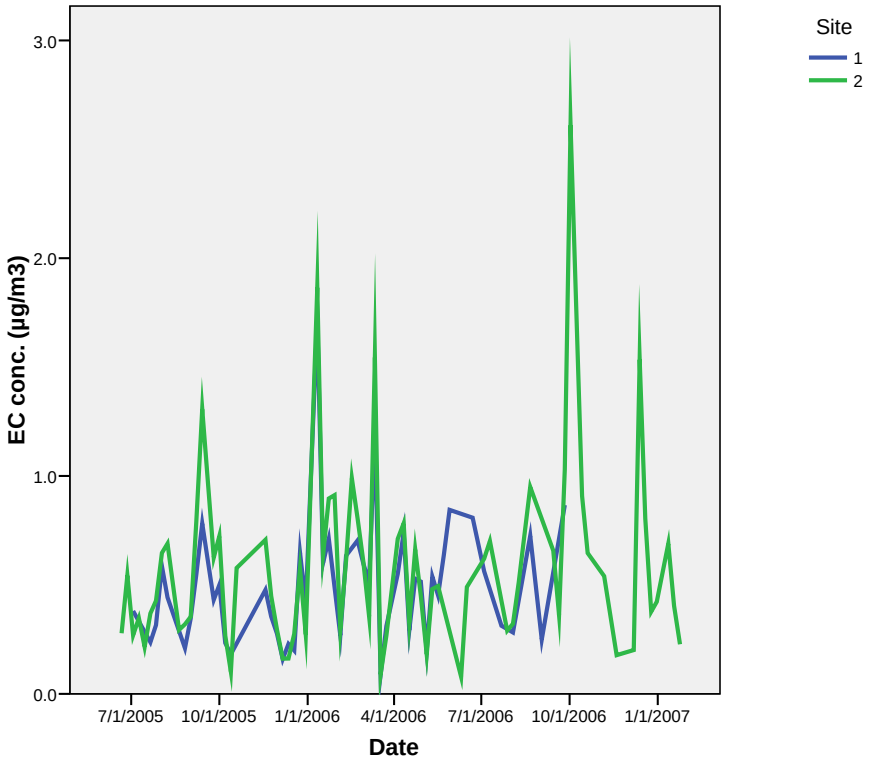


Figure 6. (a) Distribution of organic carbon $PM_{2.5}$ concentration (µg/m^3); (b) Distribution of organic carbon $PM_{2.5}$ log concentration (µg/m^3)

(a)



(b)

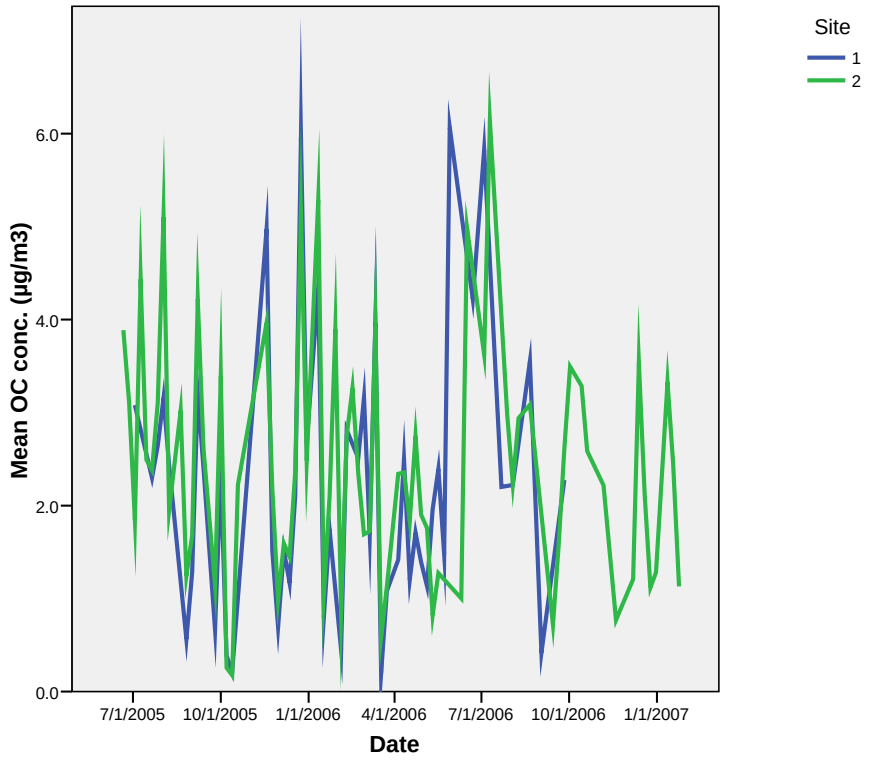
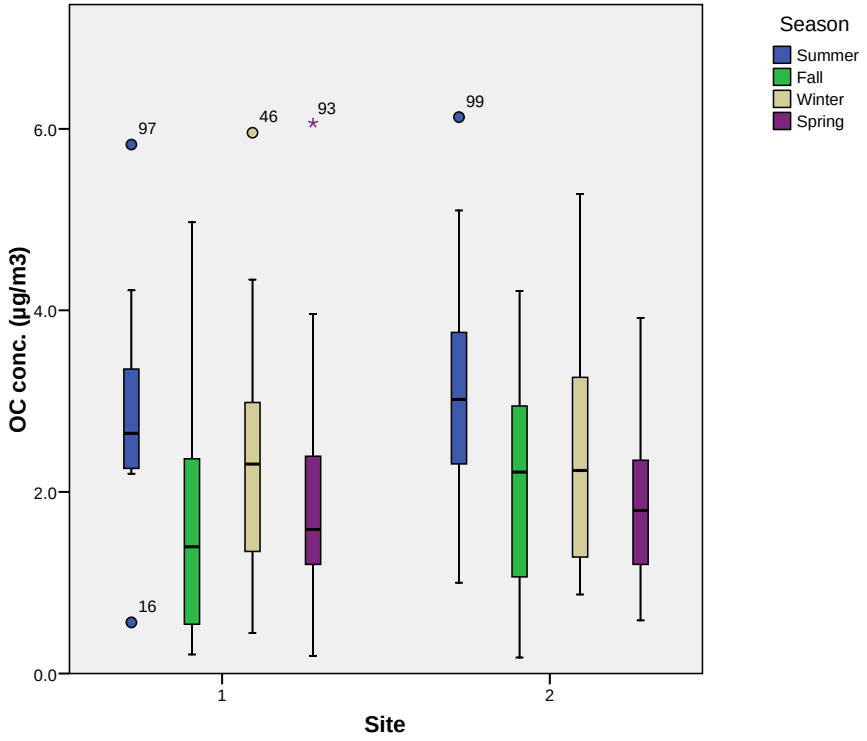


Figure 7. (a). Temporal elemental carbon concentration (µg/m^3) by site and; (b) Temporal organic carbon concentration (µg/m^3) by Site. Site 1 NJMS Headquarters; Site 2 Sports Complex

(a)



(b)

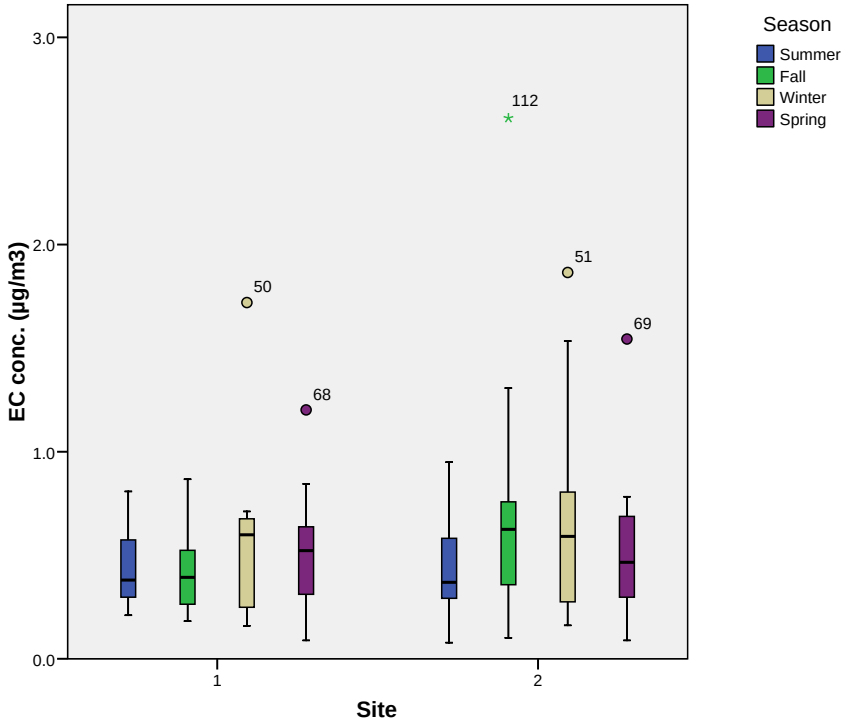
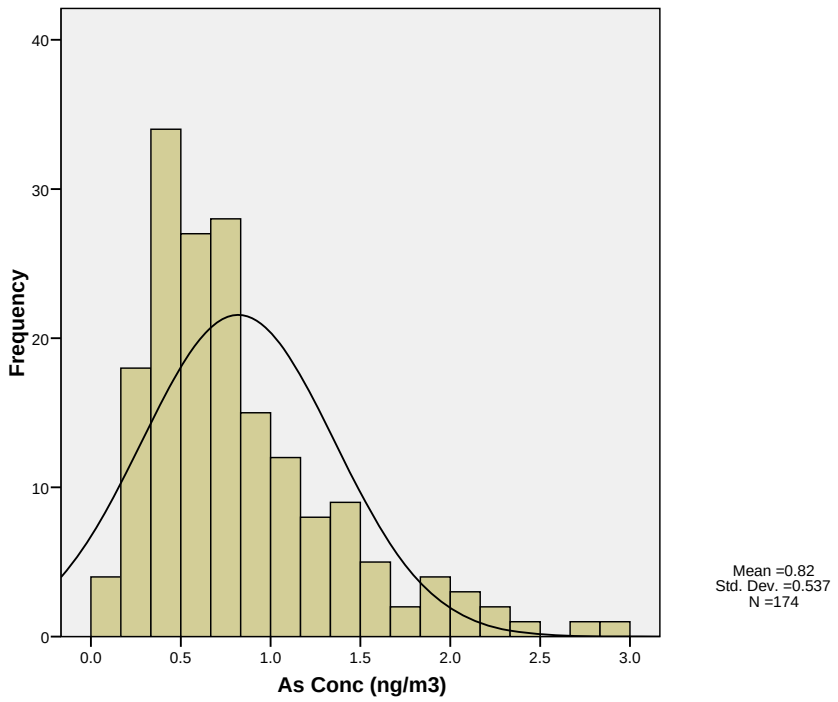


Figure 8. (a) Box and whisker plot of organic carbon concentration (µg/m^3) by site and season; (b) Box and whisker plot of elemental carbon concentration (µg/m^3) by site and season. Site 1 NJMC Headquarters; Site 2 Sports Complex

(a)



(b)

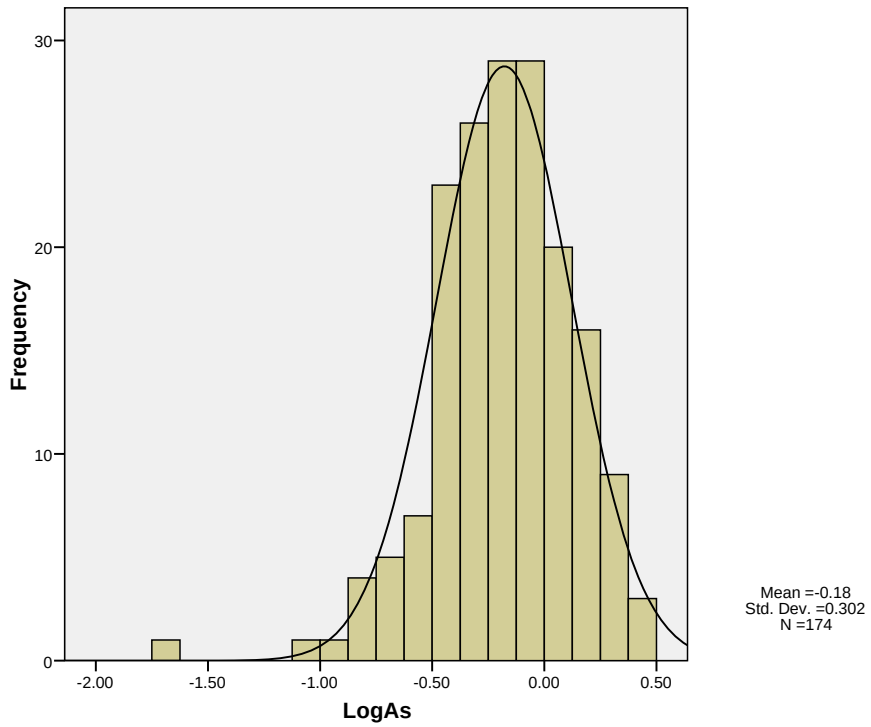
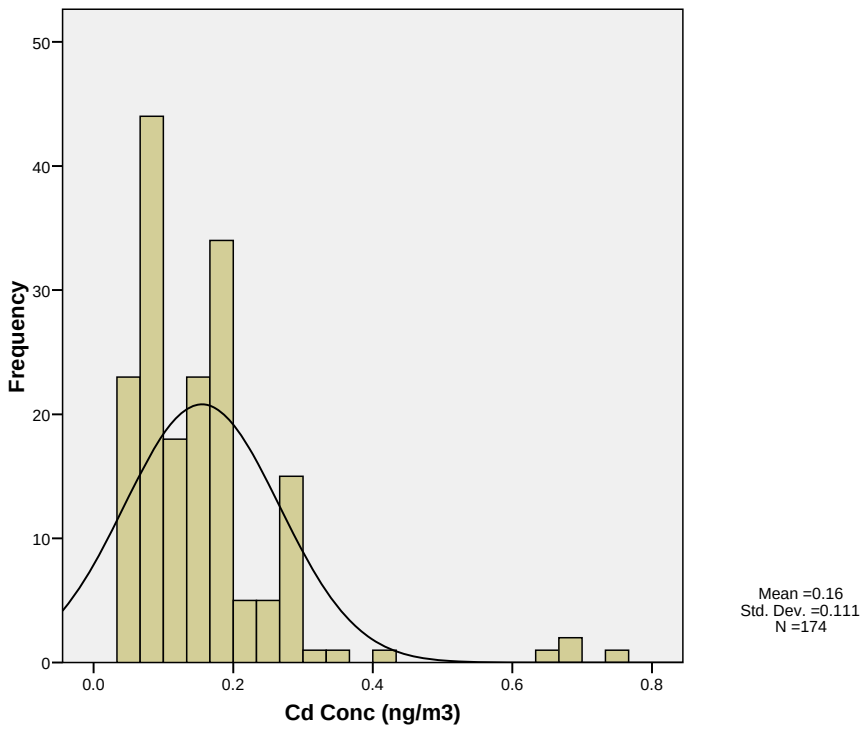


Figure 9. (a) Distribution of arsenic $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of arsenic $PM_{2.5}$ log concentration (μg/m^3)

(a)



(b)

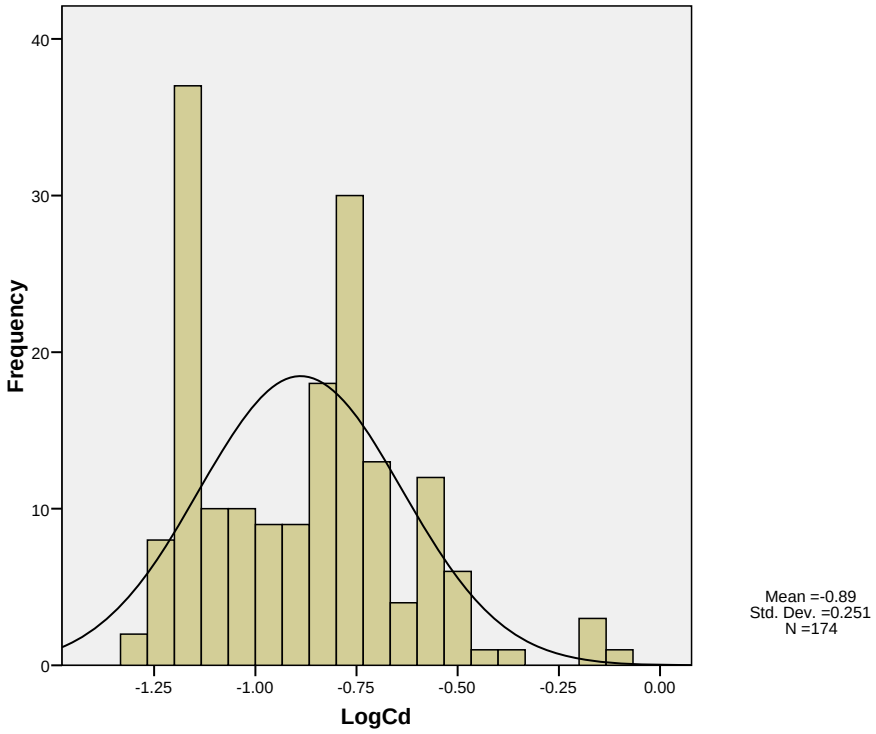
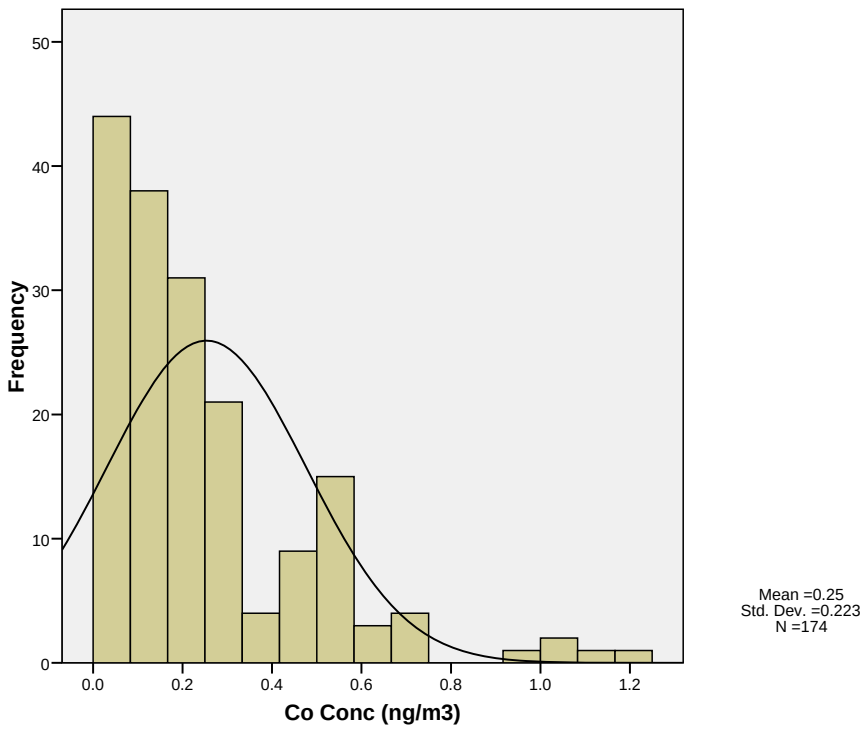


Figure 10. (a) Distribution of cadmium $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of cadmium $PM_{2.5}$ log concentration (μg/m^3)

(a)



(b)

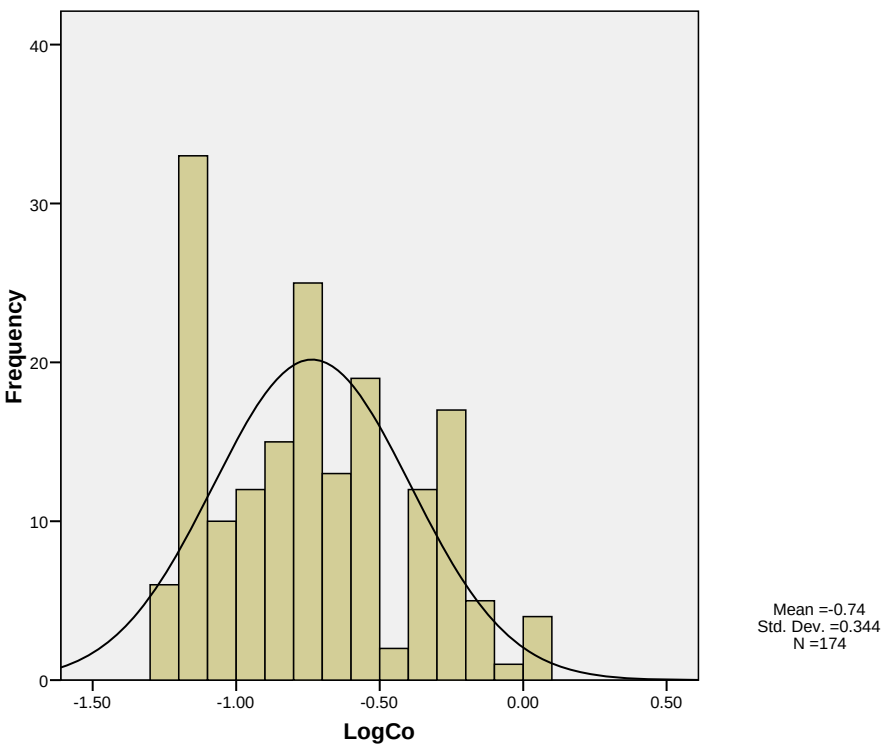
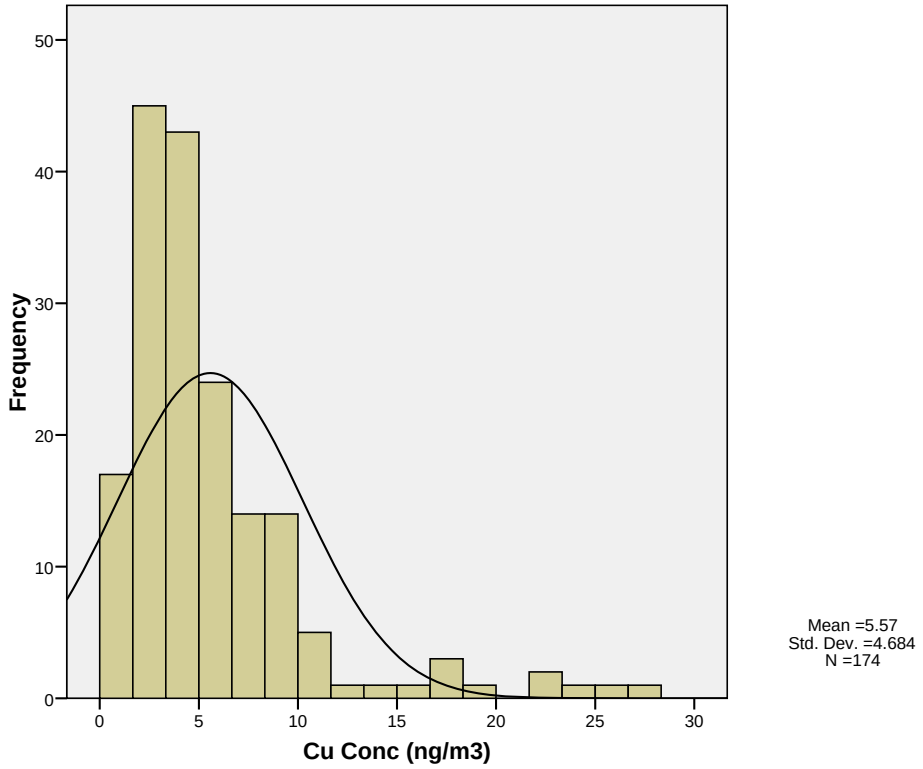


Figure 11. (a) Distribution of cobalt $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of cobalt PM2.5 log concentration (μg/m^3)

(a)



(b)

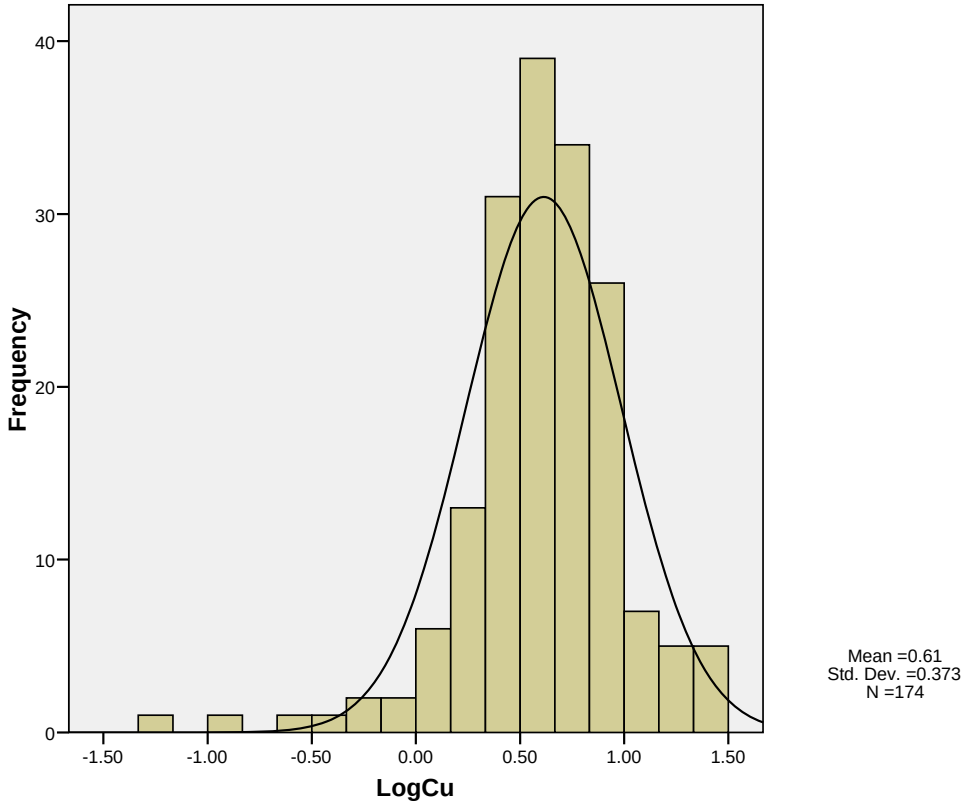
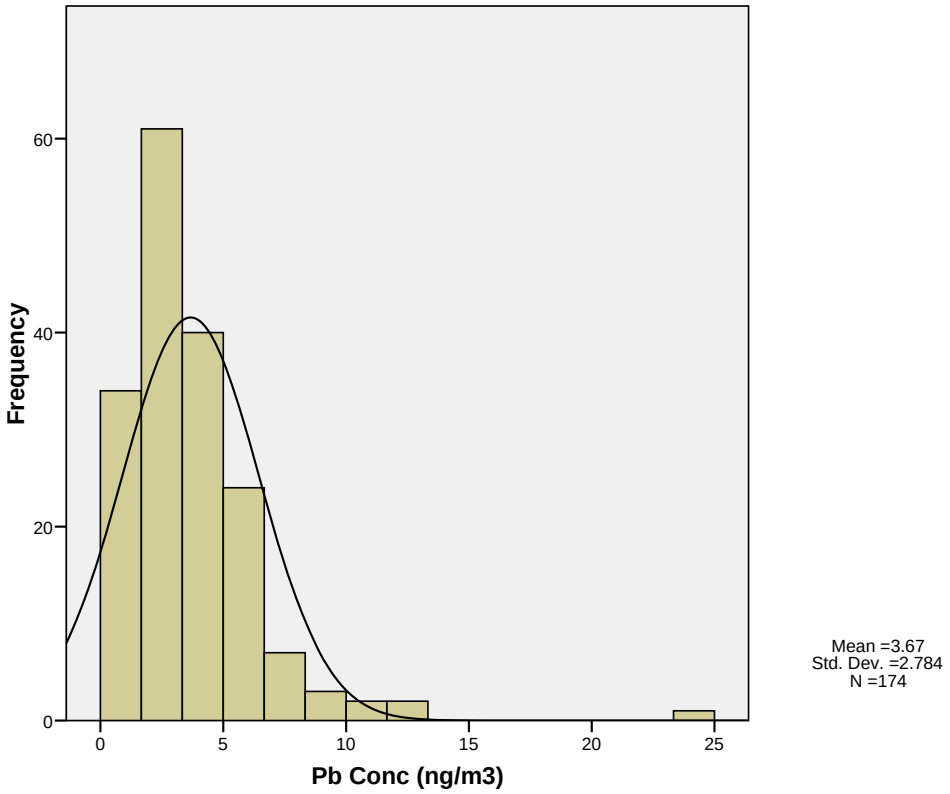


Figure 12. (a) Distribution of copper $PM_{2.5}$ concentration (µg/m^3); (b) Distribution of copper $PM_{2.5}$ log concentration (µg/m^3)

(a)



(b)

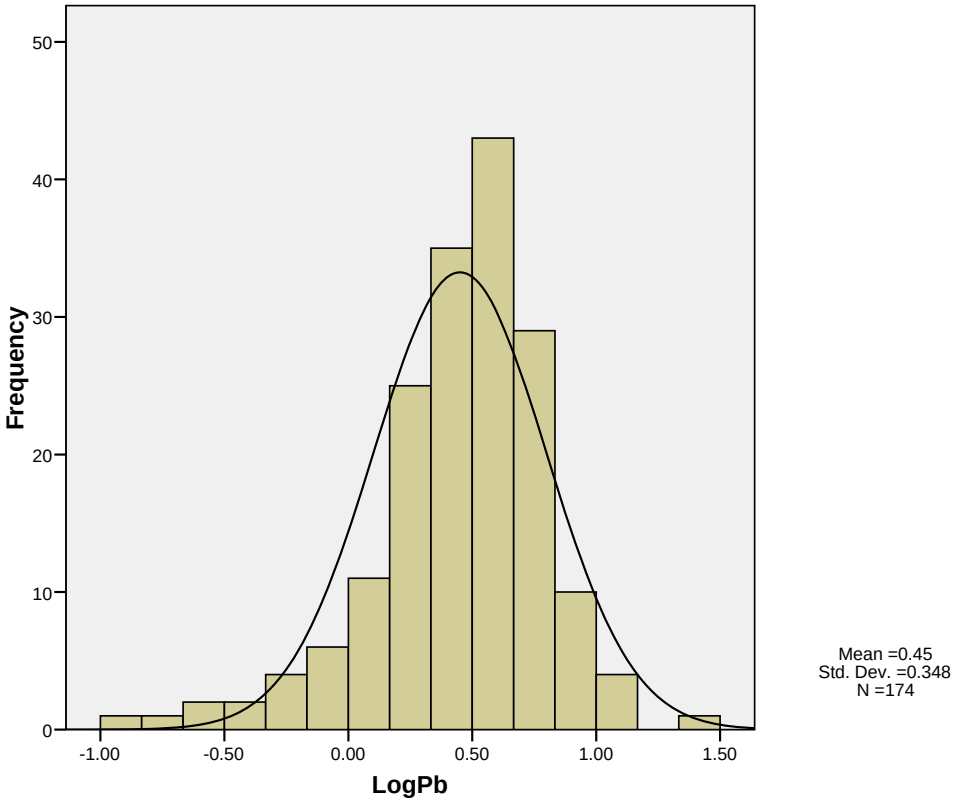
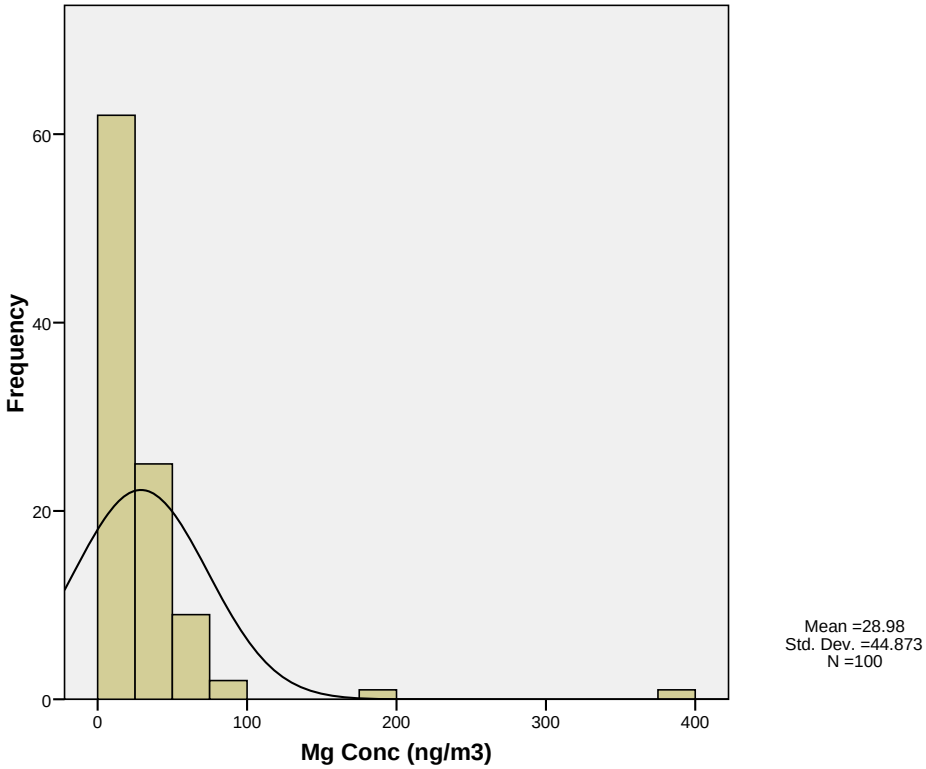


Figure 13. (a) Distribution of lead $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of lead $PM_{2.5}$ log concentration (μg/m^3)

(a)



(b)

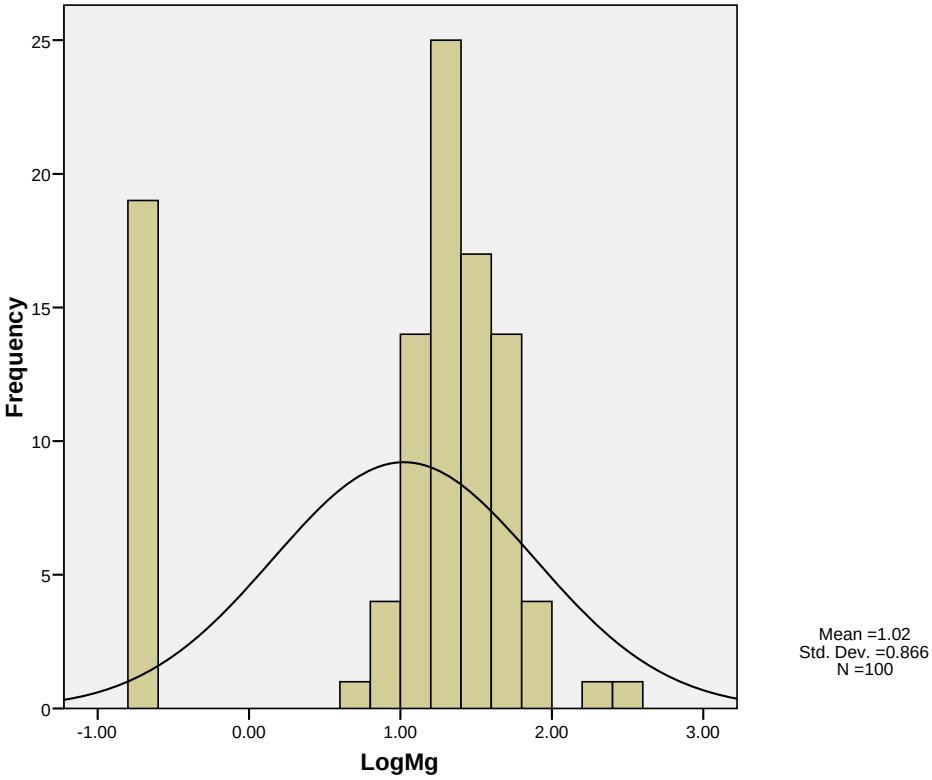
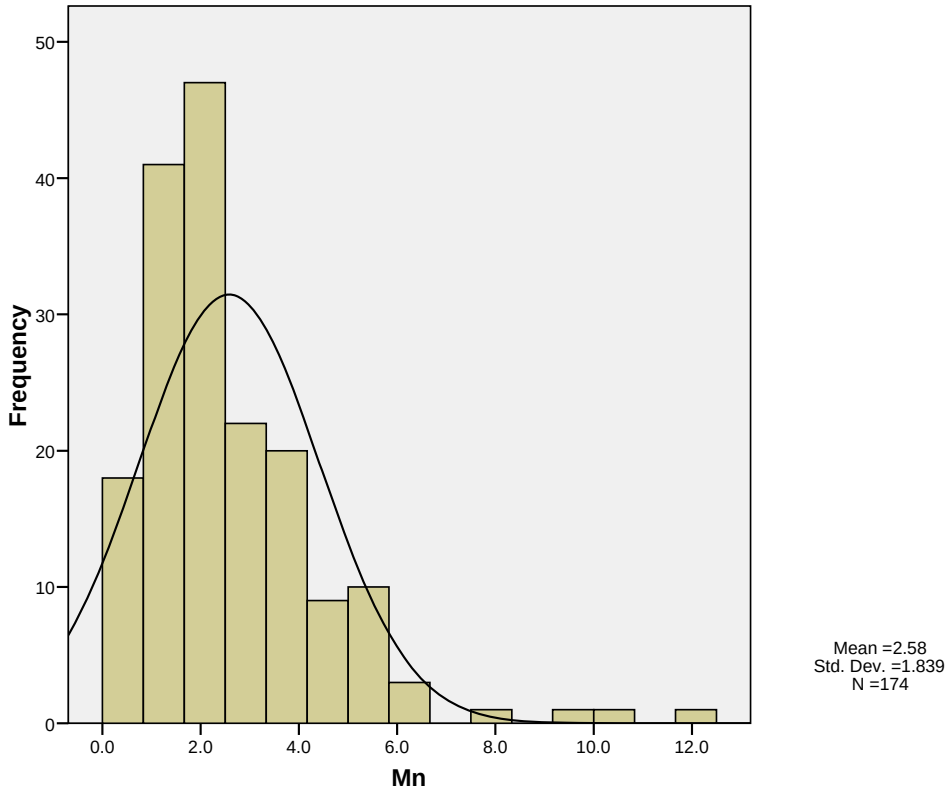


Figure 14. (a) Distribution of magnesium $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of magnesium $PM_{2.5}$ log concentration (μg/m^3)

(a)



(b)

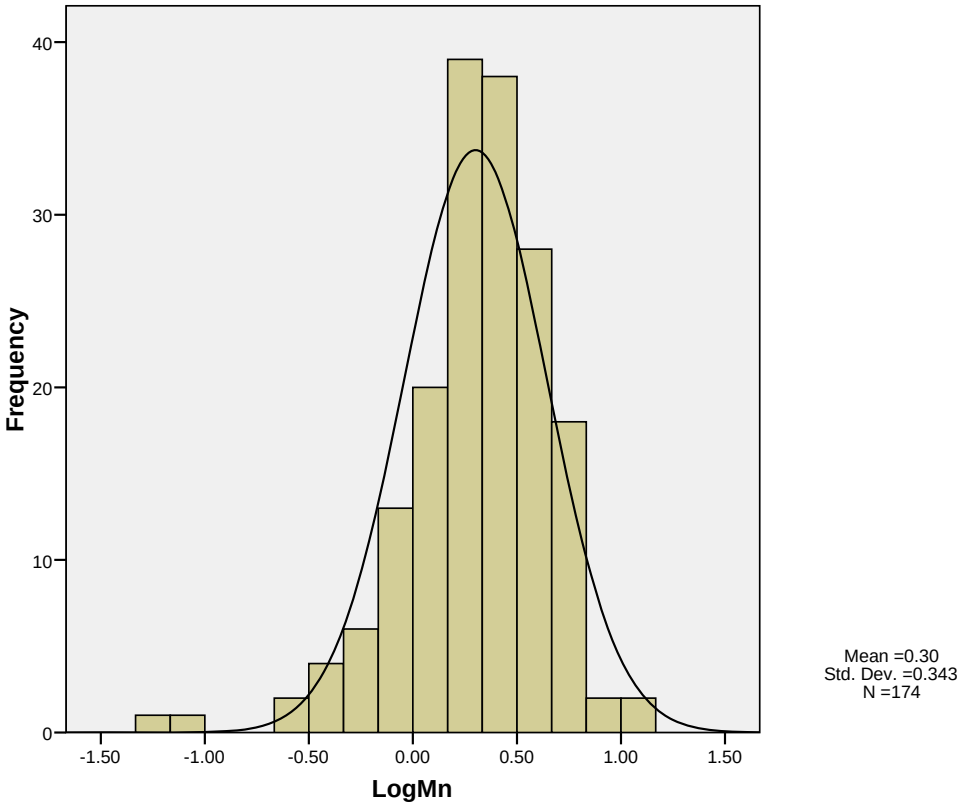
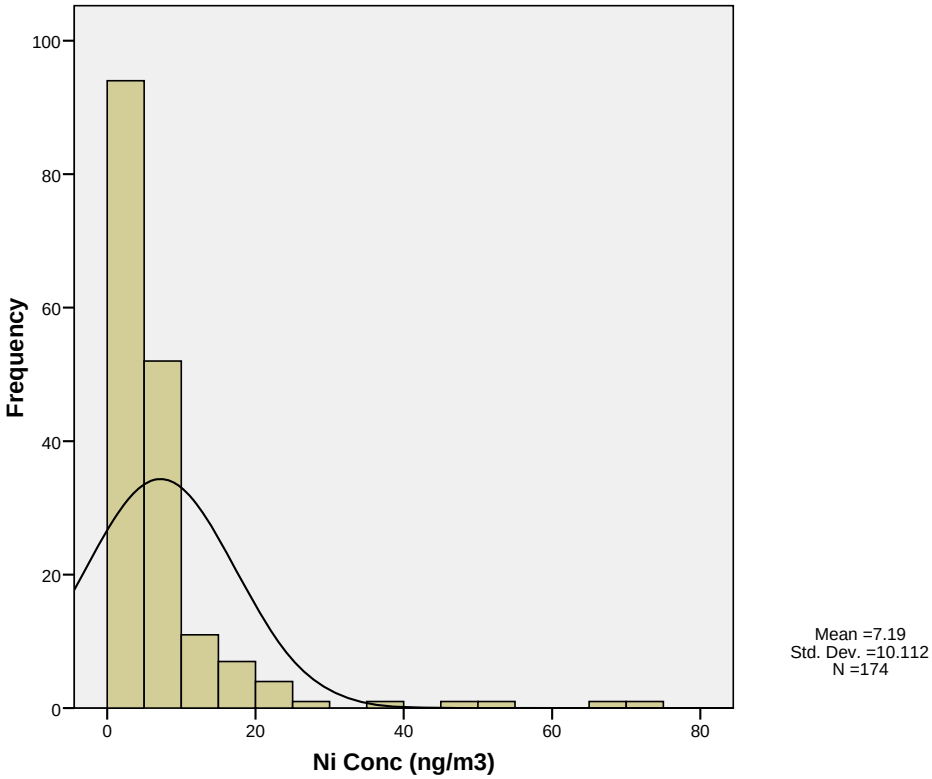


Figure 15. (a) Distribution of manganese $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of manganese $PM_{2.5}$ log concentration (μg/m^3)

(a)



(b)

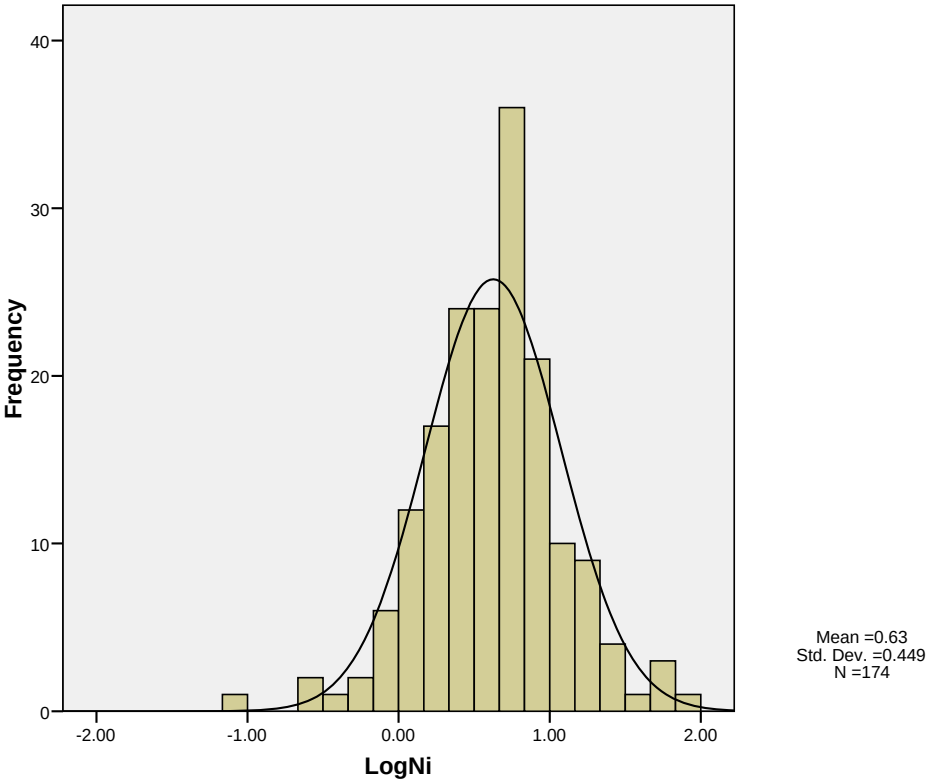
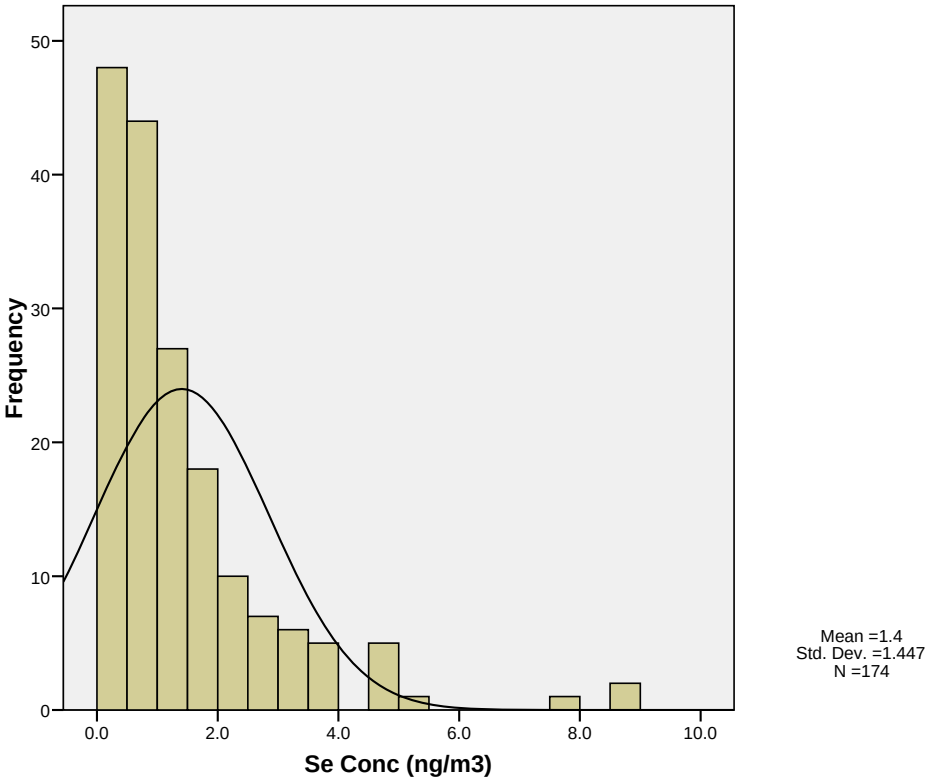


Figure 16. (a) Distribution of nickel $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of nickel $PM_{2.5}$ log concentration (μg/m^3)

(a)



(b)

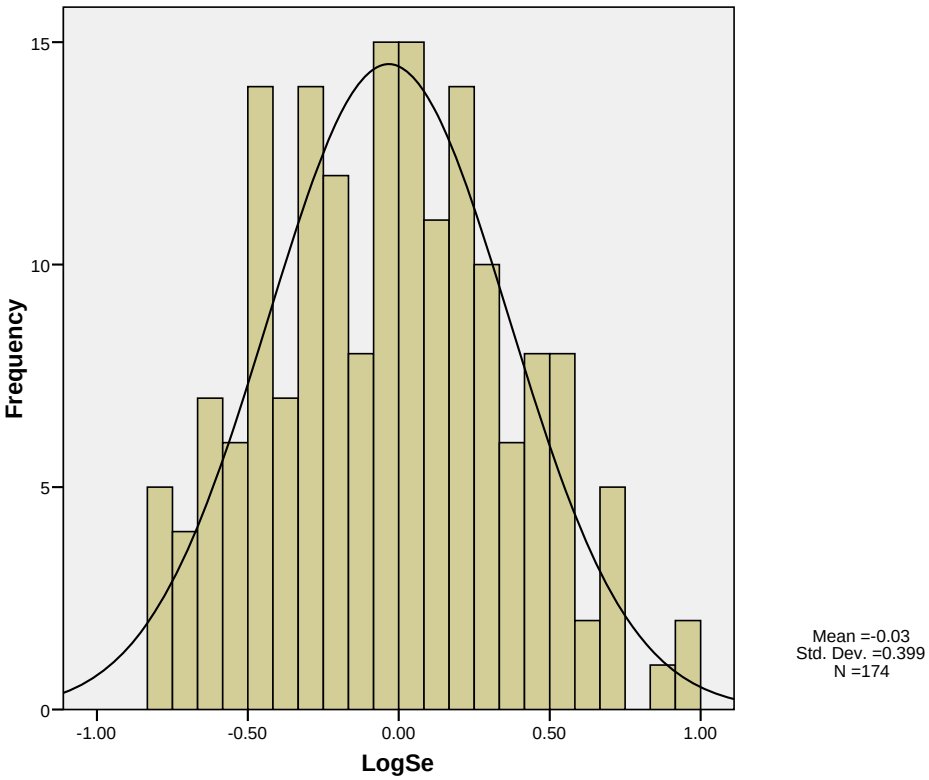
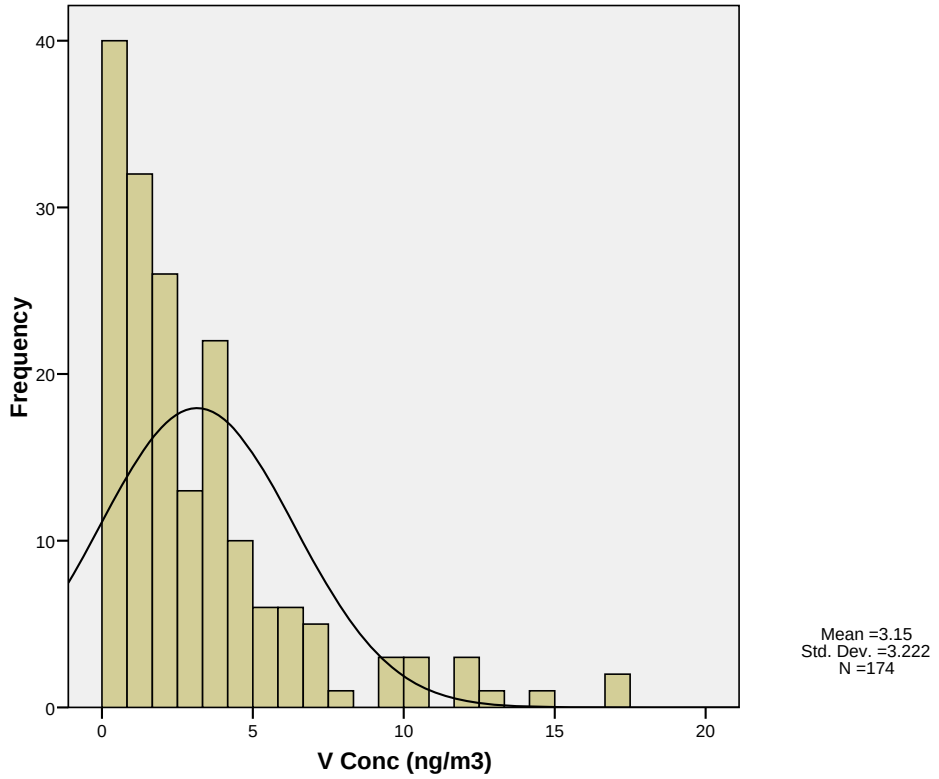


Figure 17. (a) Distribution of selenium $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of selenium $PM_{2.5}$ log concentration (μg/m^3)

(a)



(b)

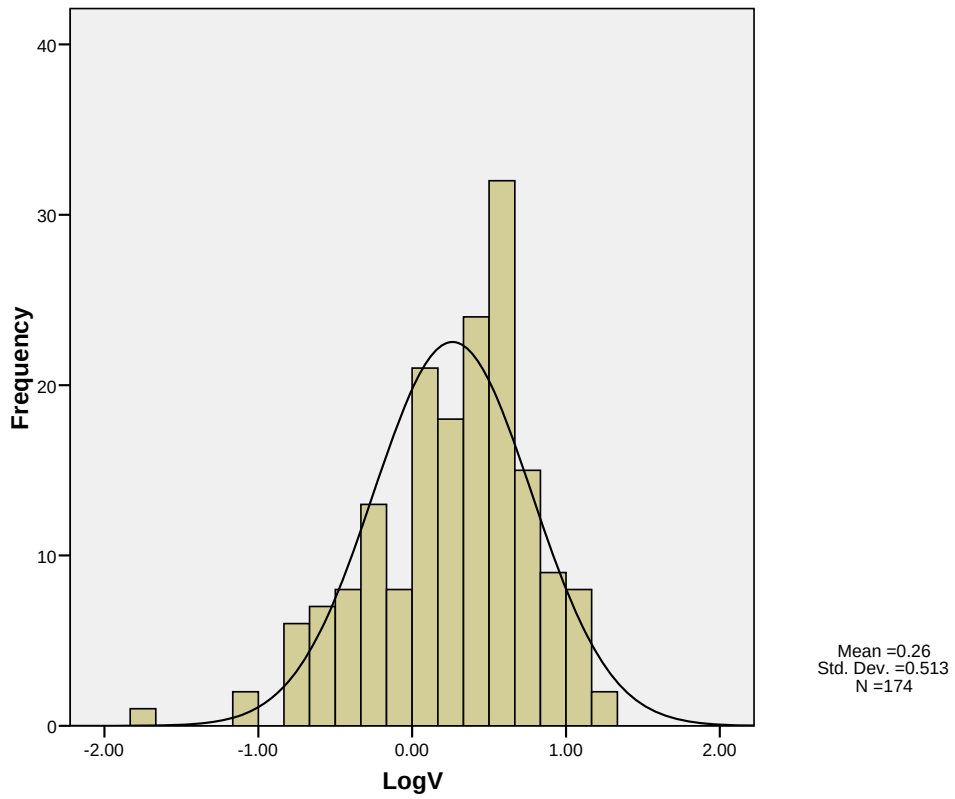


Figure 18. (a) Distribution of vanadium $PM_{2.5}$ concentration (μg/m^3); (b) Distribution of vanadium $PM_{2.5}$ log concentration (μg/m^3)

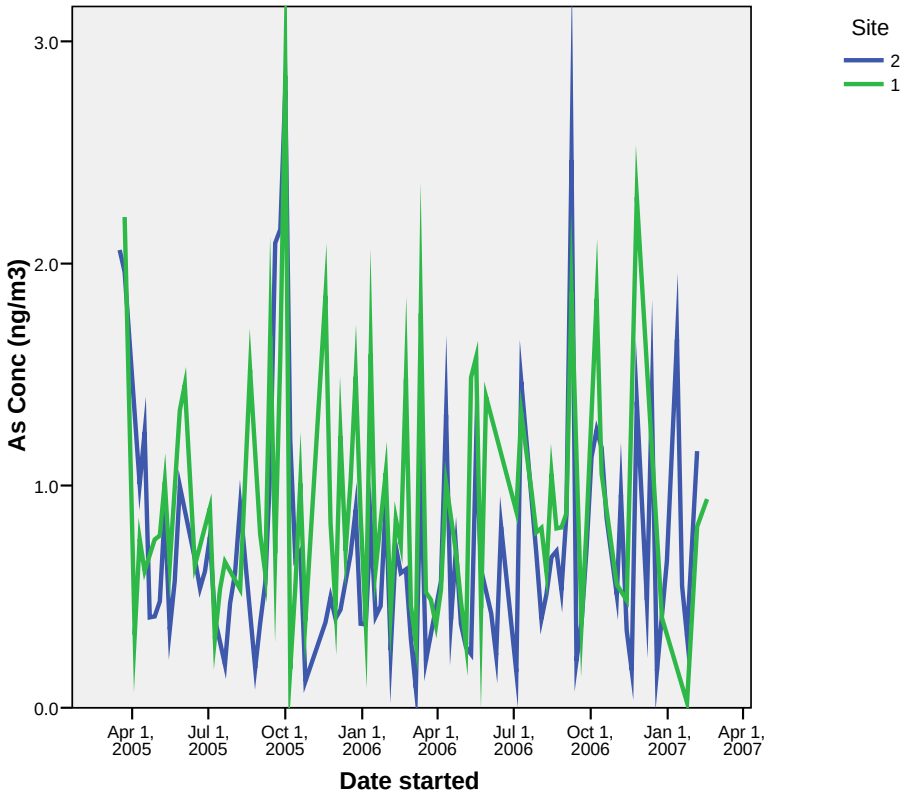


Figure 19. Temporal change in arsenic concentration (µg/m^3) by site

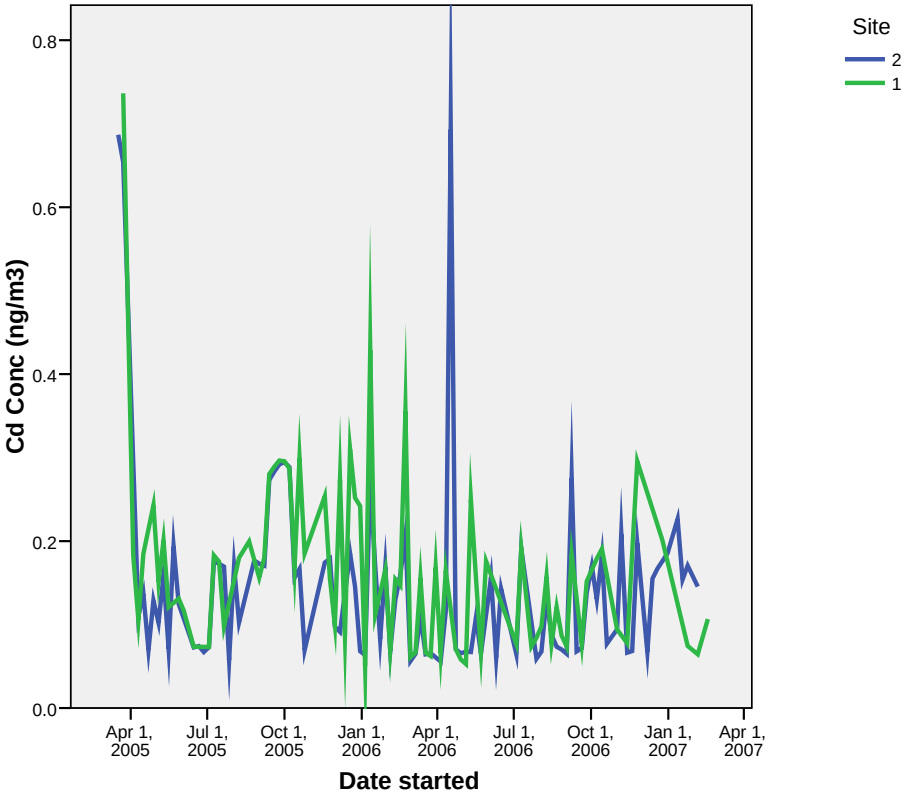


Figure 20. Temporal change in cadmium concentration (µg/m^3) by site

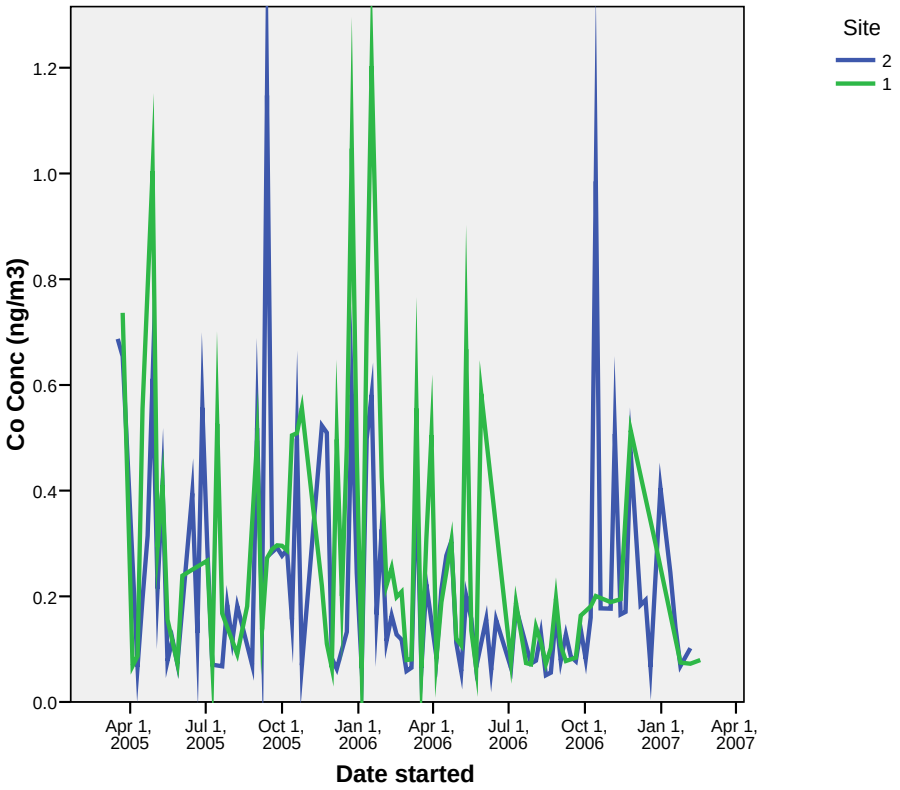


Figure 21. Temporal change in cobalt concentration (µg/m^3) by site

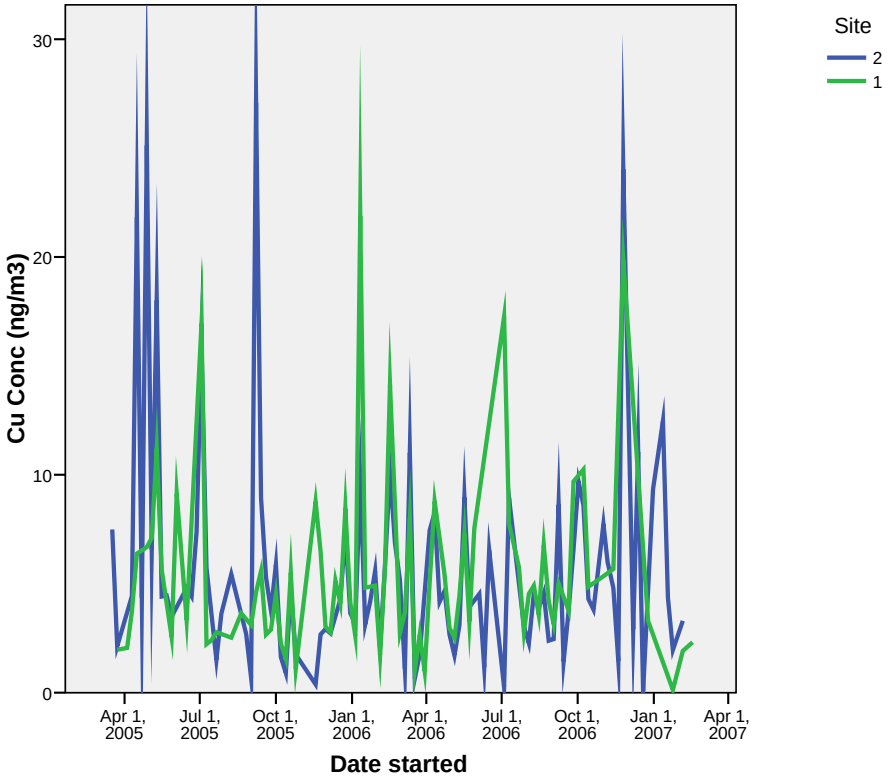


Figure 22. Temporal change in copper concentration (µg/m^3) by site

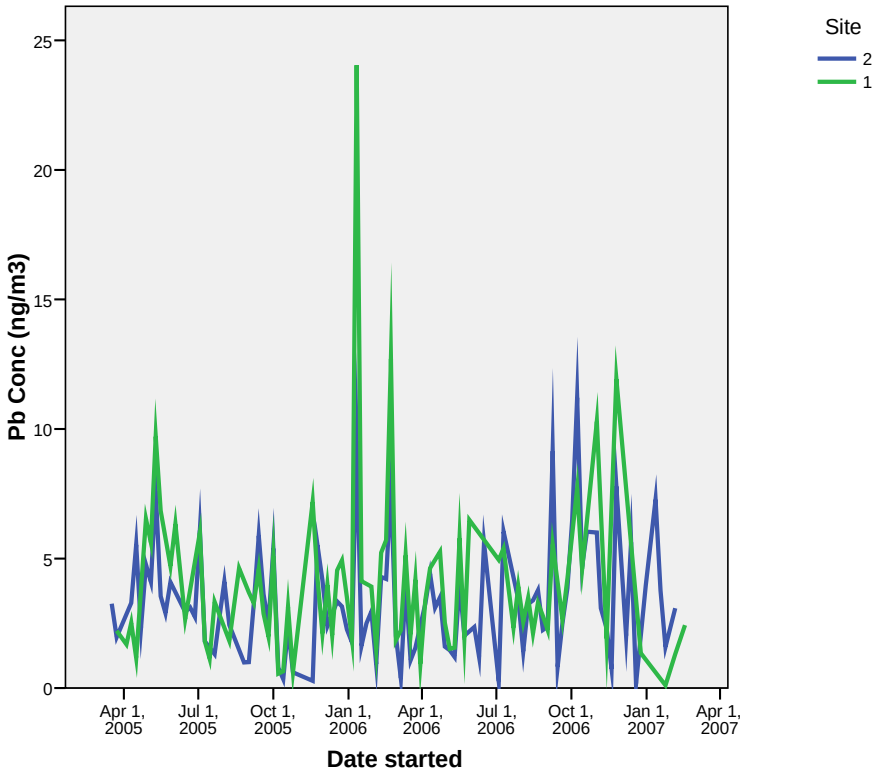


Figure 23. Temporal change in lead concentration (µg/m^3) by site

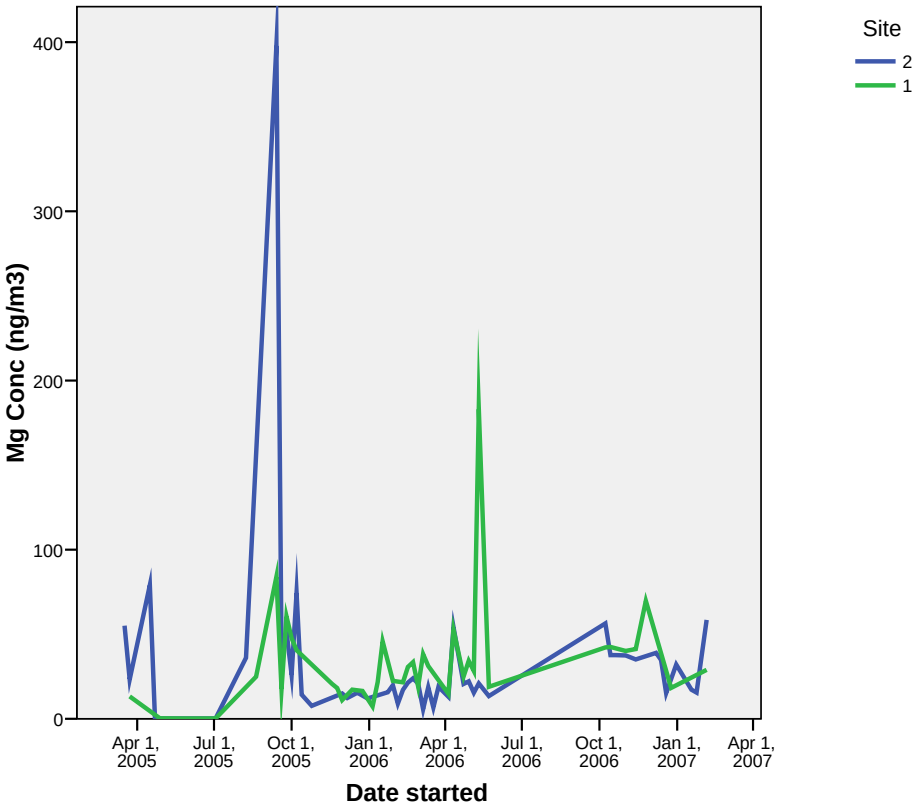


Figure 24. Temporal change in magnesium concentration (µg/m^3) by site

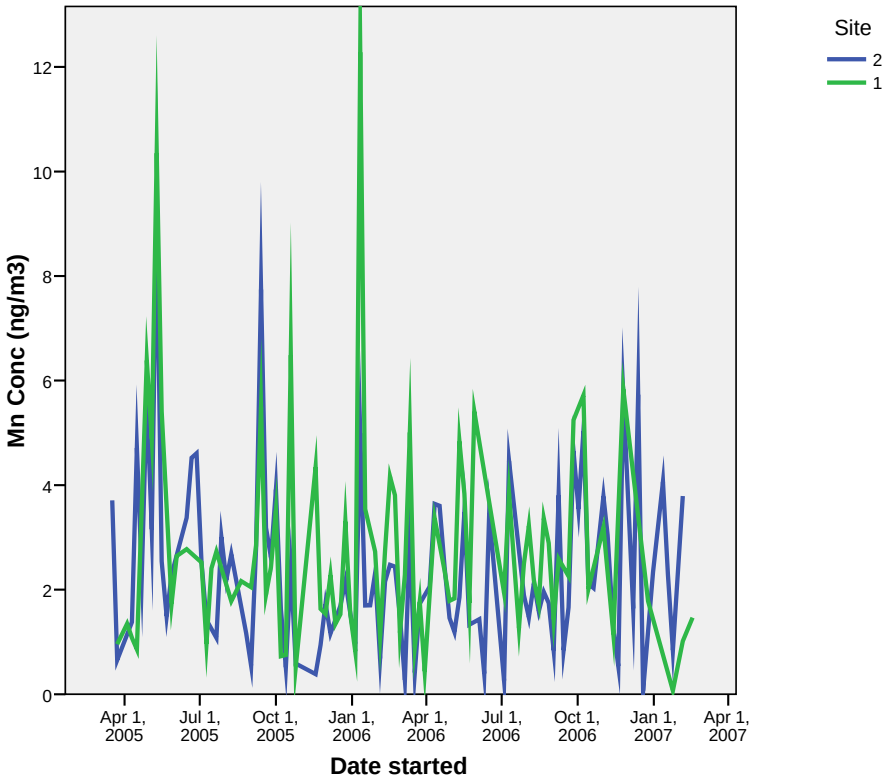


Figure 25. Temporal change in manganese concentration (µg/m^3) by site

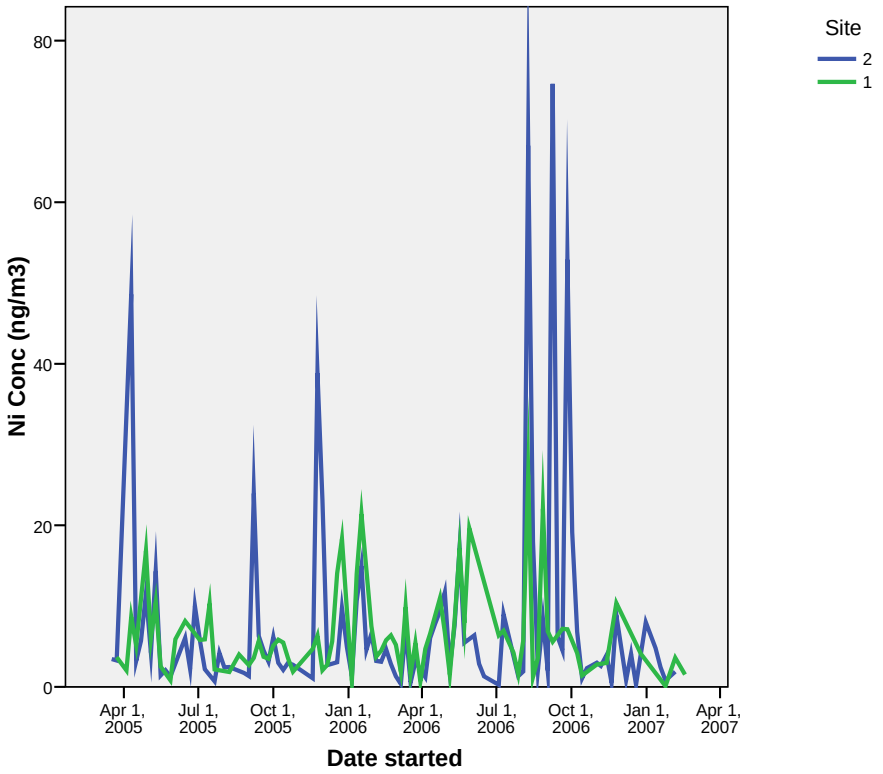


Figure 26. Temporal change in nickel concentration (µg/m^3) by site

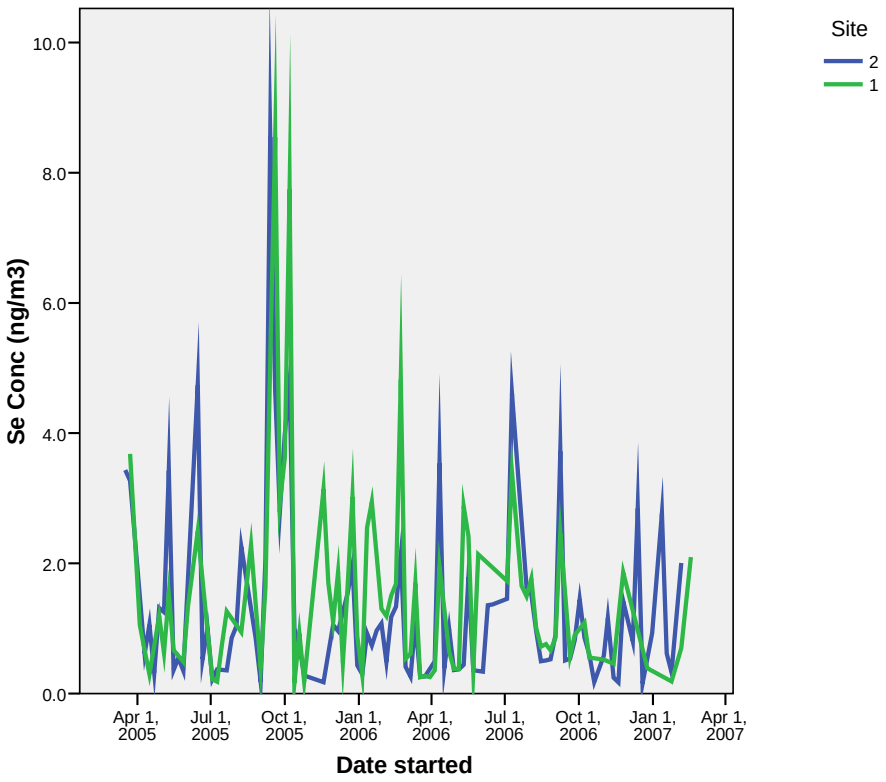


Figure 27. Temporal change in selenium concentration (µg/m^3) by site

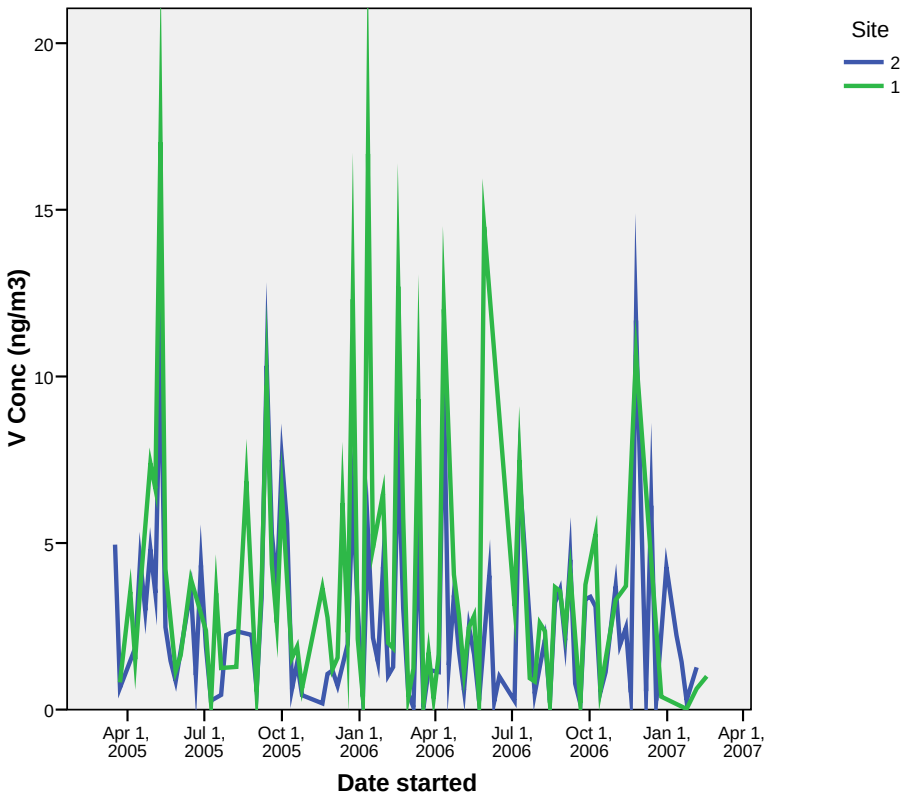


Figure 28. Temporal change in vanadium concentration (µg/m^3) by site

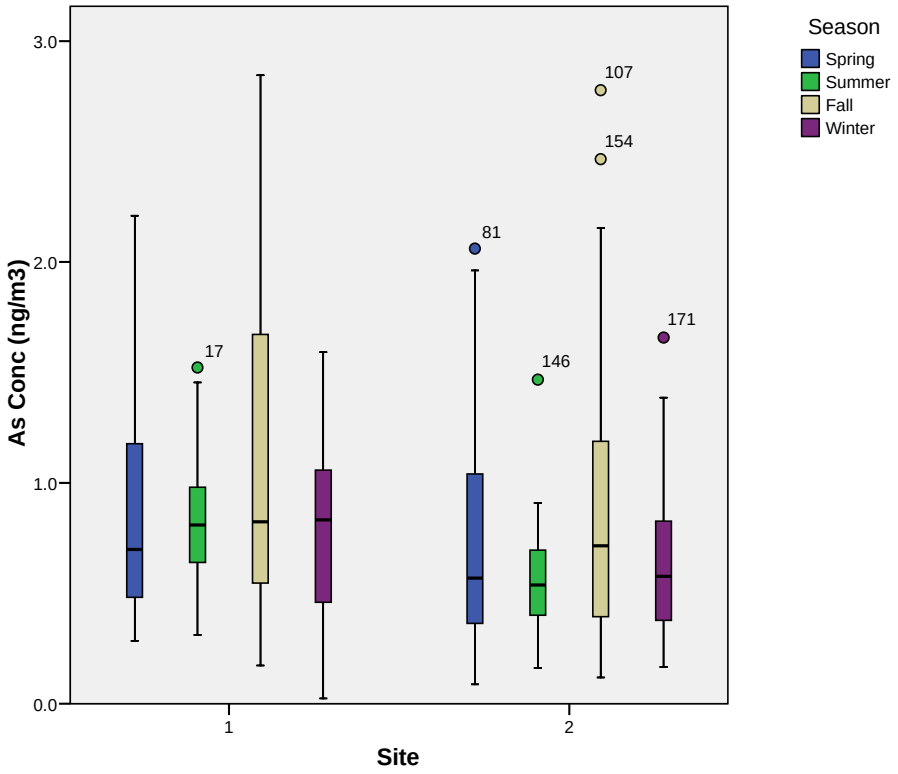


Figure 29. Box and whisker plot of arsenic concentration (µg/m^3) by site and season

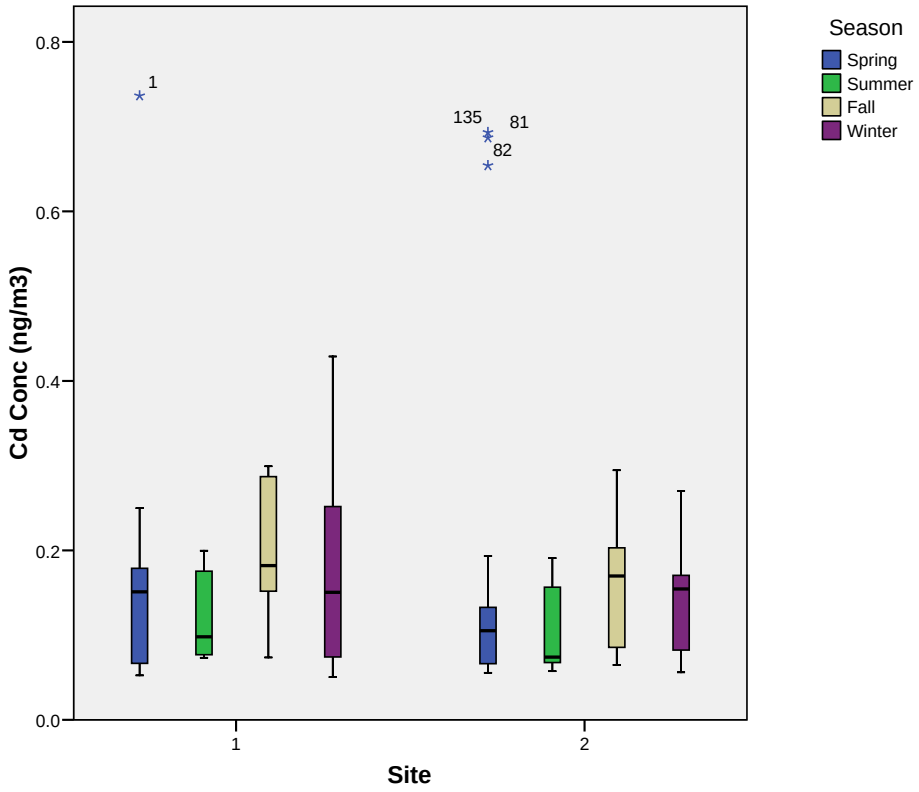


Figure 30. box and whisker plot of cadmium concentration (µg/m^3) by site and season

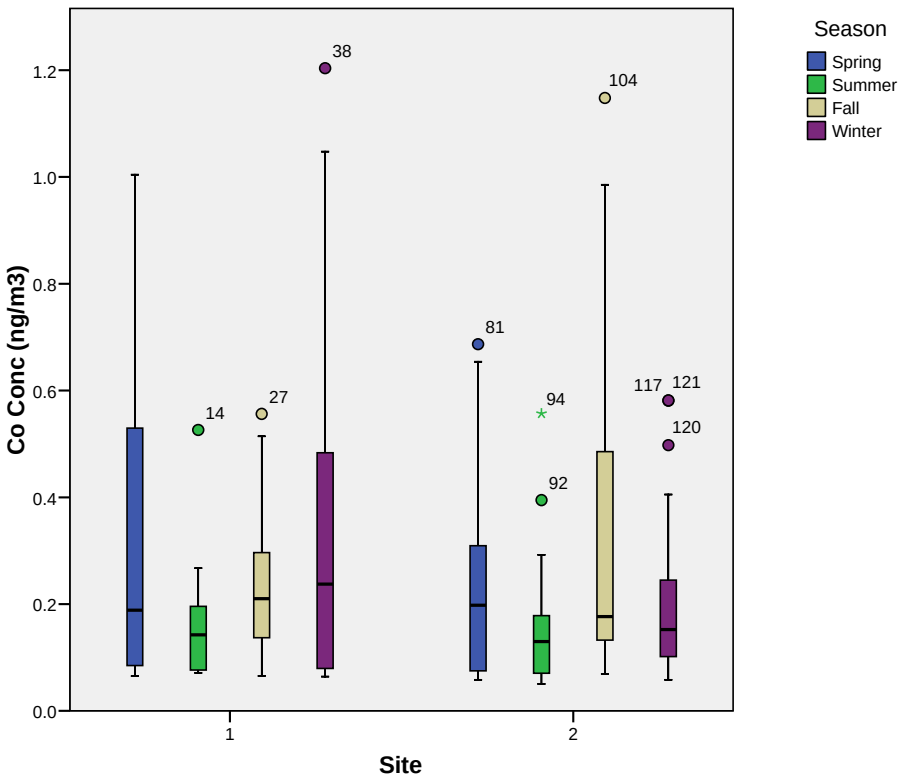


Figure 31. Box and whisker plot of cobalt concentration (µg/m^3) by site and season

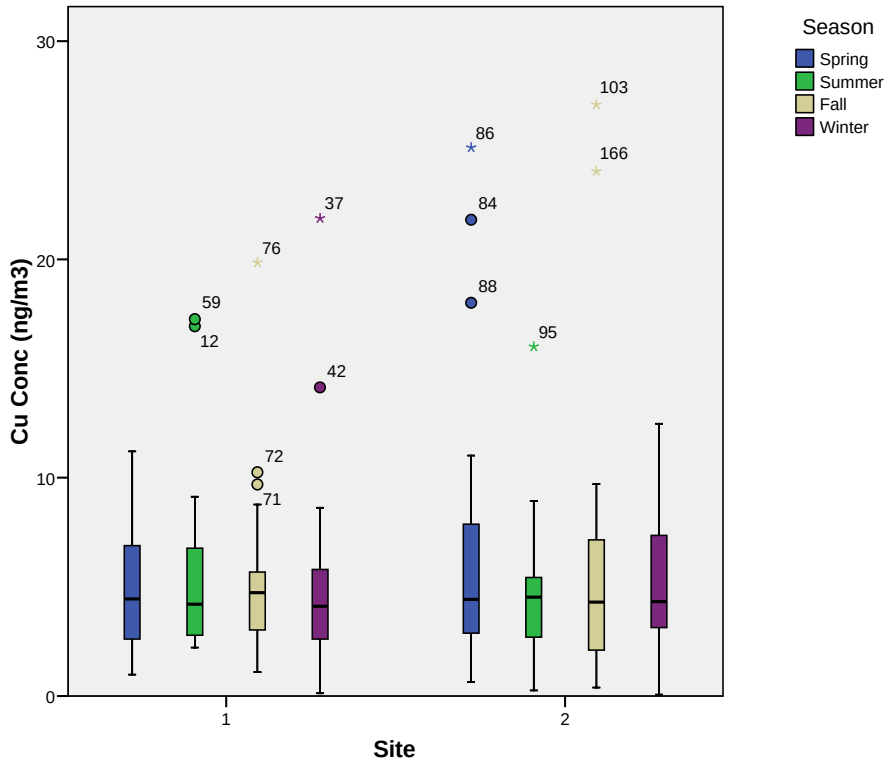


Figure 32. Box and whisker plot of copper concentration (µg/m^3) by site and season

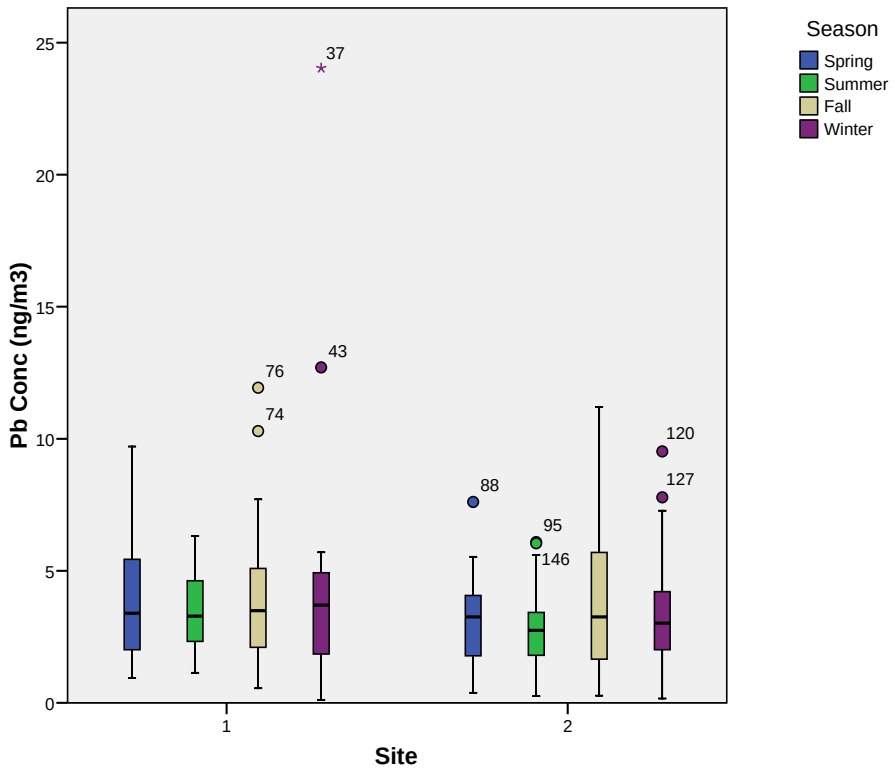


Figure 33. Box and whisker plot of lead concentration (µg/m^3) by site and season

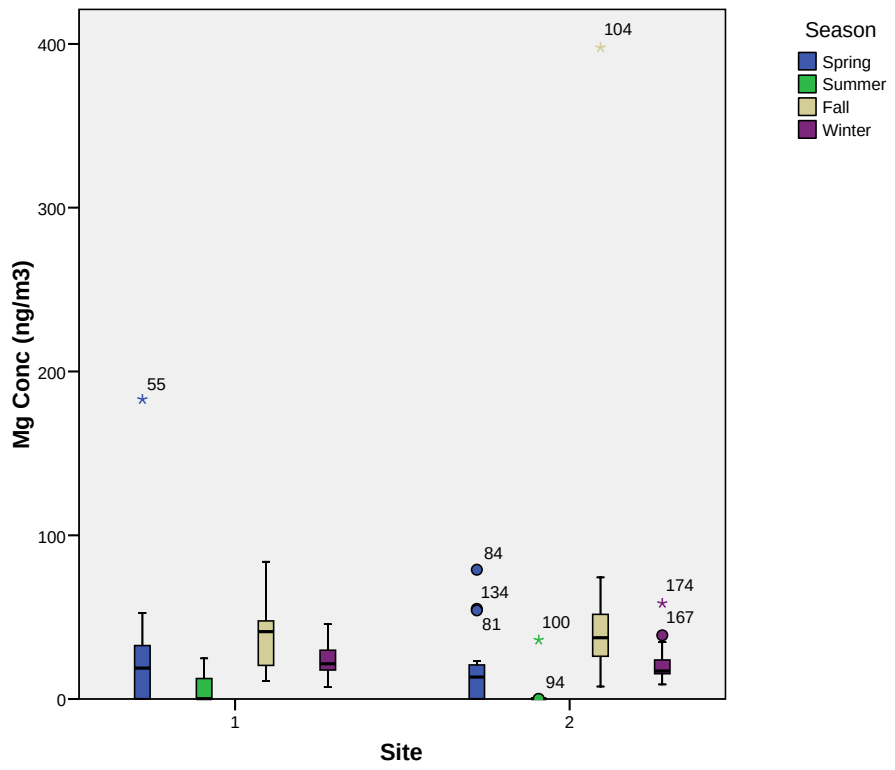


Figure 34. Box and whisker plot of magnesium concentration (µg/m^3) by site and season

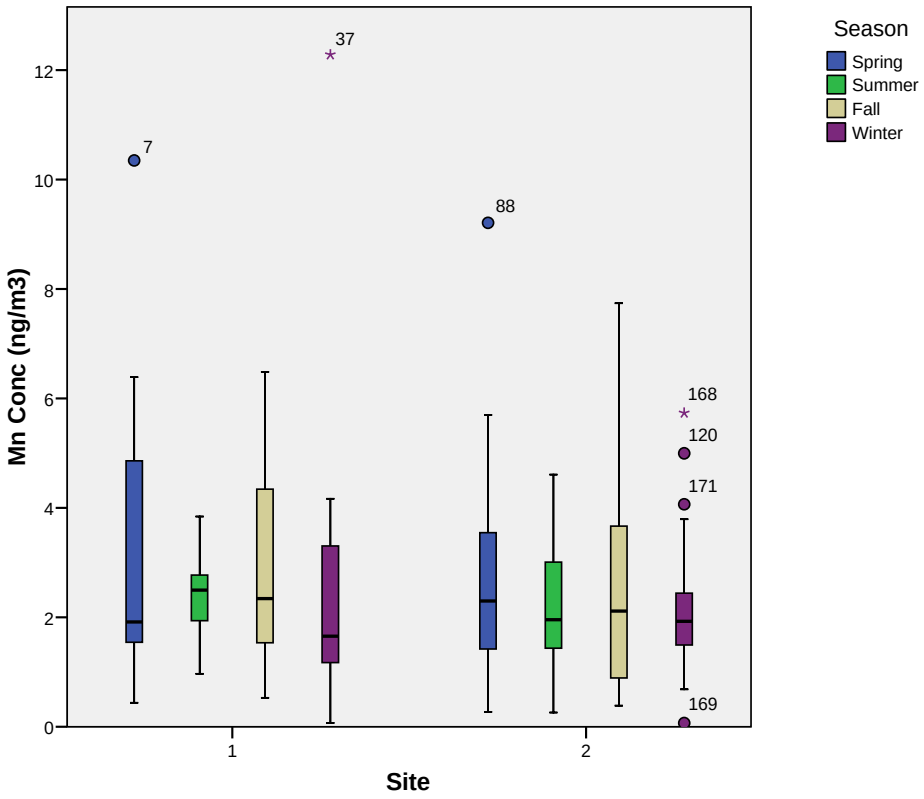


Figure 35. Box and whisker plot of manganese concentration (µg/m^3) by site and season

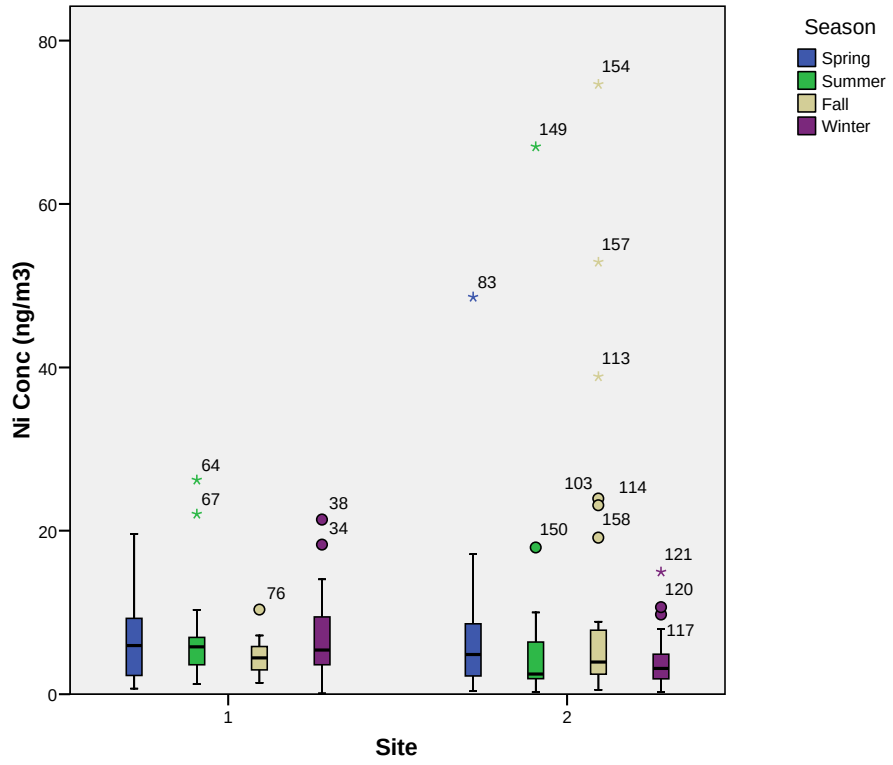


Figure 36. Box and whisker plot of nickel concentration (µg/m^3) by site and season

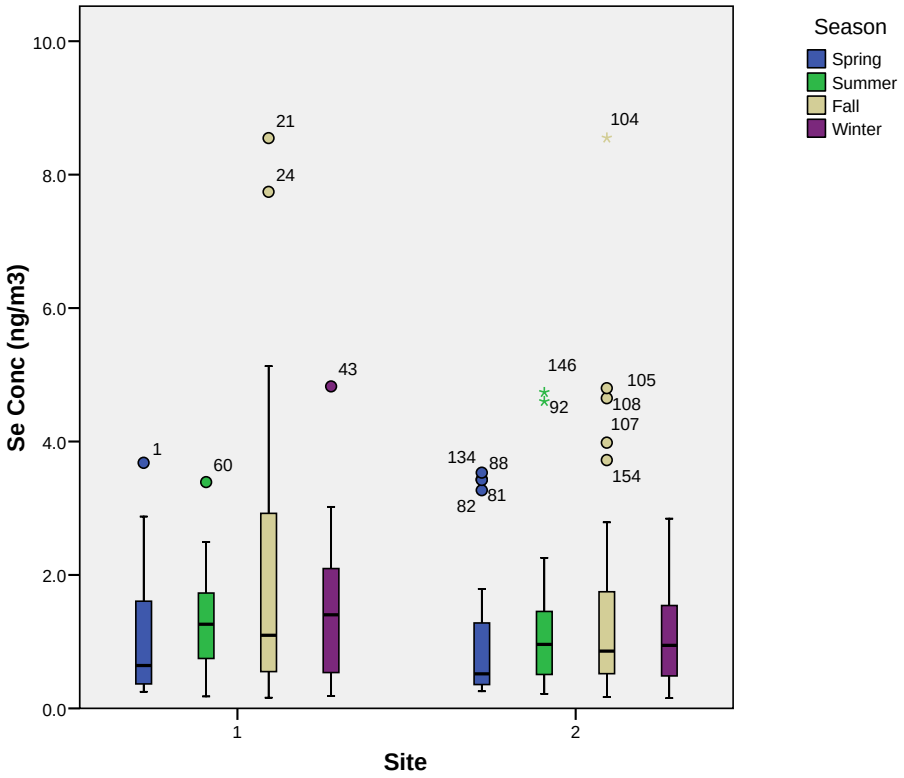


Figure 37. Box and whisker plot of selenium concentration (µg/m^3)) by site and season

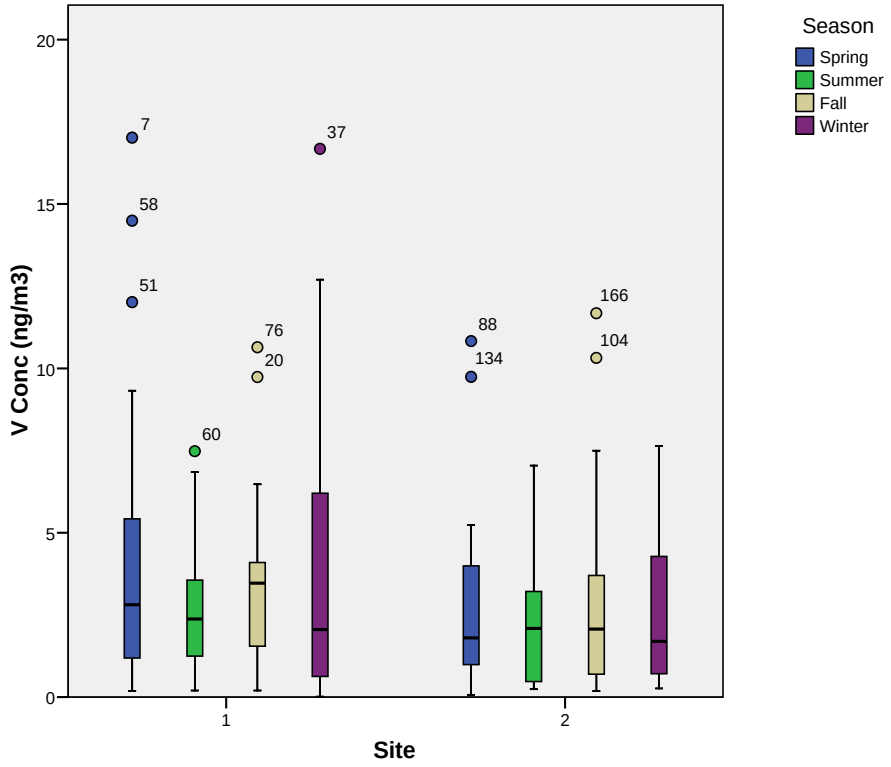
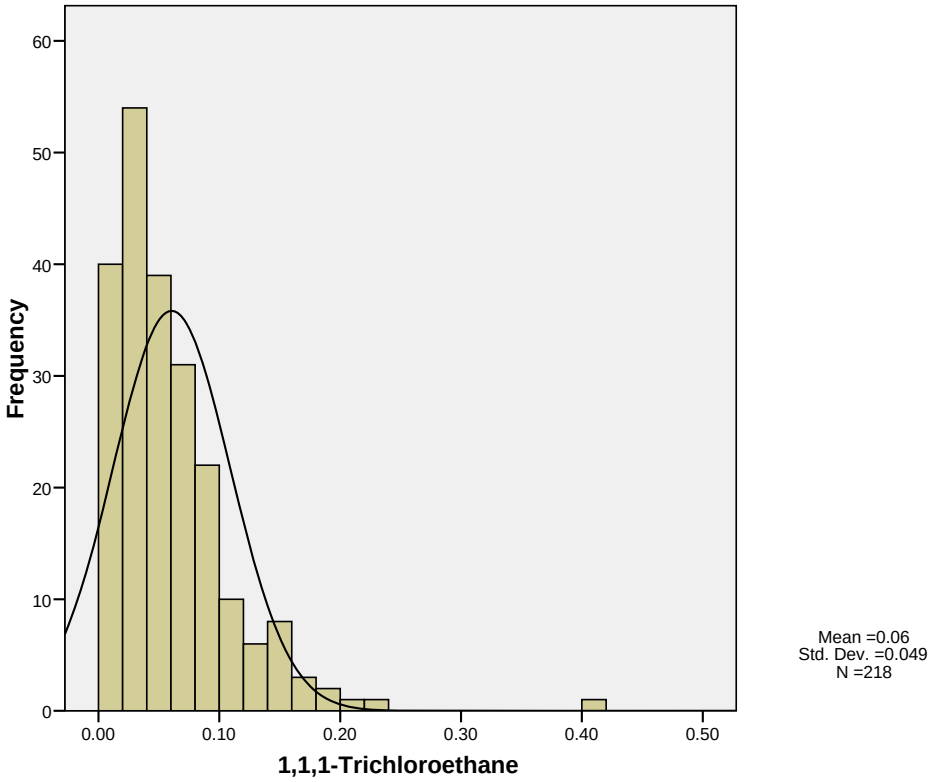


Figure 38. Box and whisker plot of vanadium concentration (µg/m^3) by site and season

(a)



(b)

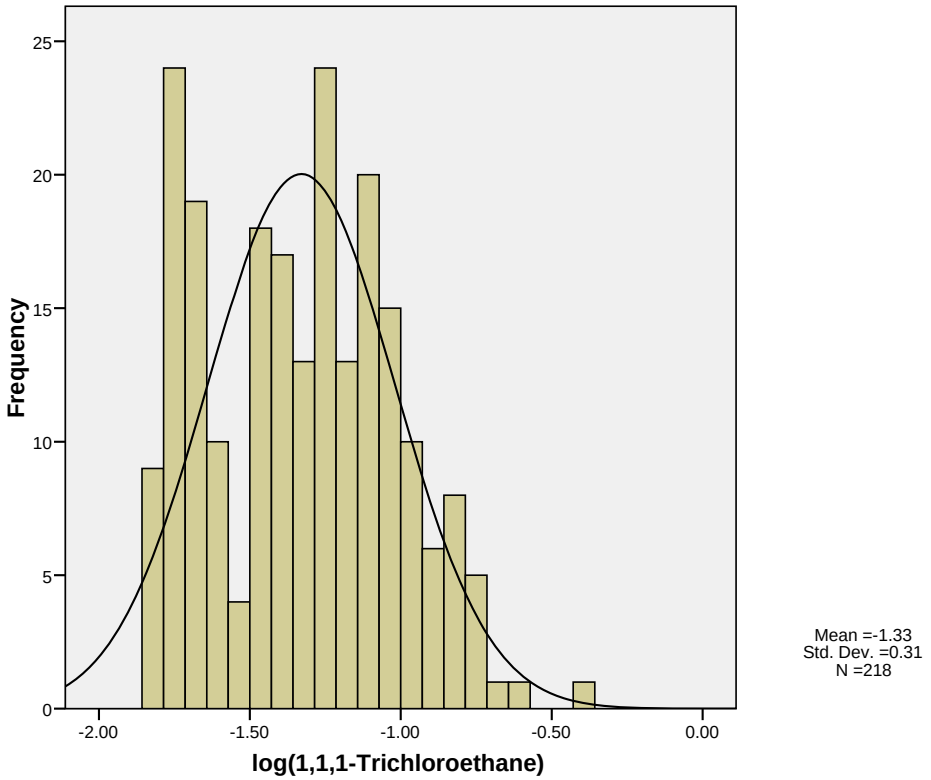
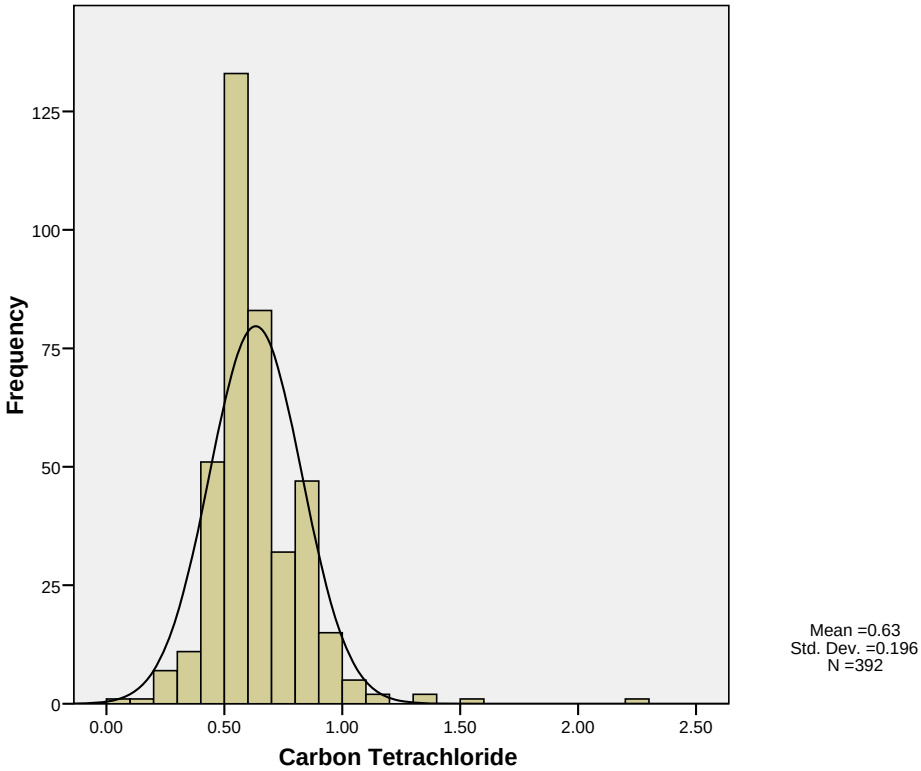


Figure 39. (a) Distribution of 111 trichloroethane concentration (µg/m^3) with normal curve; and (b) Distribution of 111 trichloroethane log concentration (µg/m^3) with normal curve

(a)



(b)

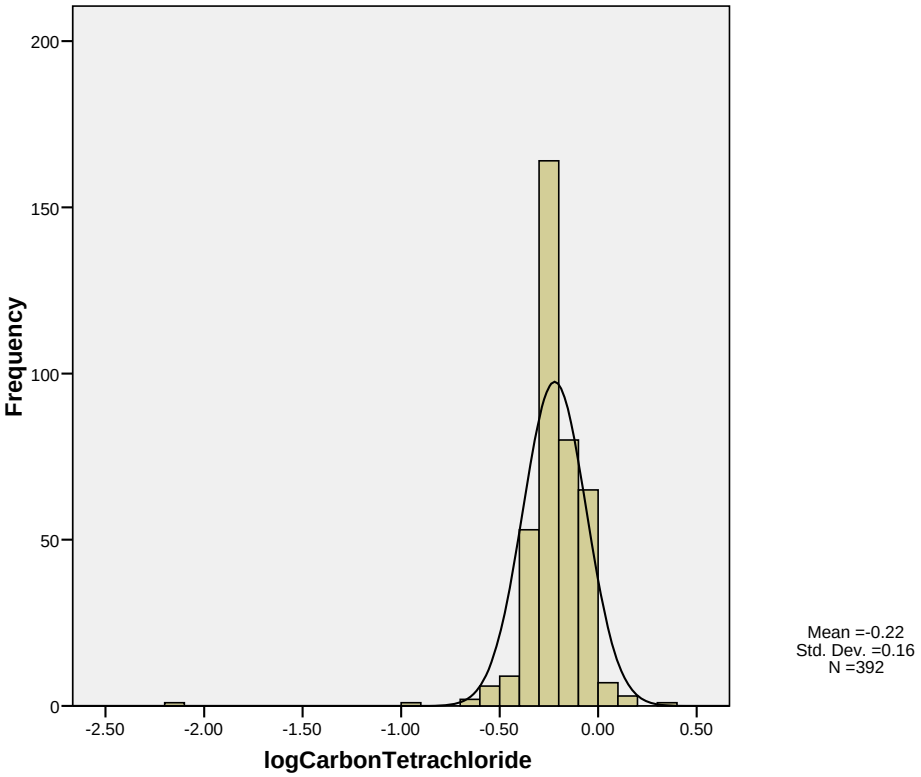
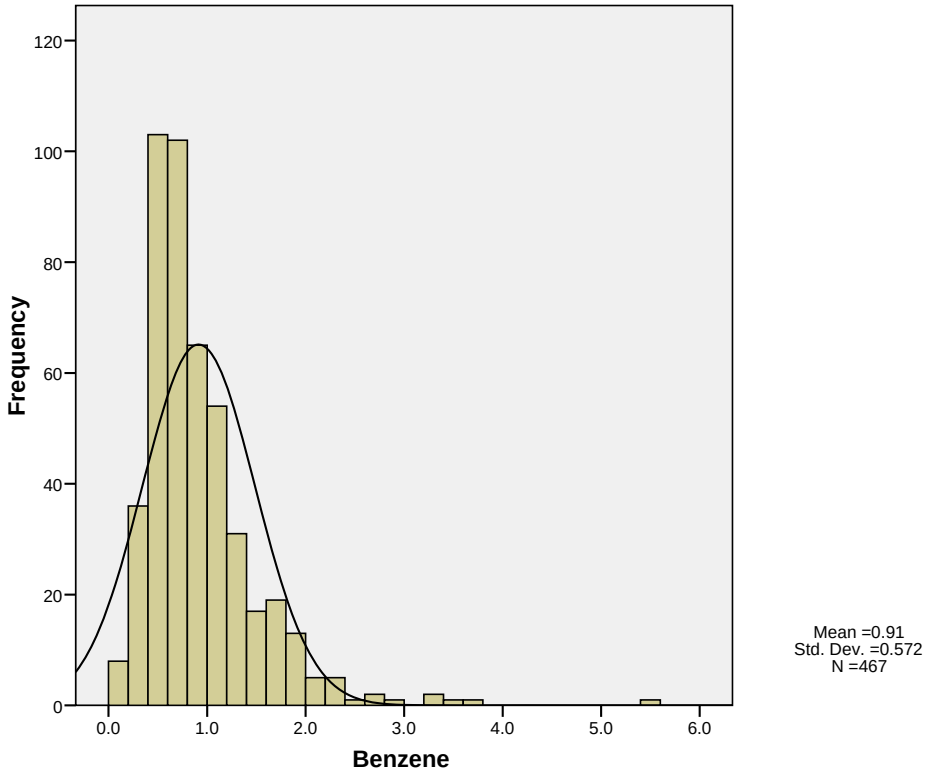


Figure 40. (a) Distribution of carbon tetrachloride concentration (µg/m^3) with normal curve; and (b) Distribution of carbon tetrachloride log concentration (µg/m^3) with normal curve

(a)



(b)

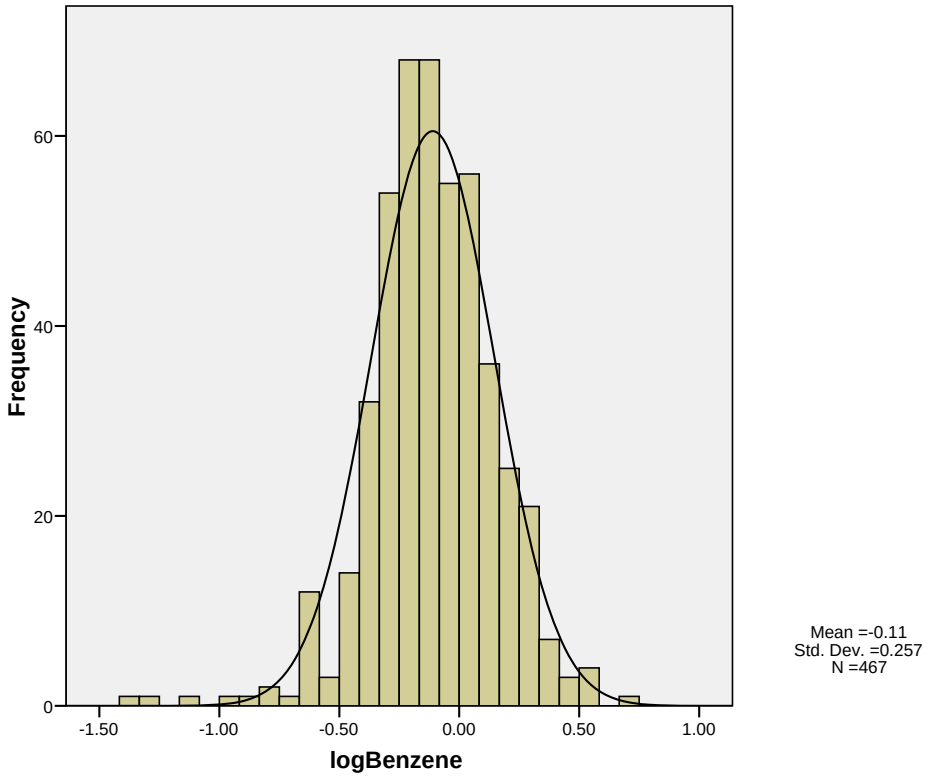
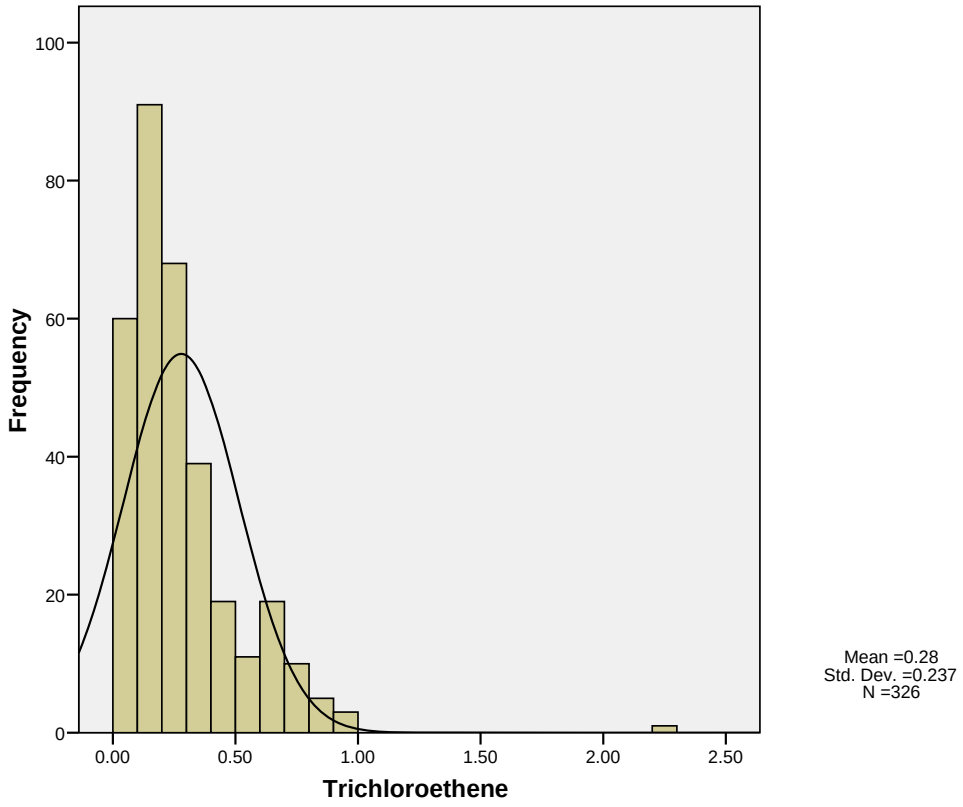


Figure 41. (a) Distribution of benzene concentration (μg/m^3) with normal curve; and (b) Distribution of benzene log concentration (μg/m^3) with normal curve

(a)



(b)

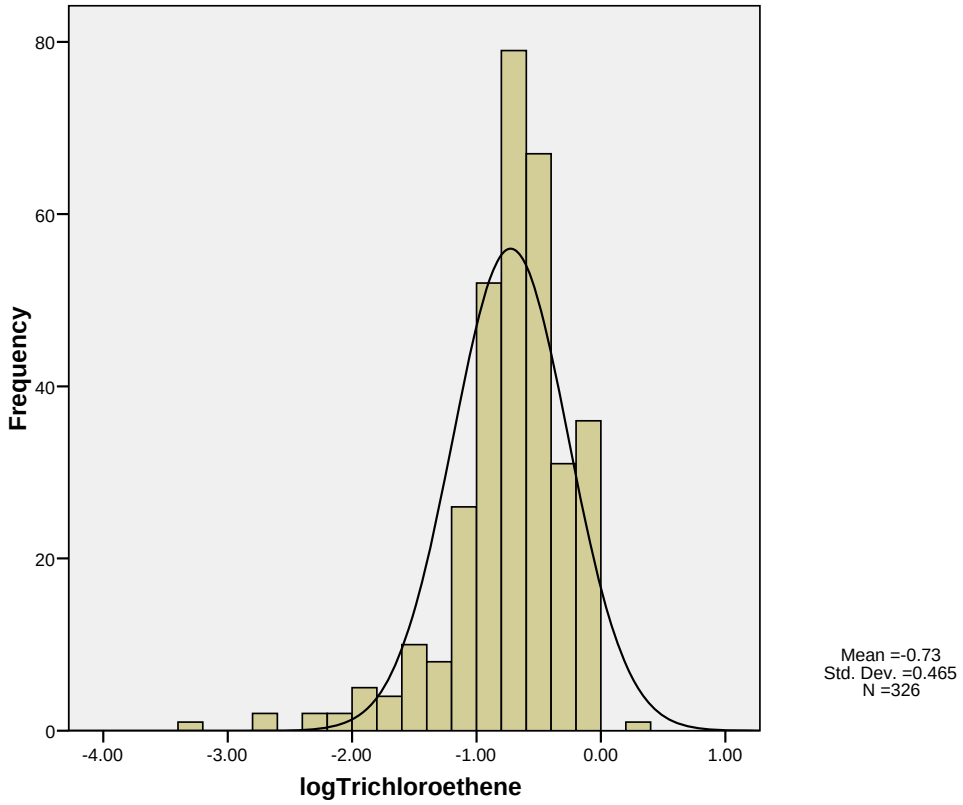
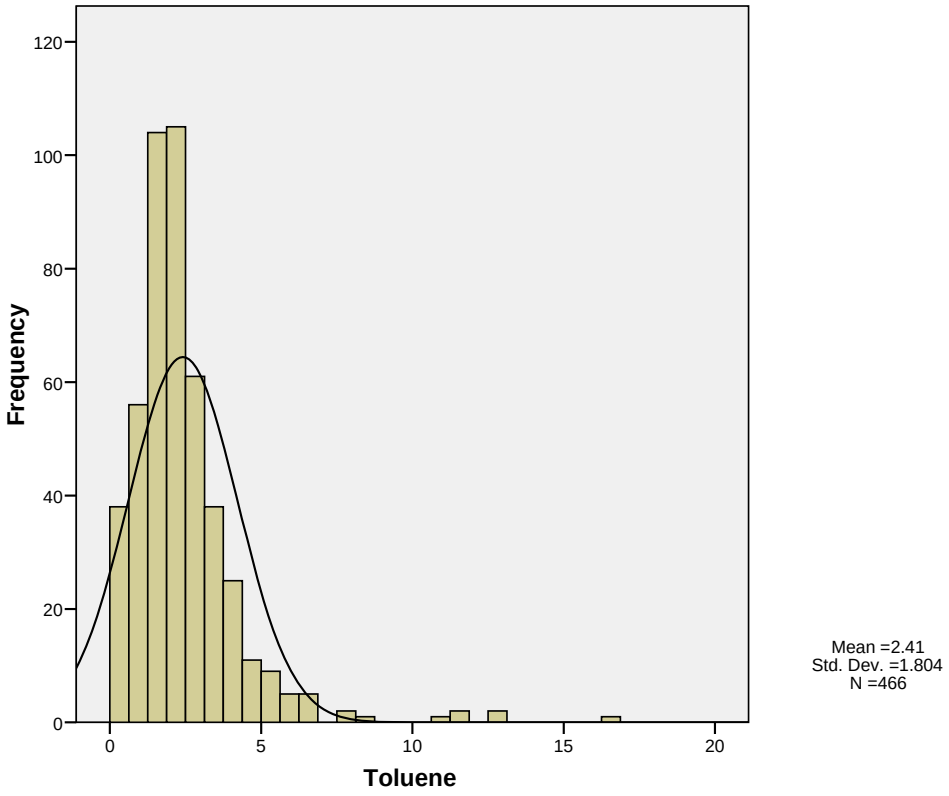


Figure 42. (a) Distribution of trichloroethene concentration (µg/m^3) with normal curve; and (b) Distribution of trichloroethene log concentration (µg/m^3) with normal curve

(a)



(b)

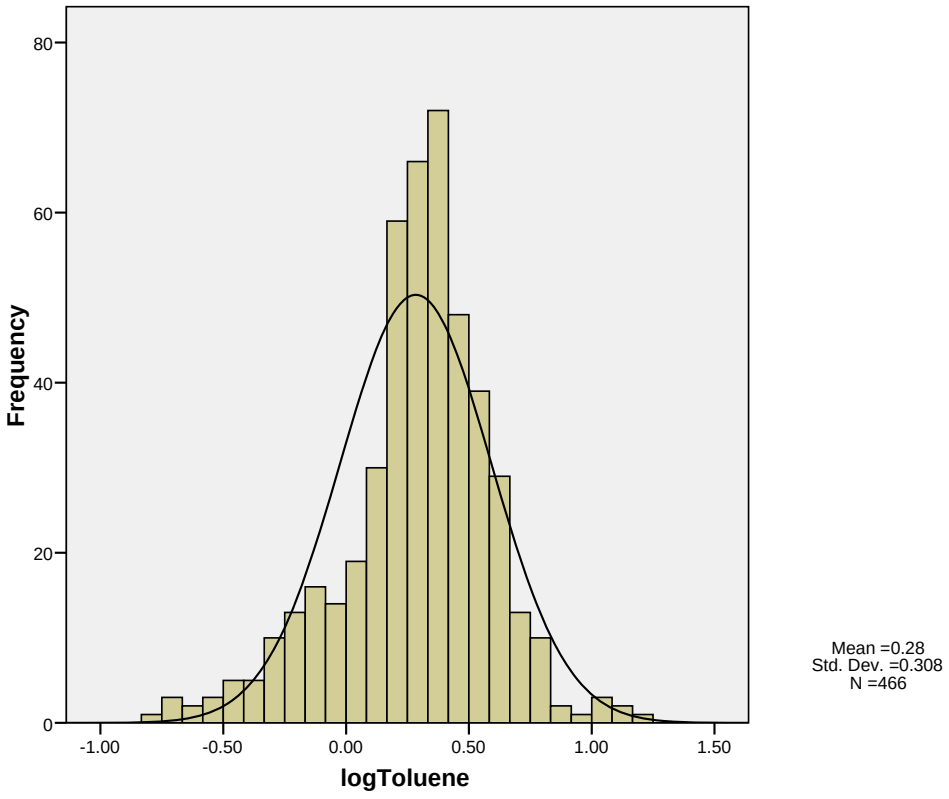
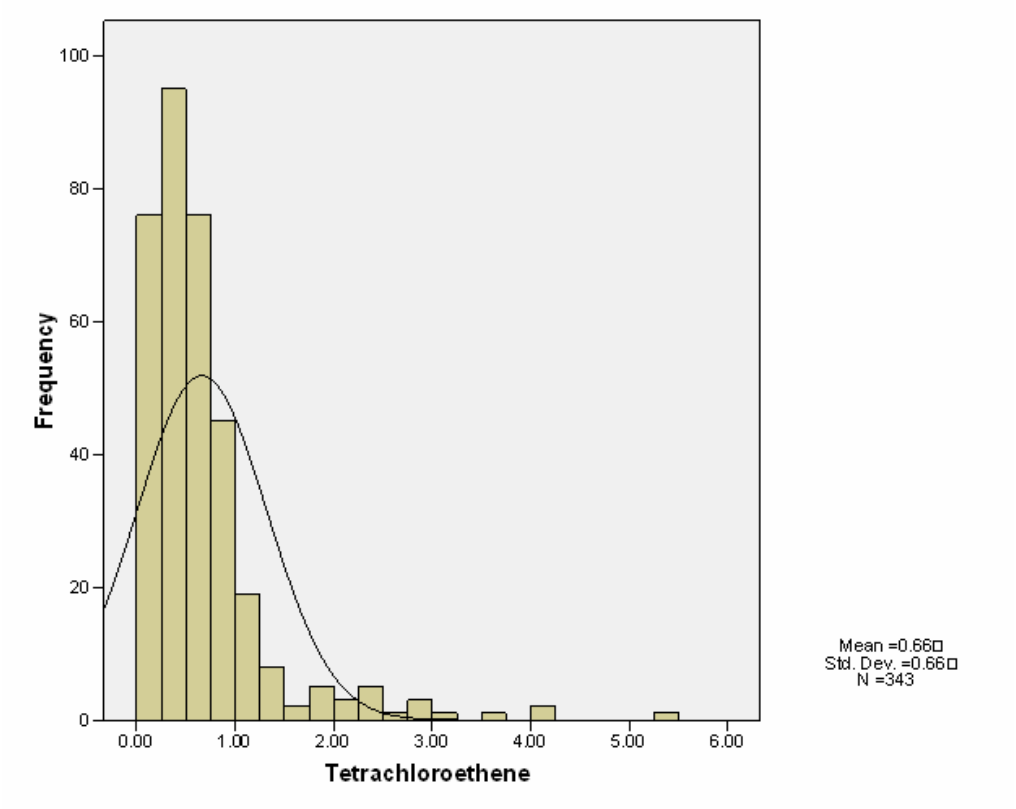


Figure 43. (a) Distribution of toluene concentration (µg/m^3) with normal curve; and (b) Distribution of toluene log concentration (µg/m^3) with normal curve

(a)



(b)

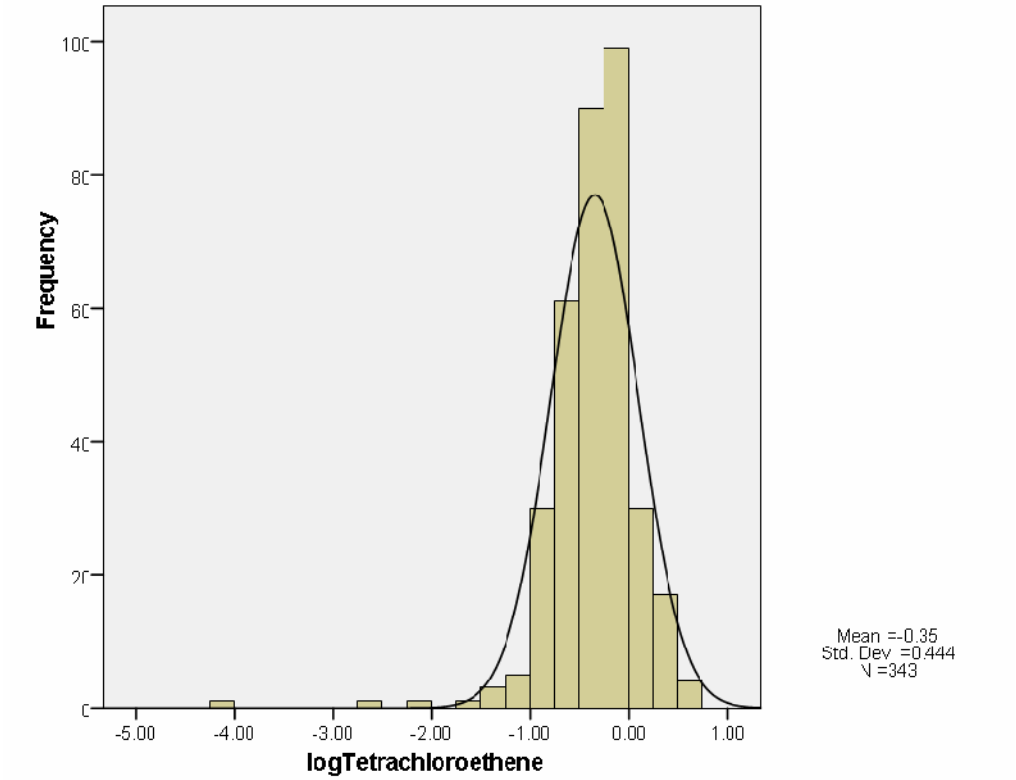
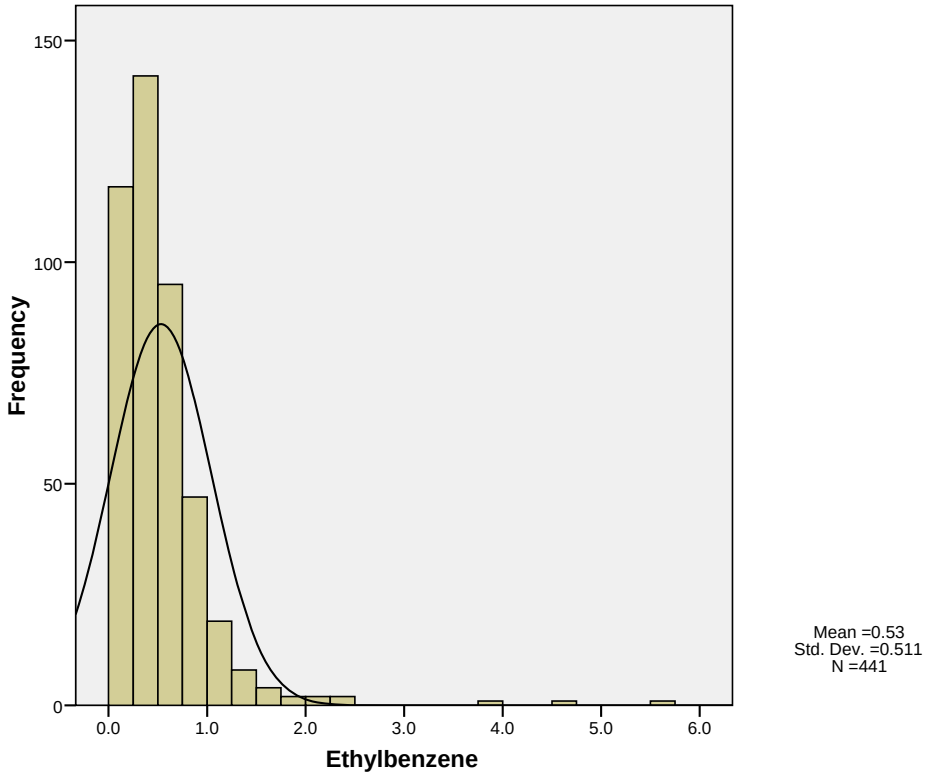


Figure 44. (a) Distribution of tetrachloroethene concentration (µg/m^3) with normal curve; and (b) distribution of tetrchloroethene log concentration (µg/m^3) with normal curve

(a)



(b)

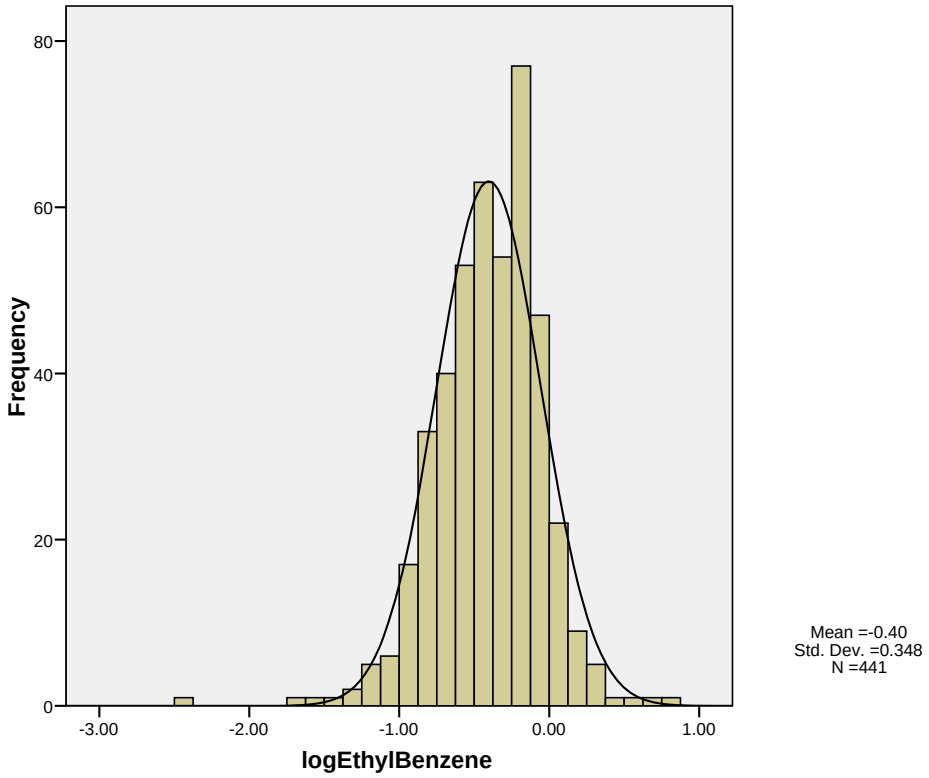
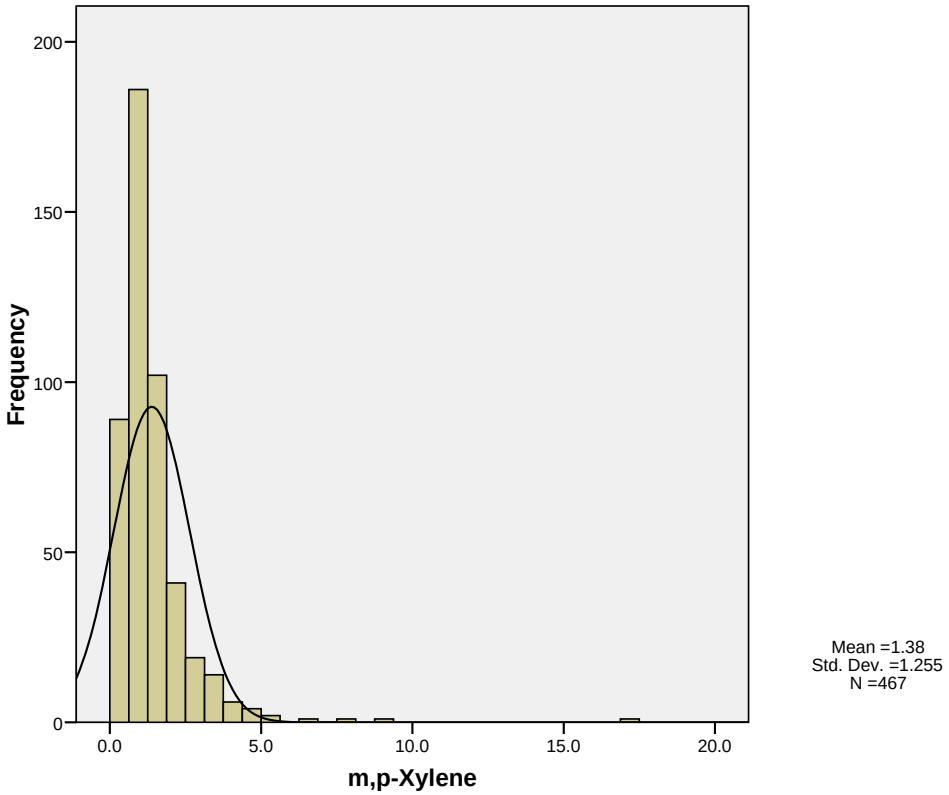


Figure 45. (a) Distribution of ethyl benzene concentration (μg/m^3) with normal curve; and (b) Distribution of ethyl benzene log concentration (μg/m^3) with normal curve

(a)



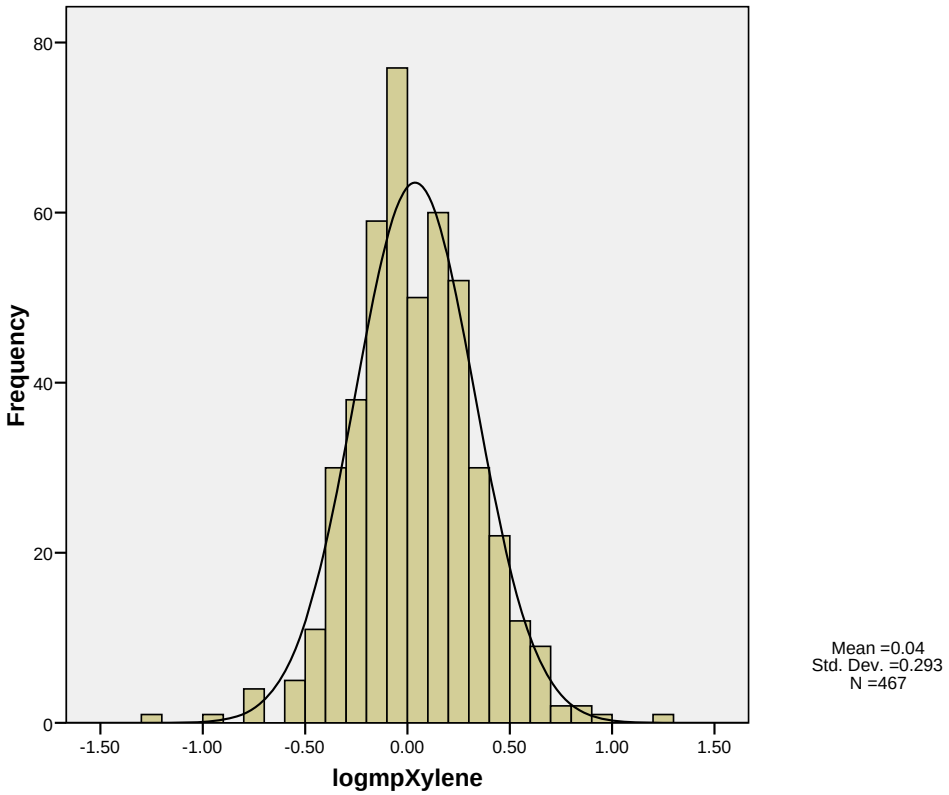
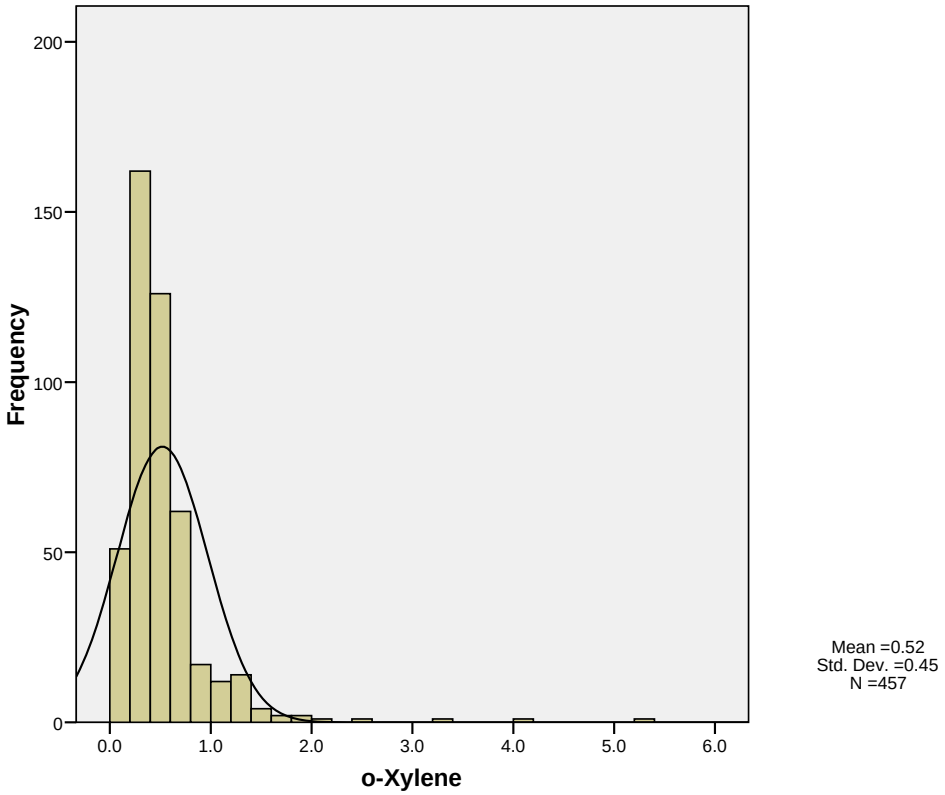


Figure 46. (a) Distribution of *m/p* xylene concentration (µg/m^3) with normal curve; and (b) Distribution of *m/p* xylene log concentration (µg/m^3) with normal curve

(a)



(b)

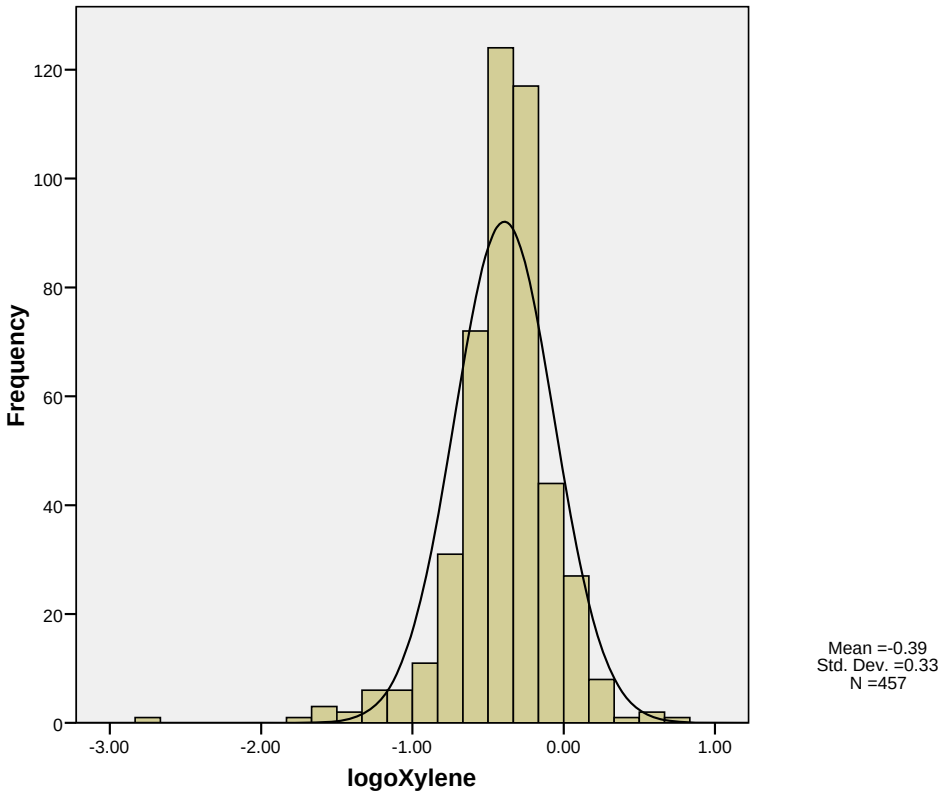
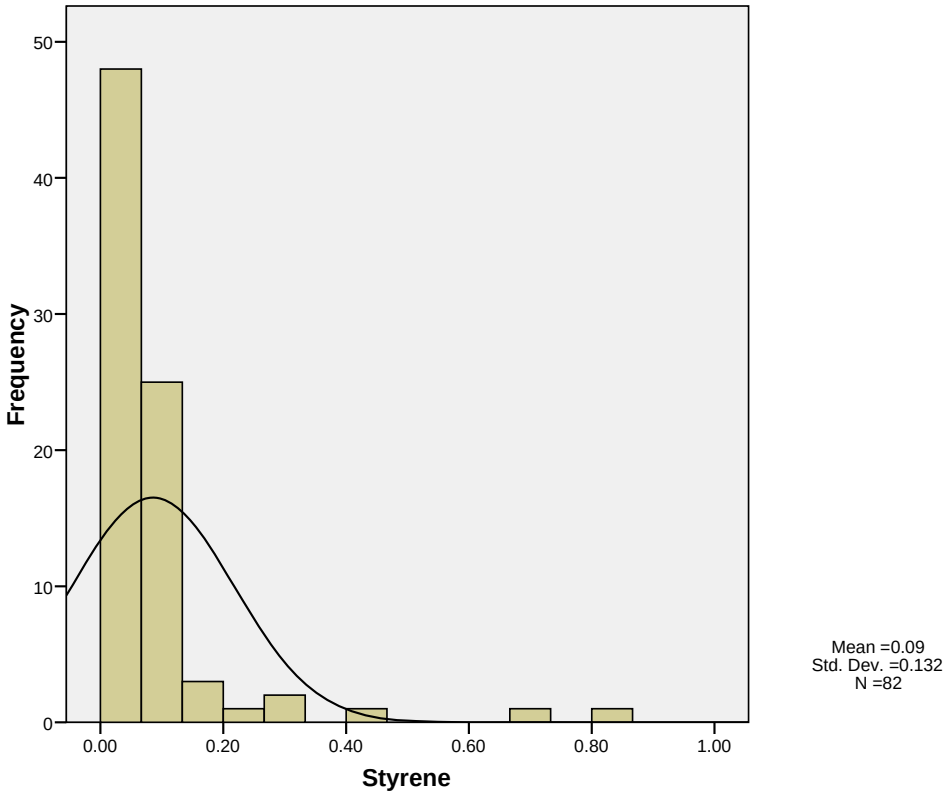


Figure 47. (a) Distribution of *o* xylene concentration (μg/m^3) with normal curve; and (b) Distribution of *o* xylene log concentration (μg/m^3) with normal curve

(a)



(b)

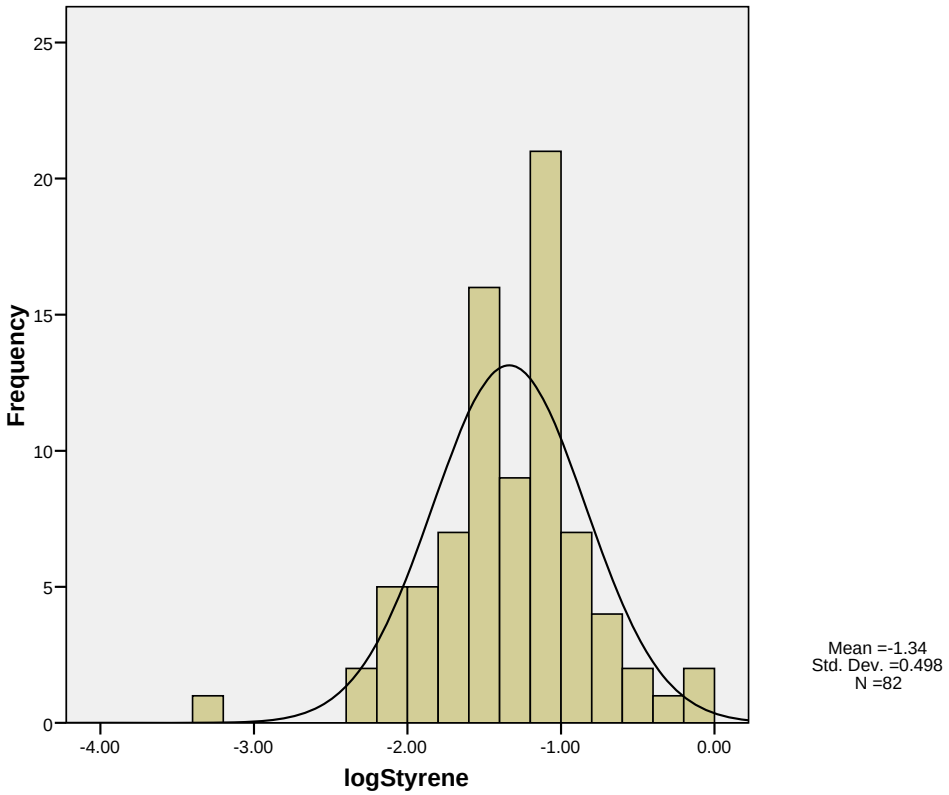
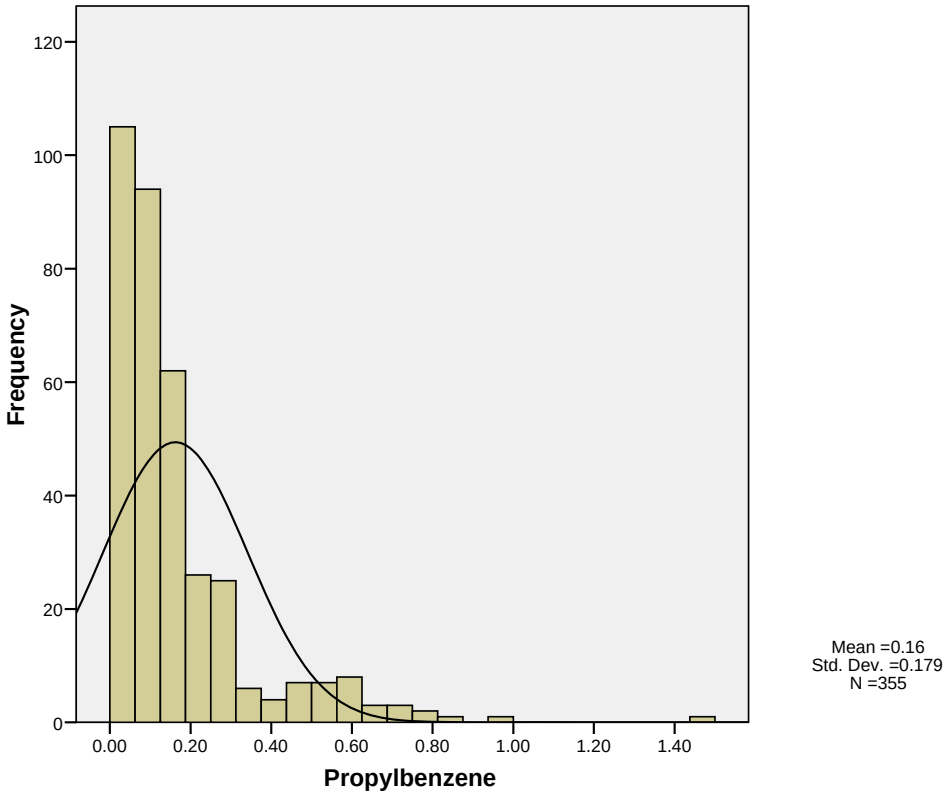


Figure 48. (a) Distribution of styrene concentration (µg/m^3) with normal curve; and (b) Distribution of styrene log concentration (µg/m^3) with normal curve

(a)



(b)

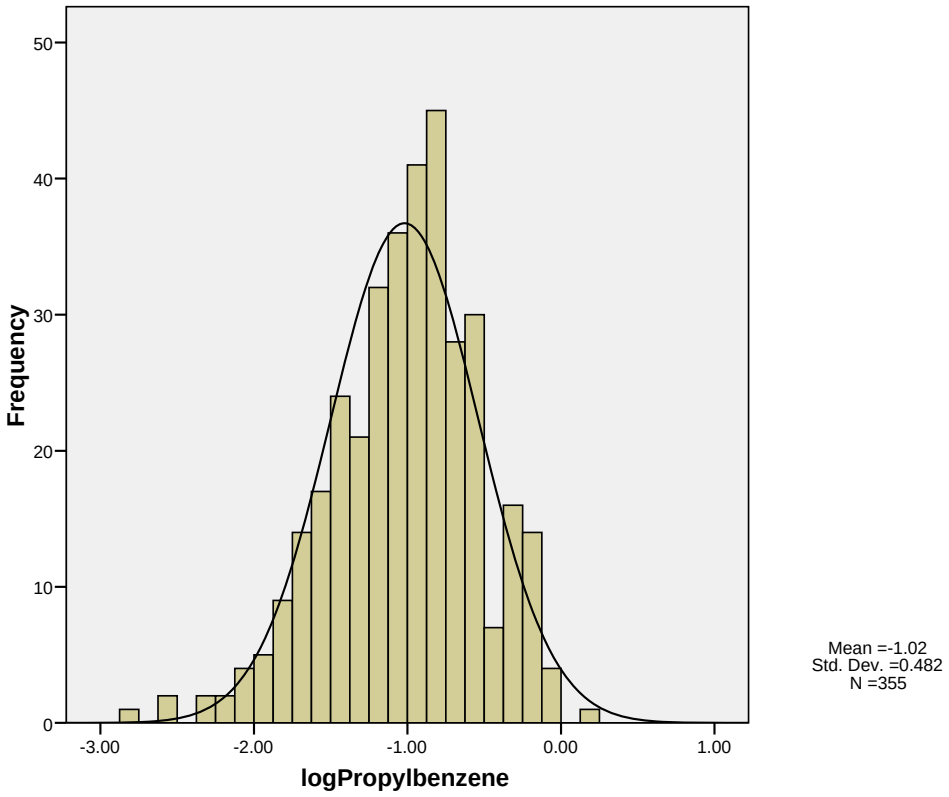
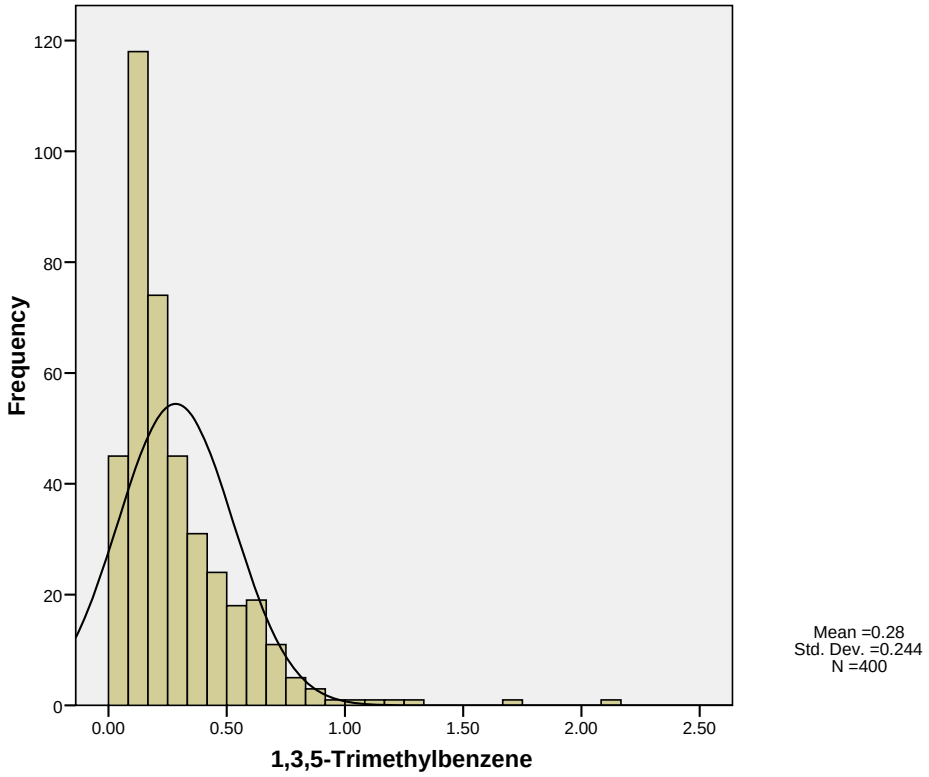


Figure 49. (a) Distribution of propyl benzene concentration (µg/m^3) with normal curve; and (b) Distribution of propyl benzene log concentration (µg/m^3) with normal curve

(a)



(b)

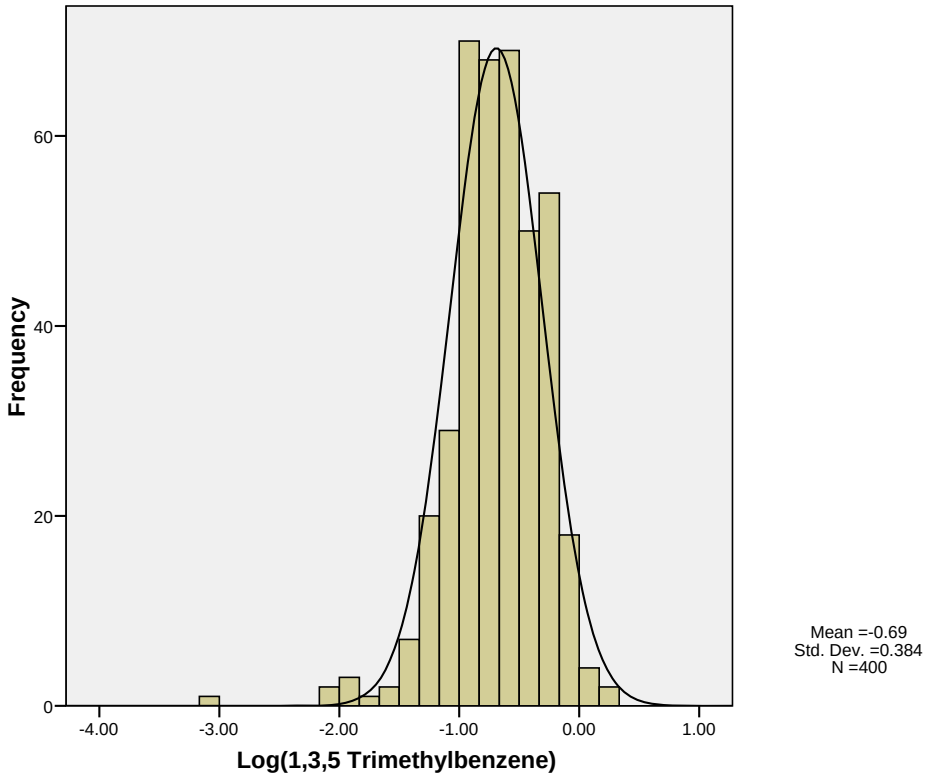
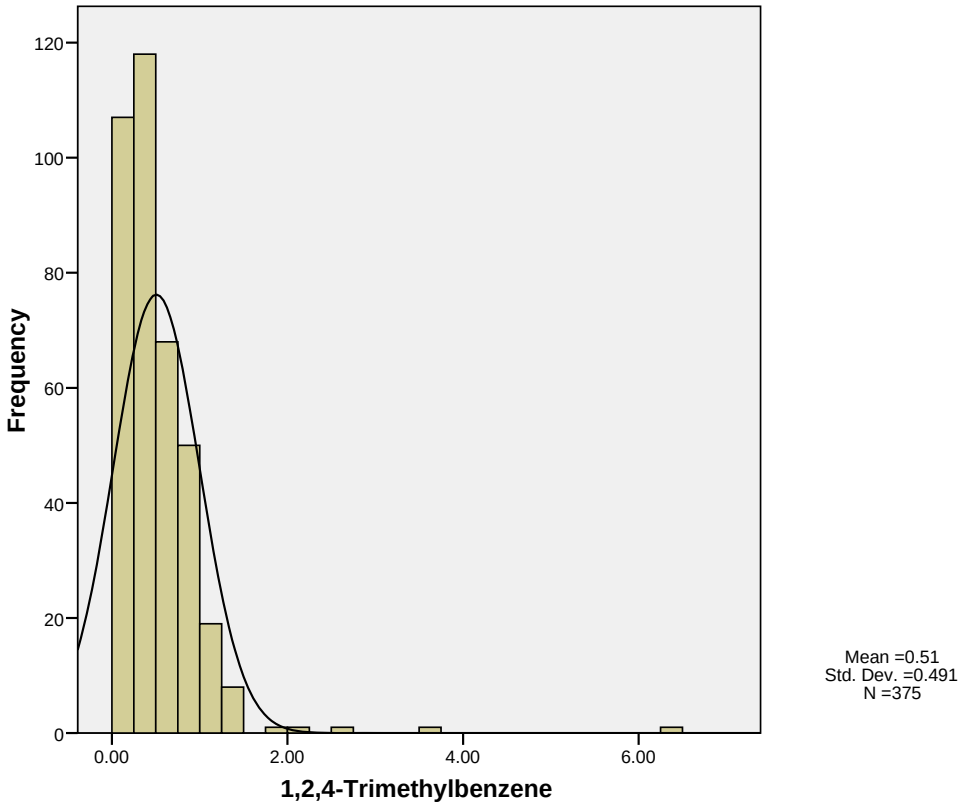


Figure 50. (a) Distribution of 1,3,5 trimethylbenzene concentration (µg/m^3) with normal curve; and (b) Distribution of 1,3,5 trimethylbenzene log concentration (µg/m^3) with normal curve

(a)



(b)

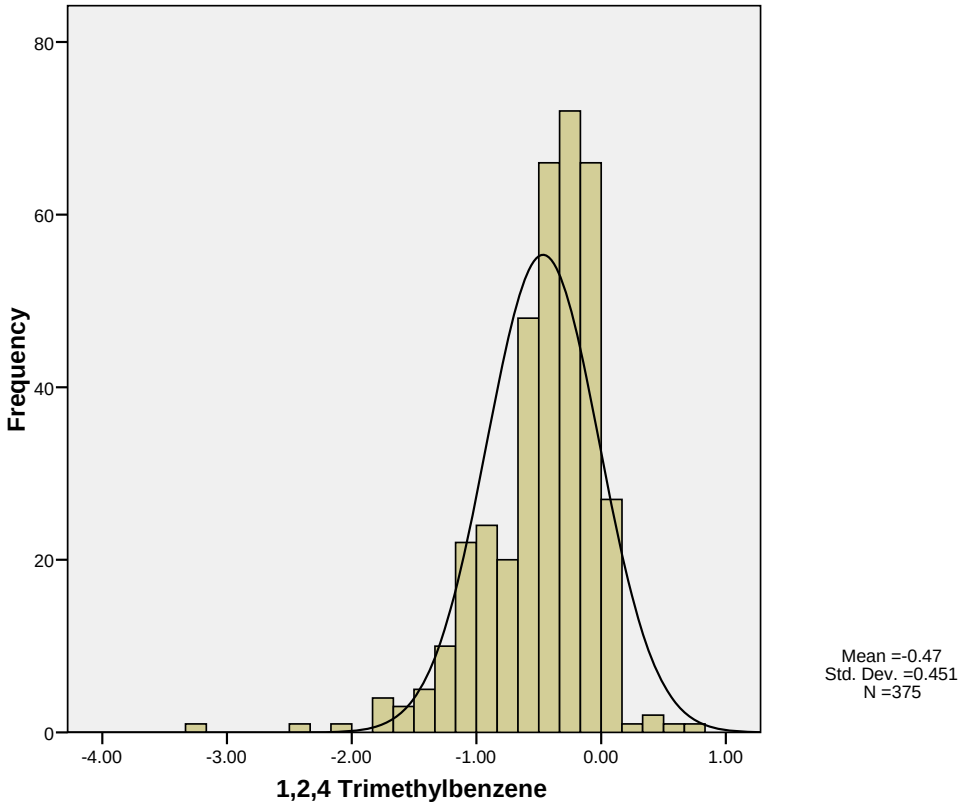
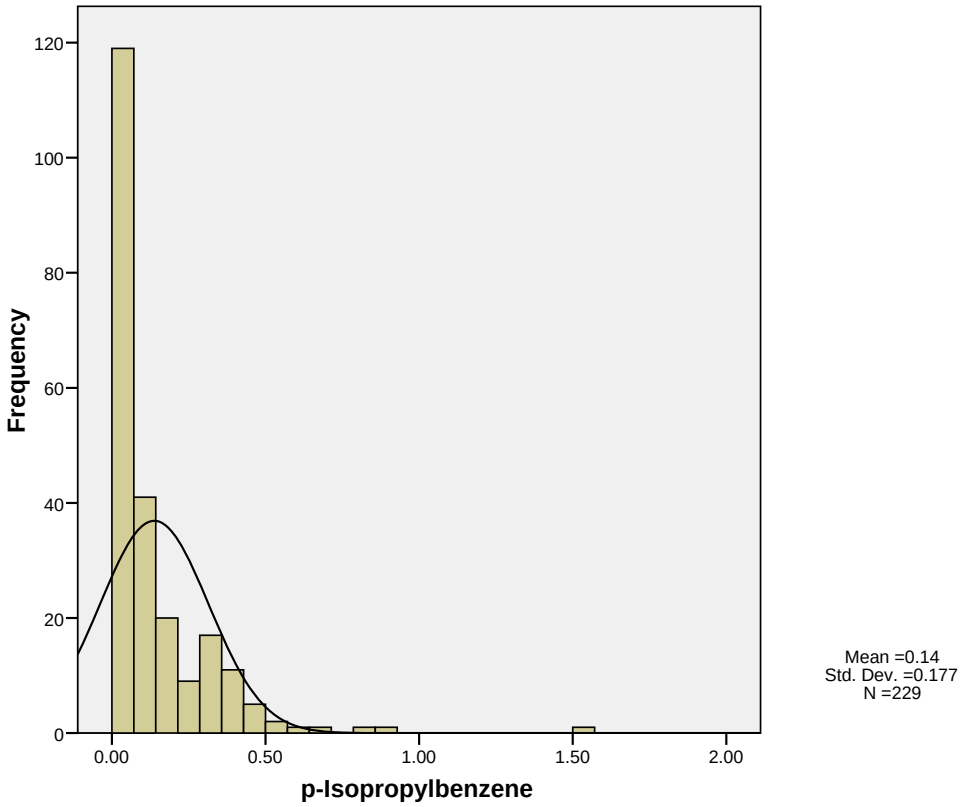


Figure 51. (a) Distribution of 1,2,4 trimethylbenzene concentration (µg/m^3) with normal curve; and (b) Distribution of 1,2,4 trimethylbenzene log concentration (µg/m^3) with normal curve

(a)



(b)

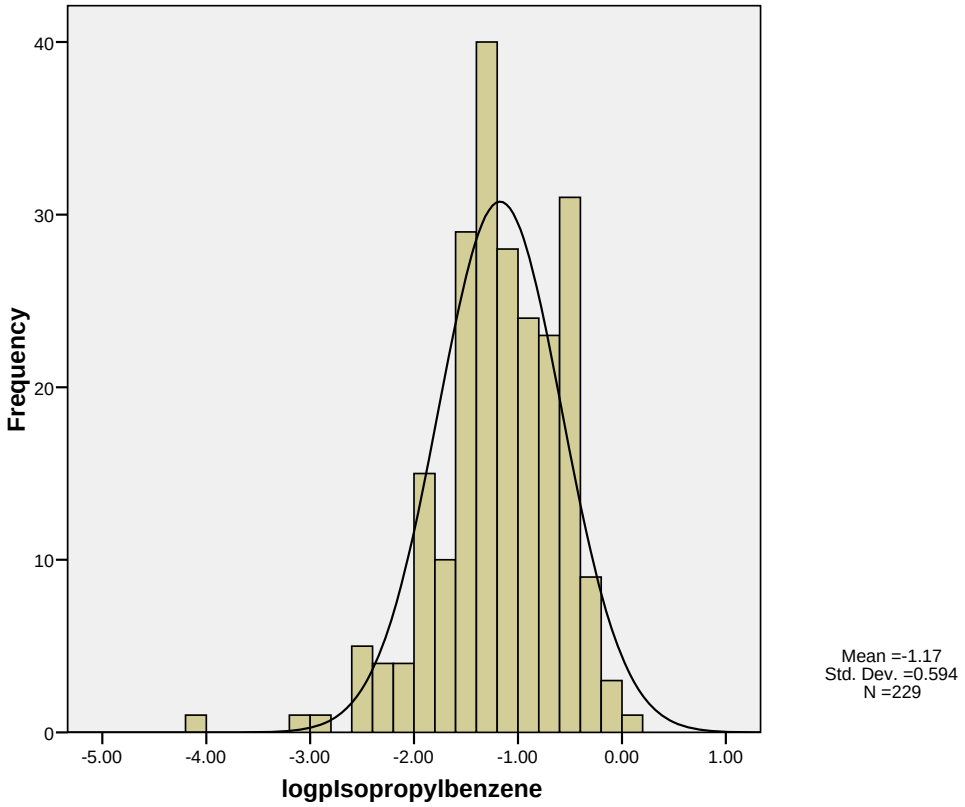
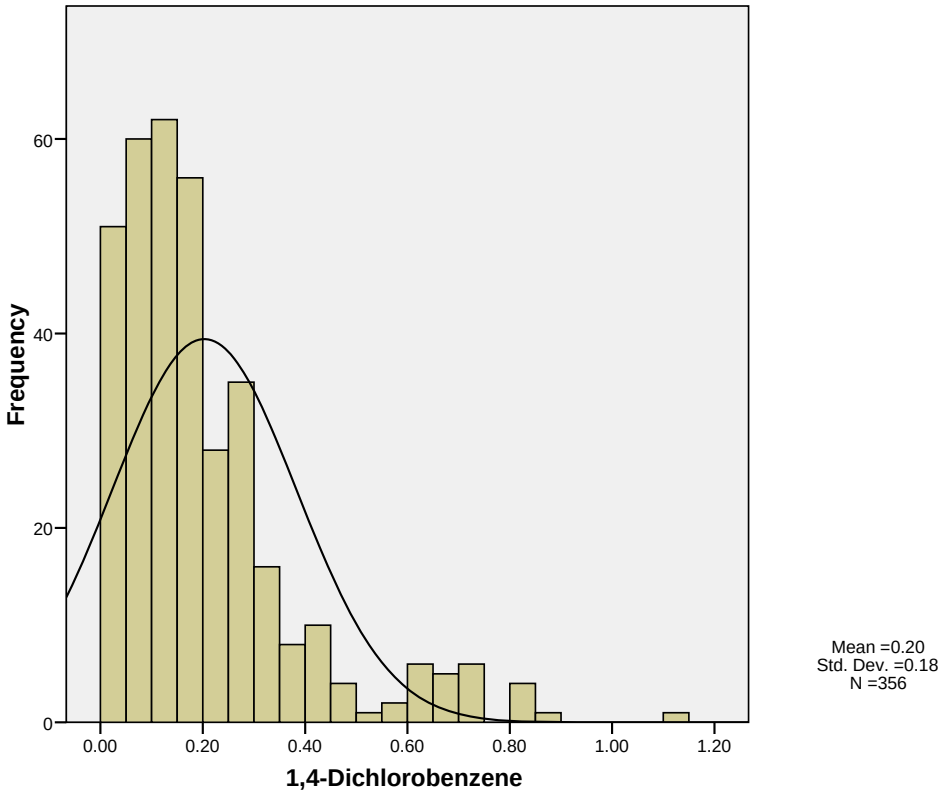


Figure 52. (a) Distribution of *p* Isopropylbenzene Concentration (µg/m^3) with Normal Curve; and (b) Distribution of *p* isopropylbenzene log concentration (µg/m^3) with normal curve

(a)



(b)

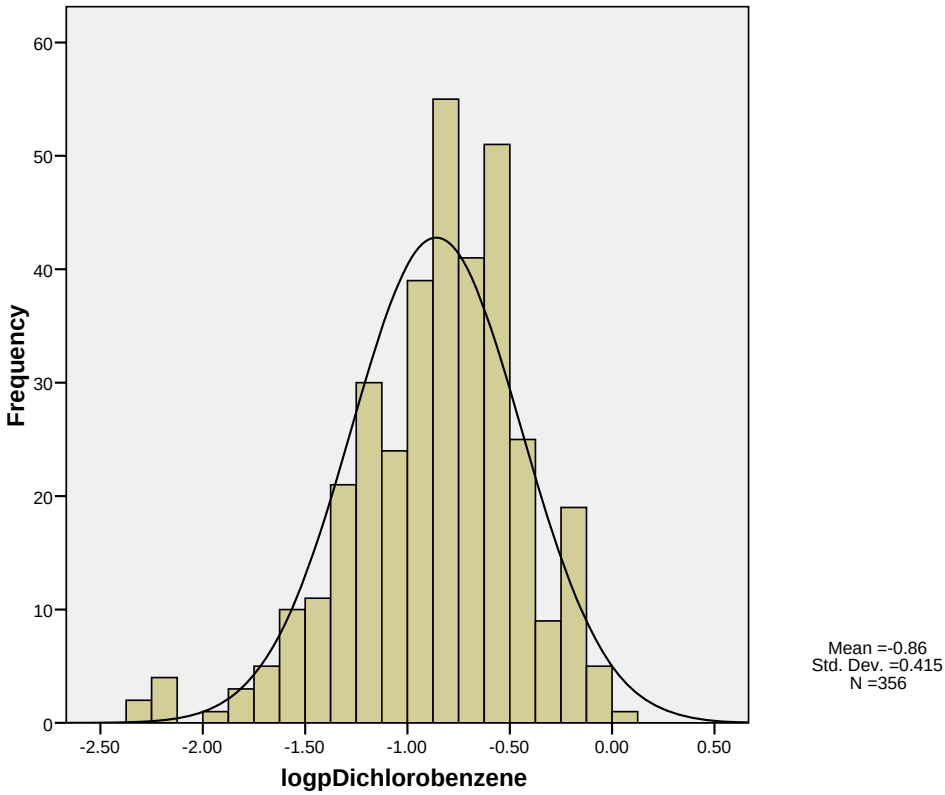
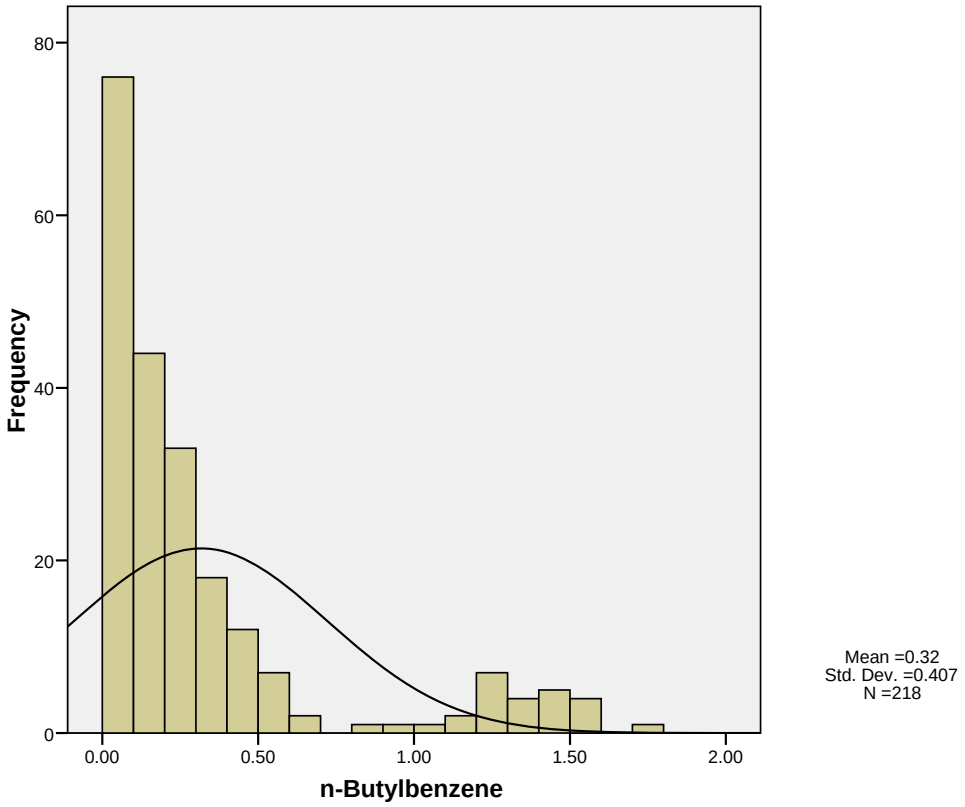


Figure 53. (a) Distribution of *p* dichlorobenzene concentration (µg/m^3) with normal curve; and (b) Distribution of *p* dichlorobenzene log concentration (µg/m^3) with normal curve

(a)



(b)

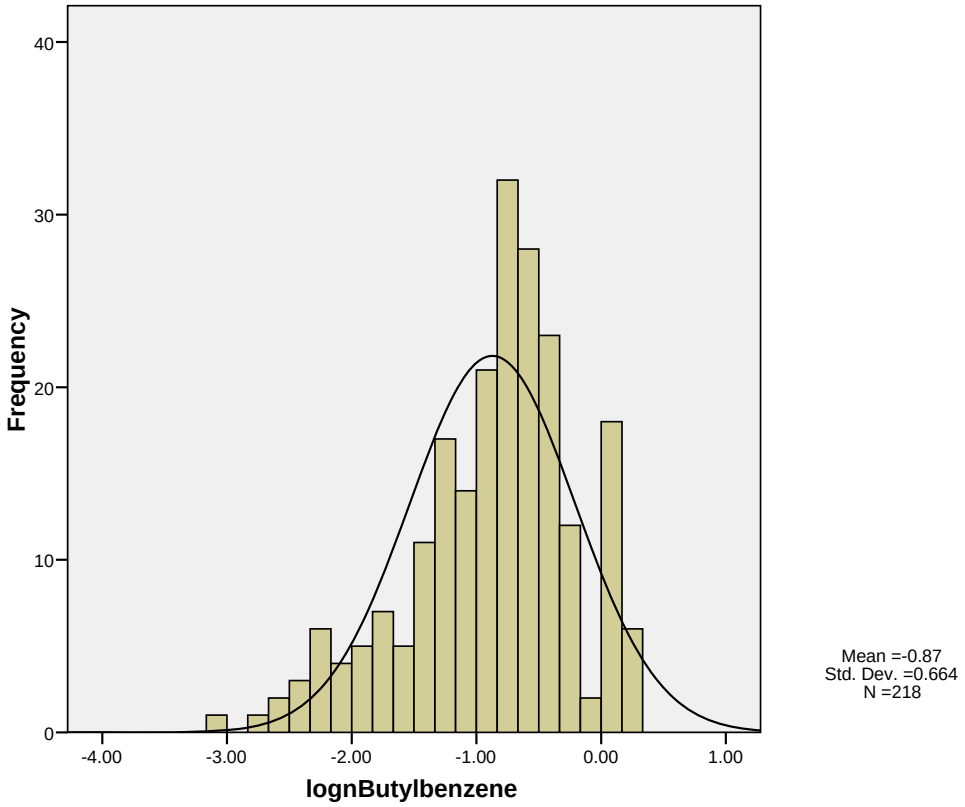
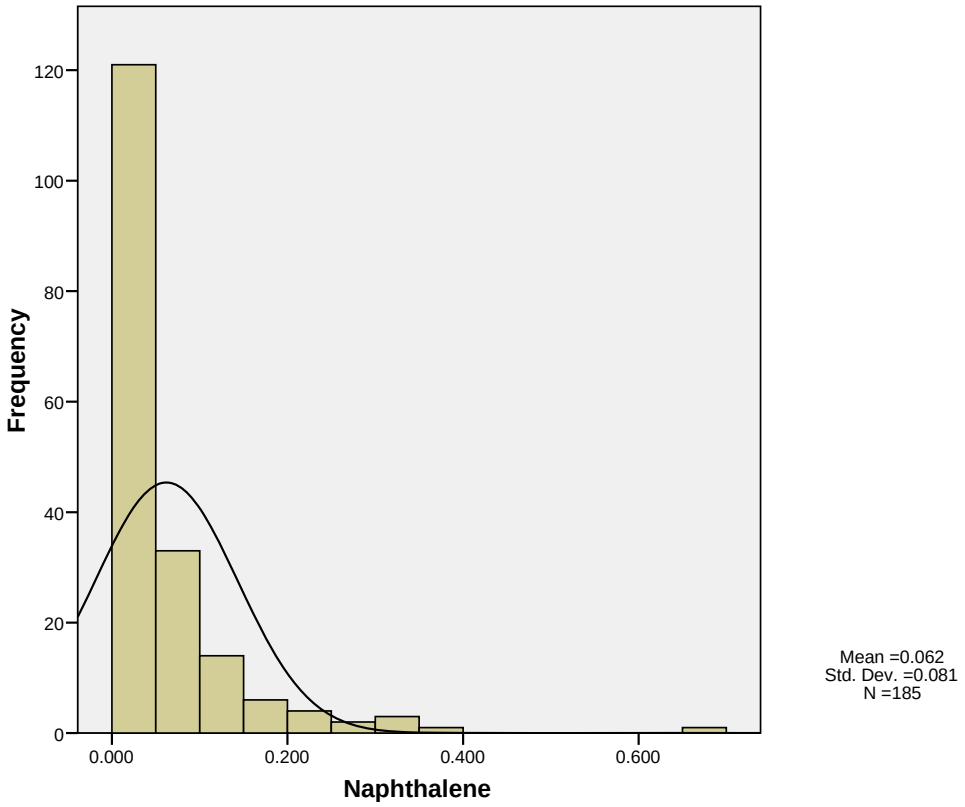


Figure 54. (a) Distribution of butylbenzene concentration (µg/m^3) with normal curve; and (b) Distribution of butylbenzene log concentration (µg/m^3) with normal curve

(a)



(b)

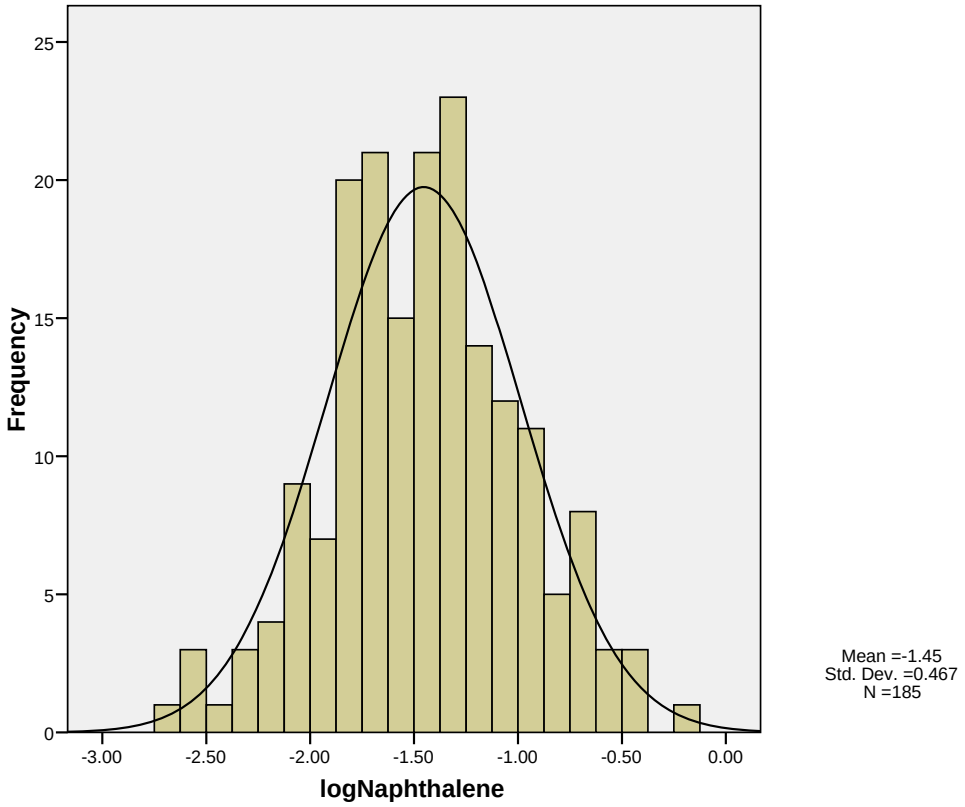


Figure 55. (a) Distribution of naphthalene concentration (μg/m^3) with normal curve; and (b) Distribution of naphthalene log concentration (μg/m^3) with normal curve

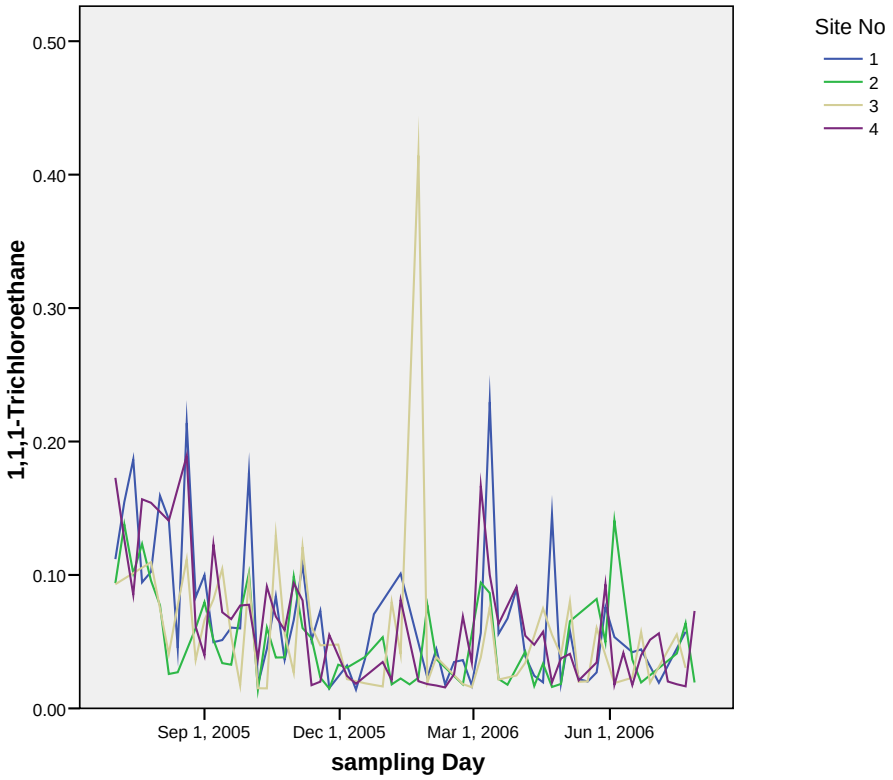


Figure 56. Temporal change in 1,1,1 trichloroethane concentration (µg/m^3) by site

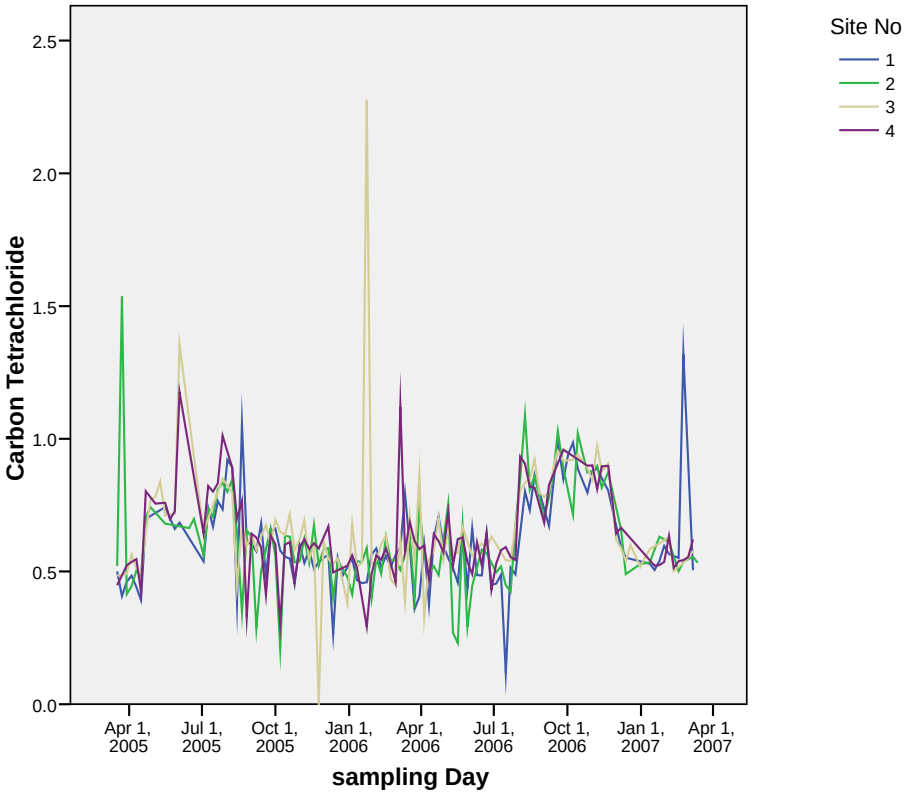


Figure 57. Temporal change in carbon tetrachloride concentration (µg/m^3) by site

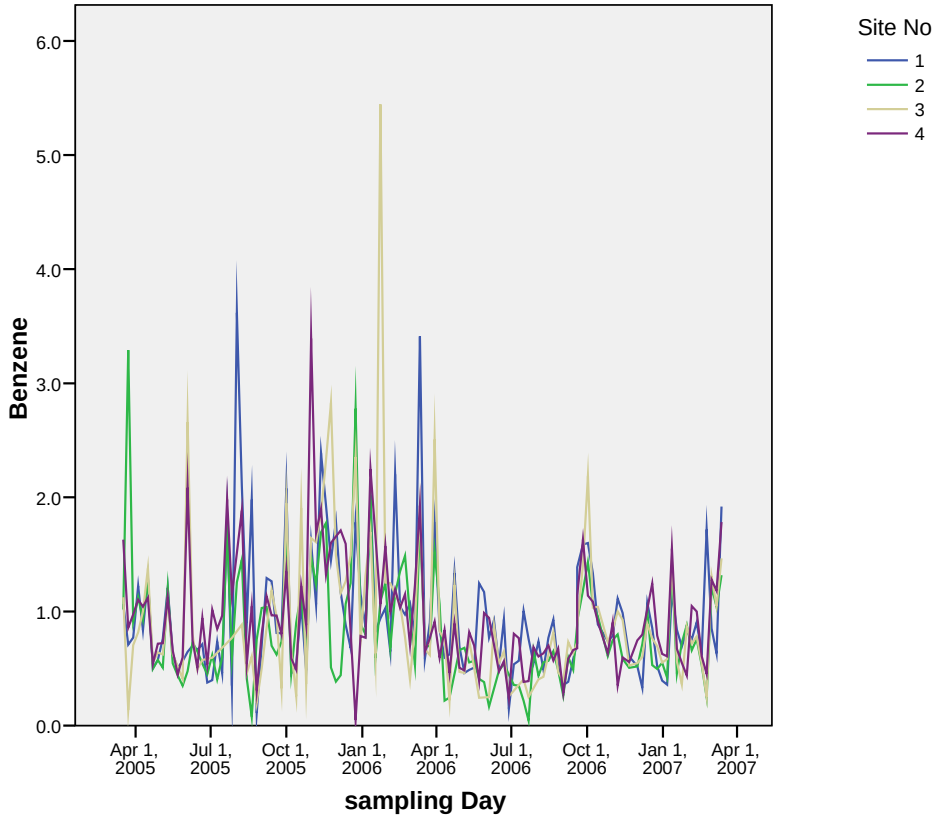


Figure 58. Temporal change in benzene concentration (µg/m^3) by site

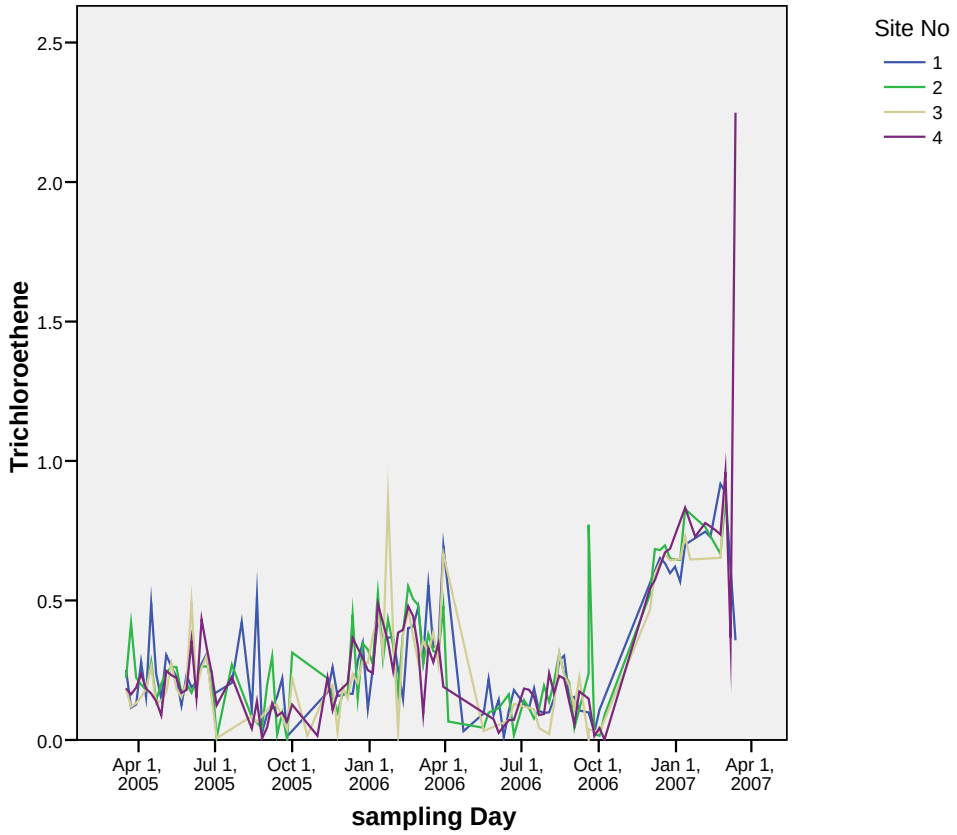


Figure 59. Temporal change in trichloroethene concentration (µg/m^3) by site

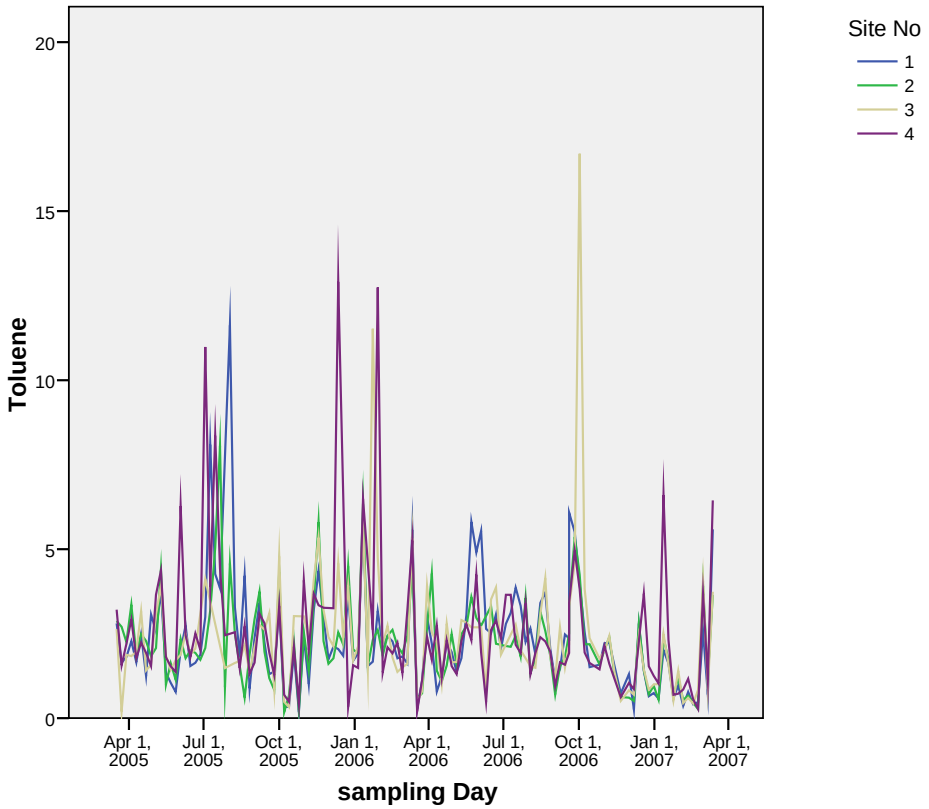


Figure 60. Temporal change in toluene concentration (µg/m^3) by site

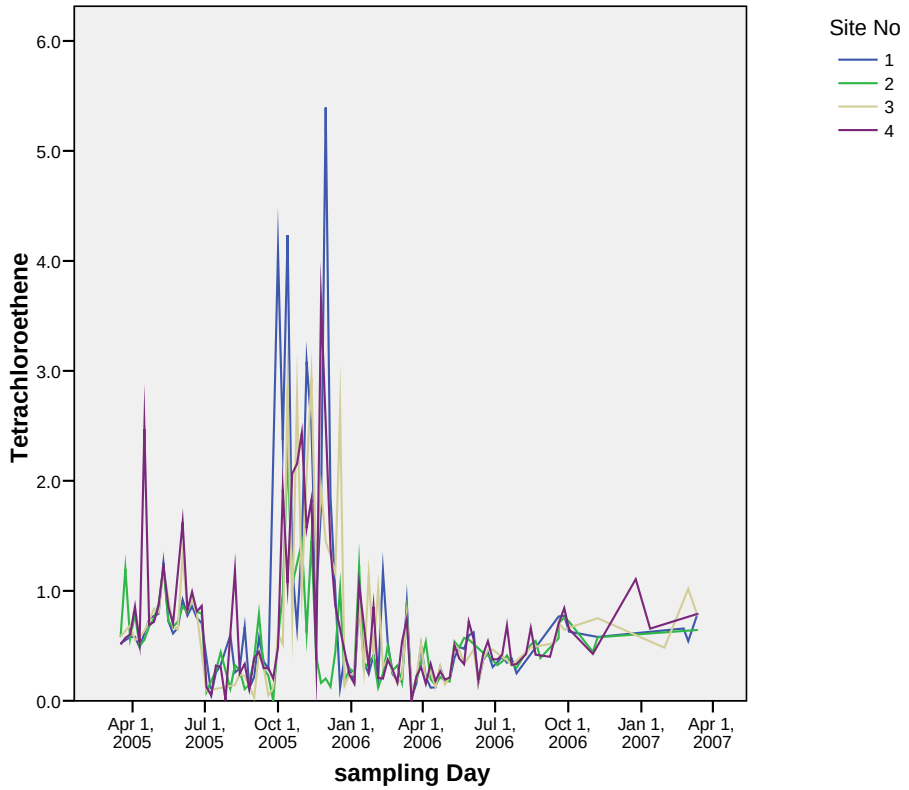


Figure 61. Temporal change in tetrachloroethene concentration (µg/m^3) by site

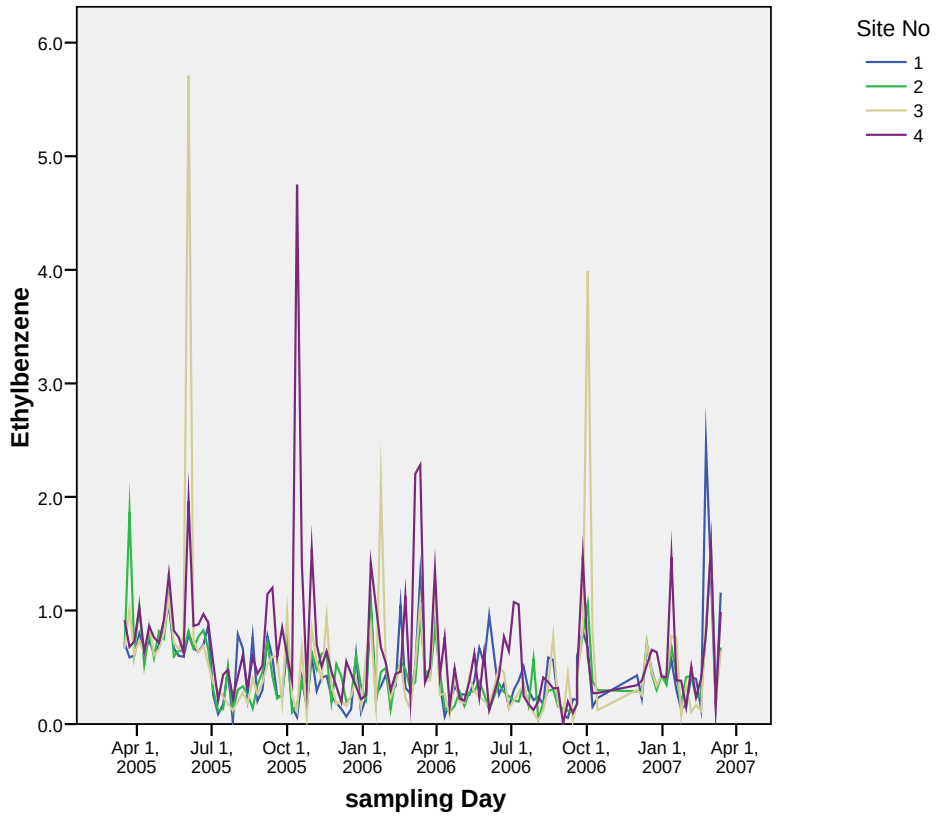


Figure 62. Temporal change in ethyl benzene concentration (µg/m^3) by site

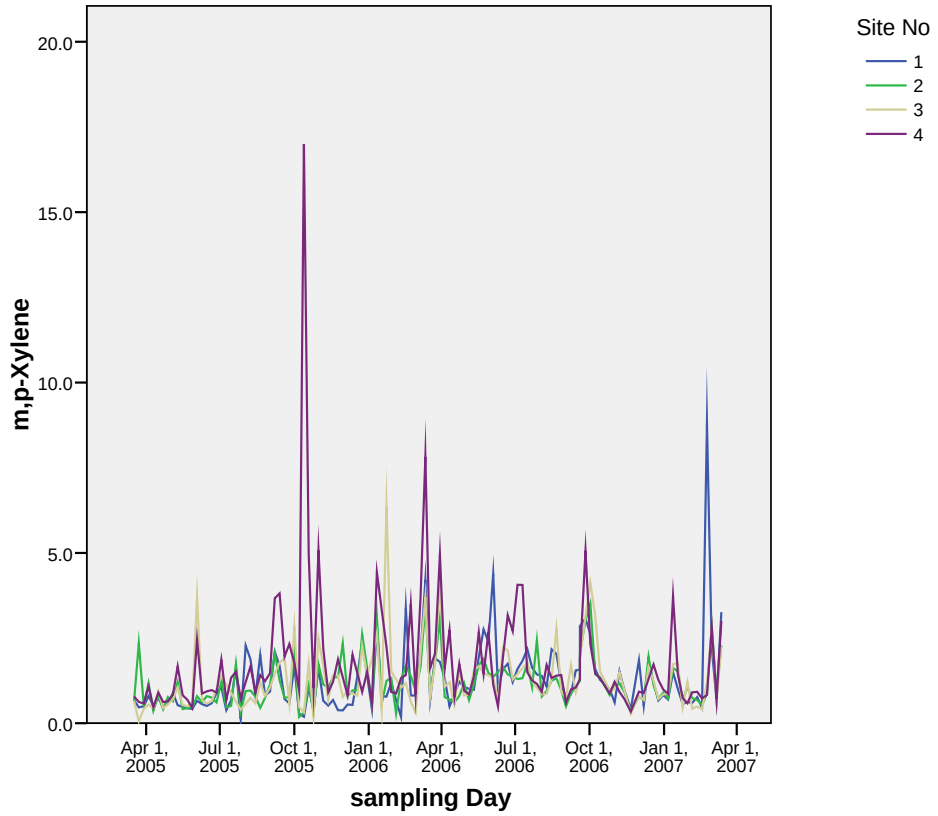


Figure 63. Temporal change in *m/p* xylene concentration (µg/m^3) by site

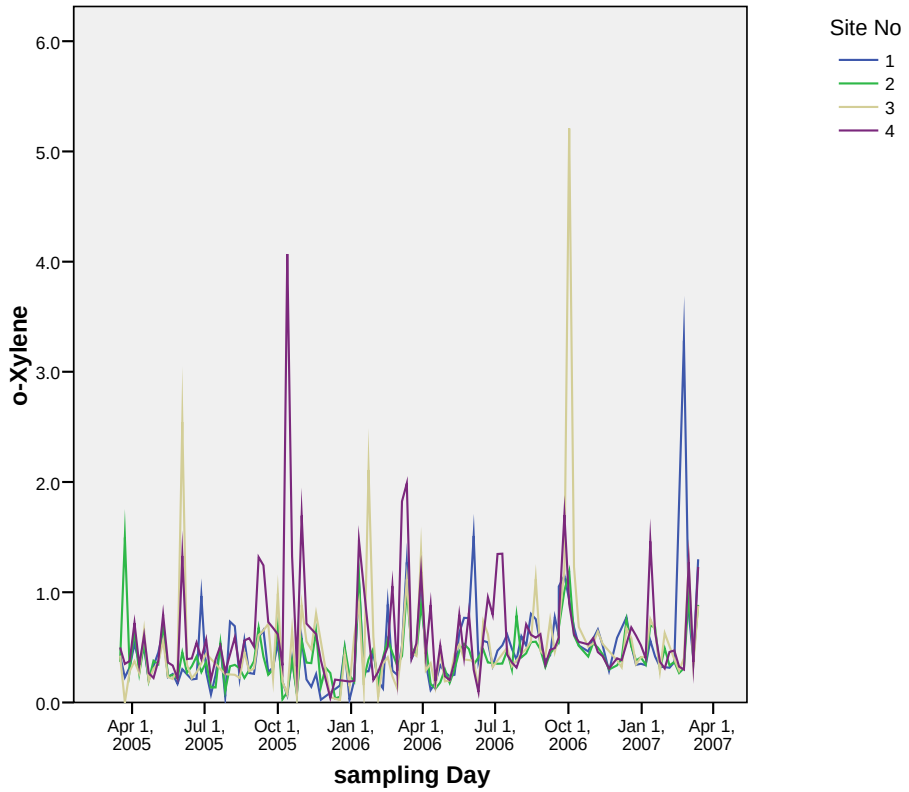


Figure 64. Temporal change in *o* xylene concentration (µg/m^3) by site

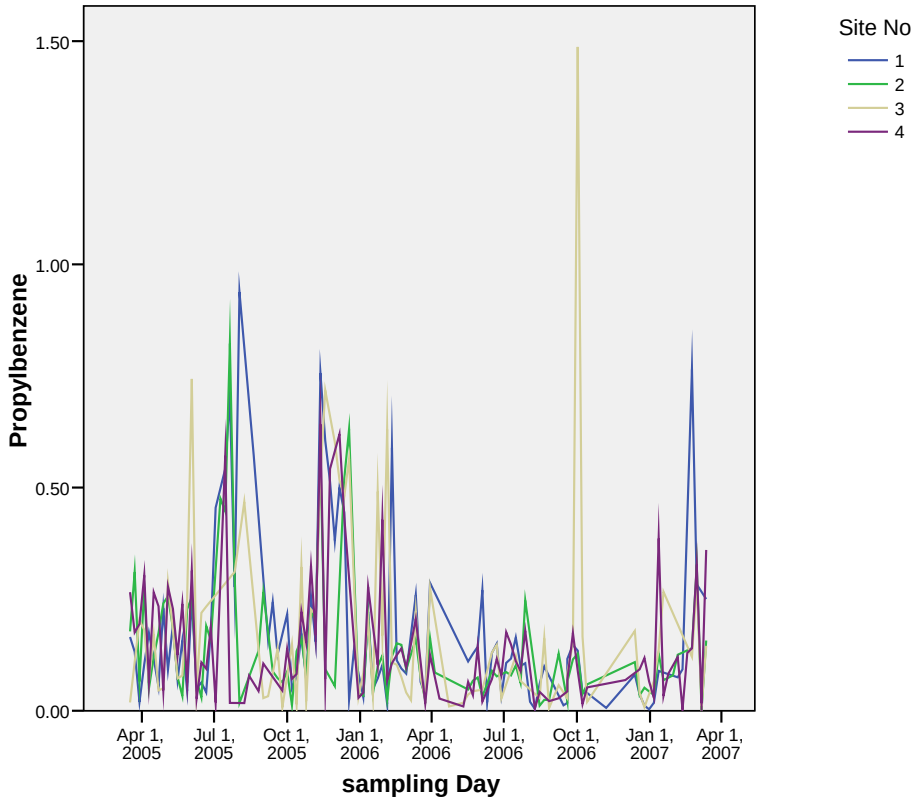


Figure 65. Temporal change in propylbenzene concentration (µg/m^3) by site

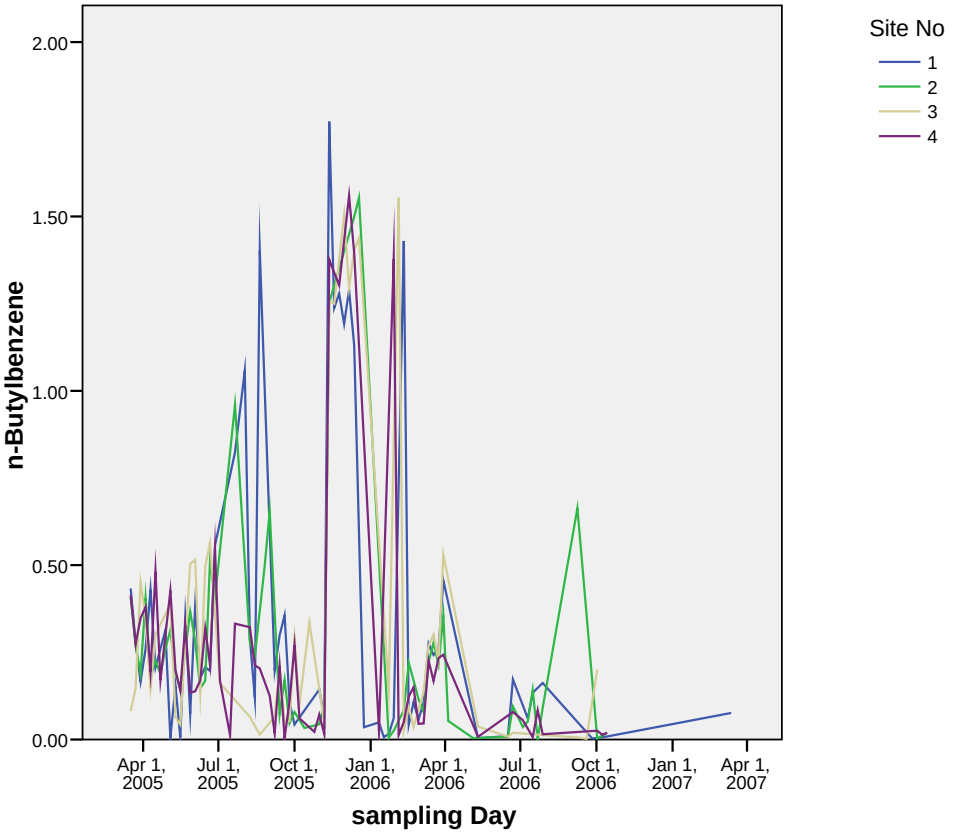


Figure 66. Temporal change in n-butylbenzene concentration (µg/m^3) by site

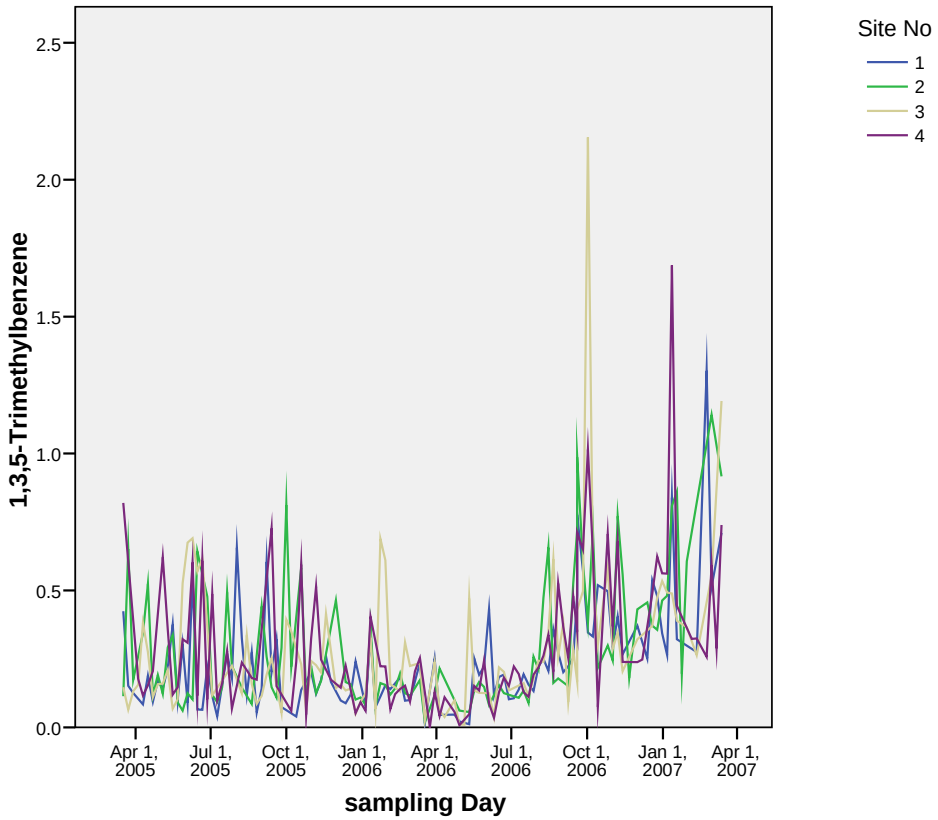


Figure 67. Temporal change in 1,3,5 trimethylbenzene concentration (µg/m^3) by site

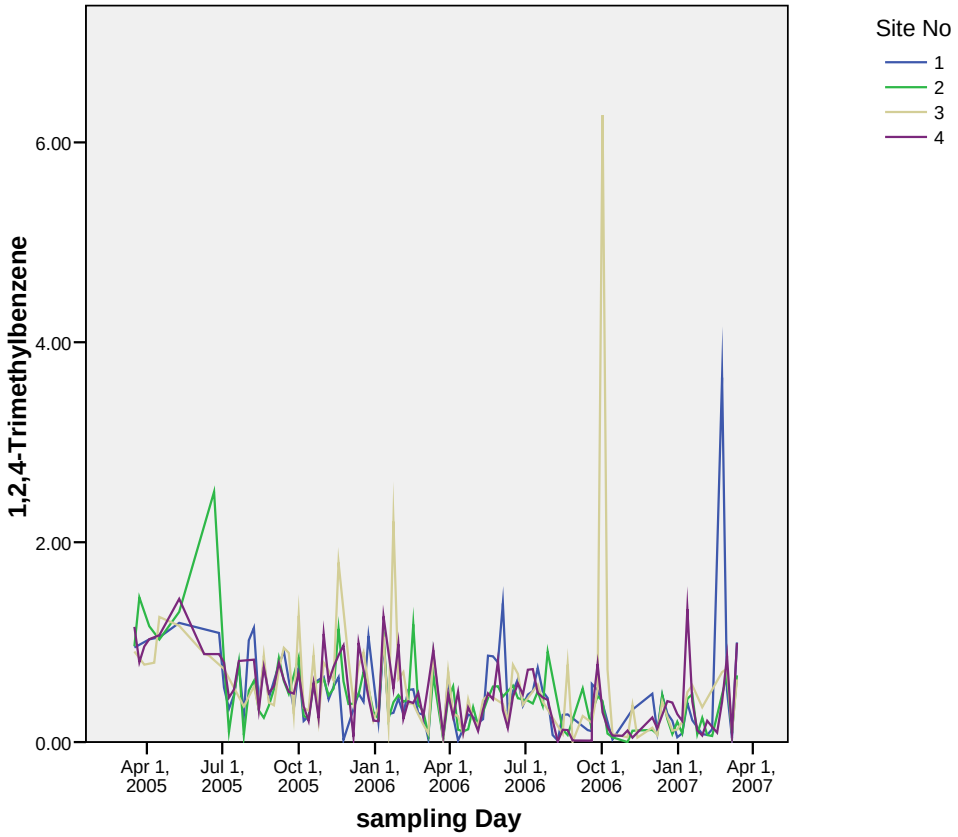


Figure 68. Temporal change in 1,2,4 trimethylbenzene concentration (µg/m^3) by site

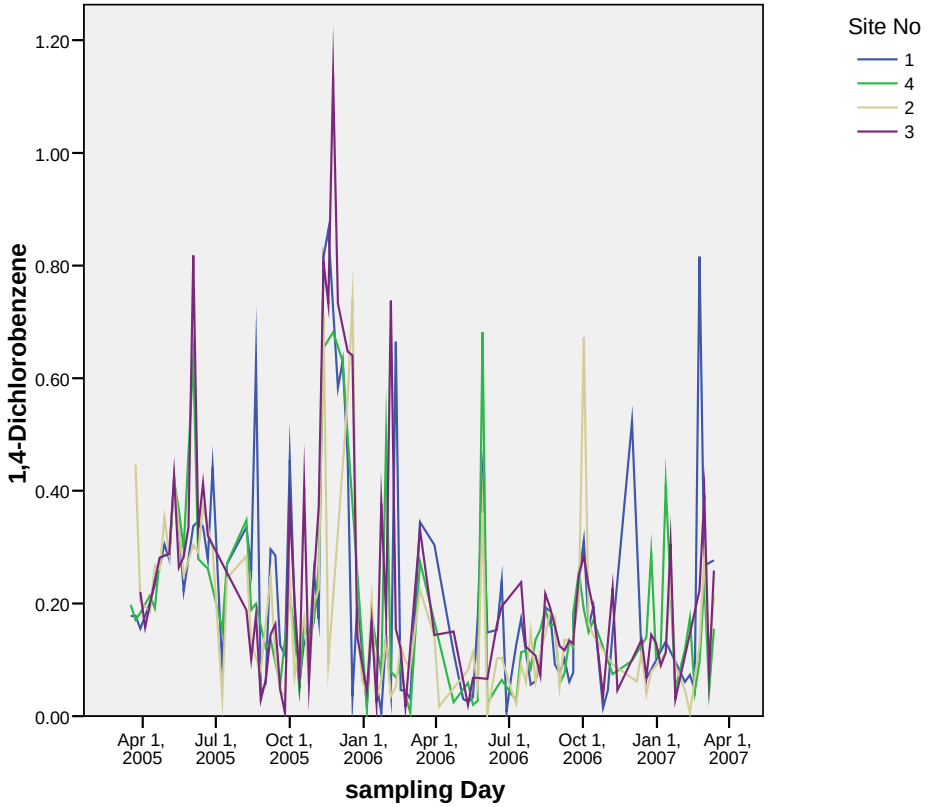


Figure 69. Temporal change in 1,4 dichlorobenzene concentration (µg/m^3) by site

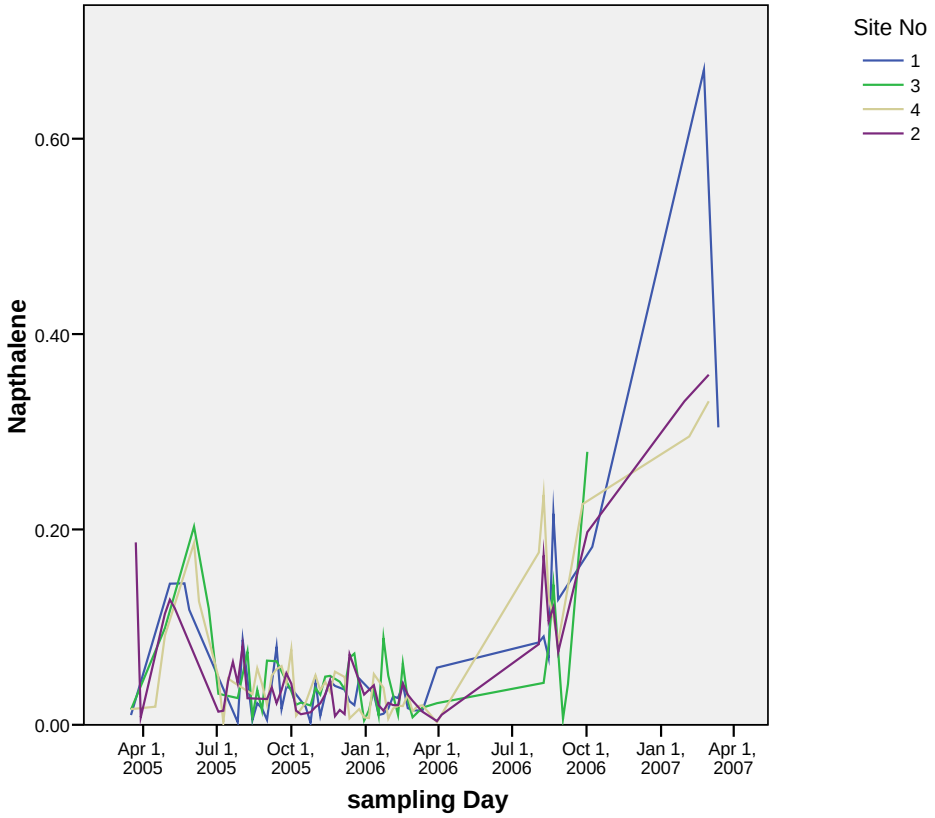


Figure 70. Temporal change in naphthalene concentration (µg/m³) by site

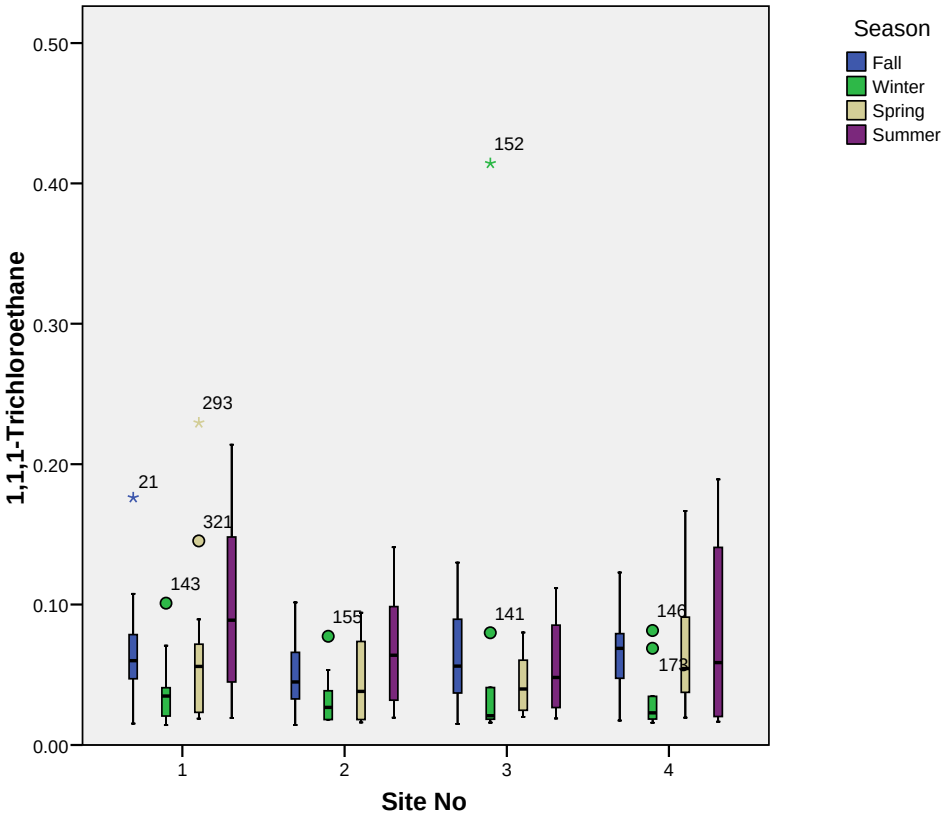


Figure 71. Box and whisker plot of 1,1,1-trichloroethane concentration (µg/m³) by site and season

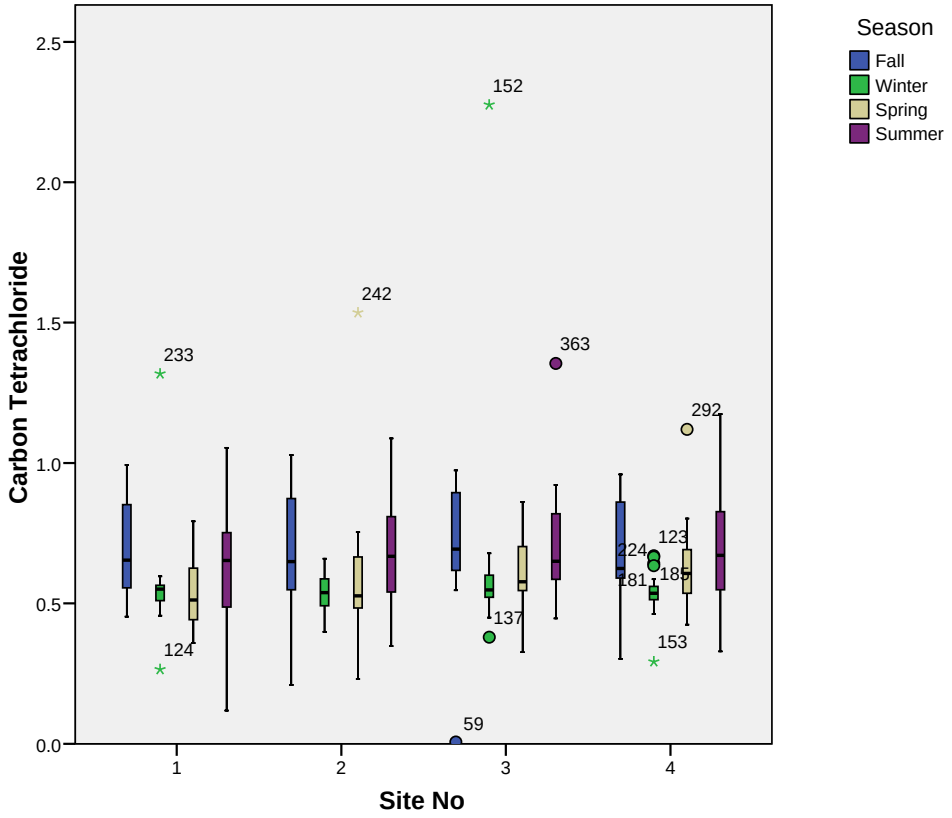


Figure 72. Box and whisker plot of carbon tetrachloride concentration (µg/m³) by site and season

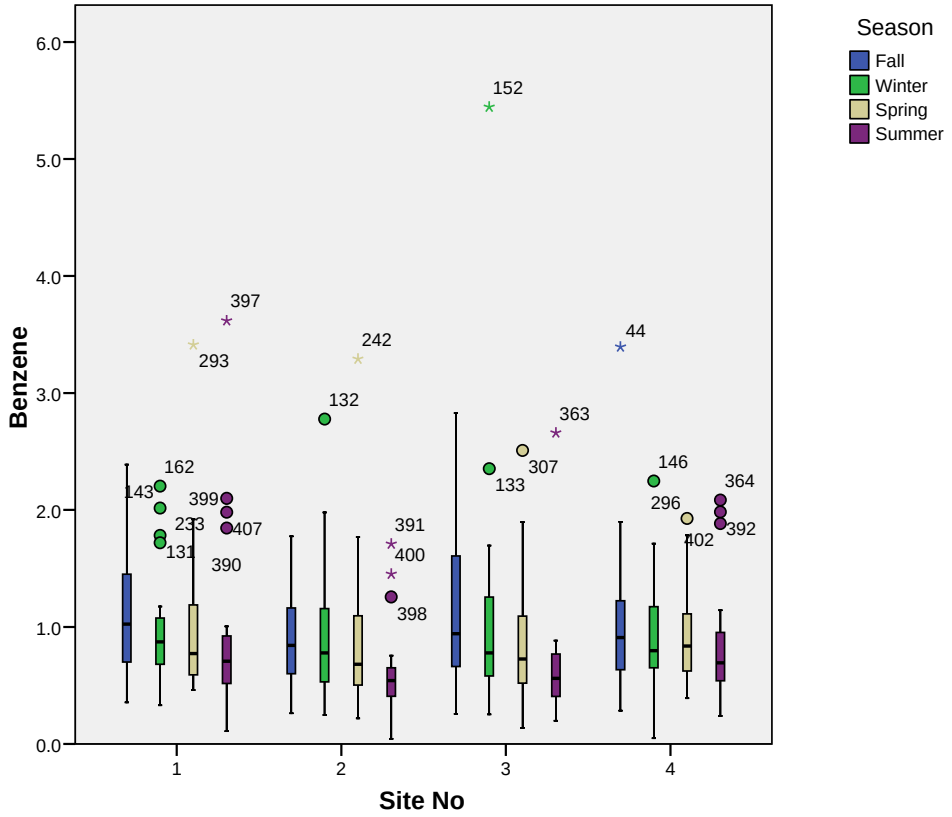


Figure 73. Box and whisker plot of benzene concentration (µg/m³) by site and season

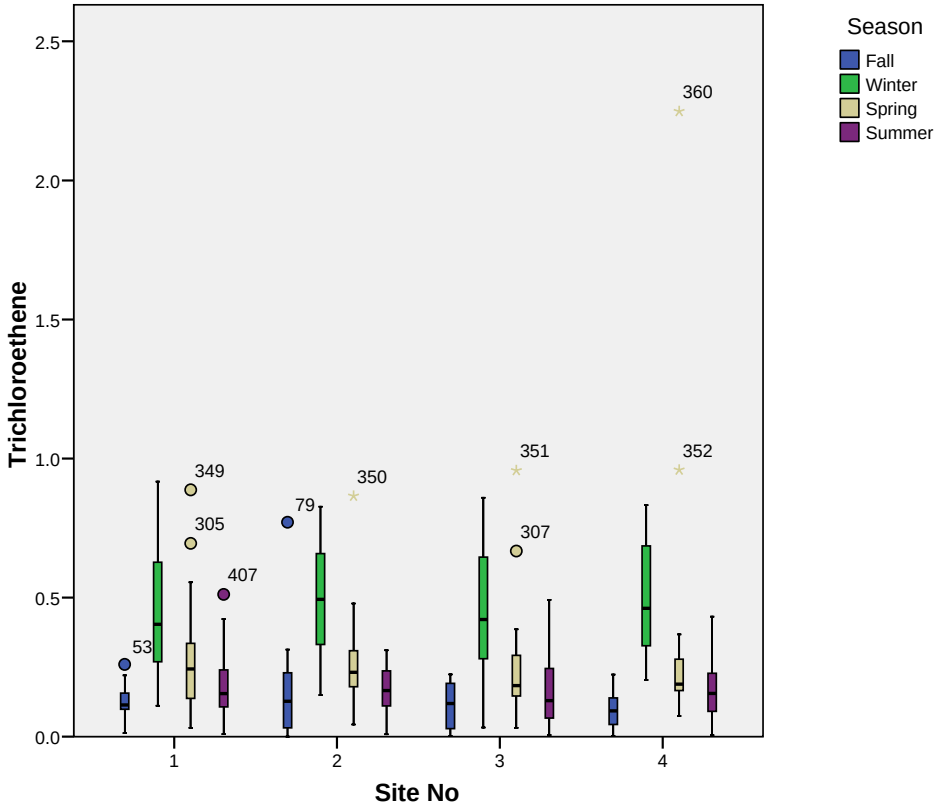


Figure 74. Box and whisker plot of trichloroethene concentration (µg/m³) by site and season

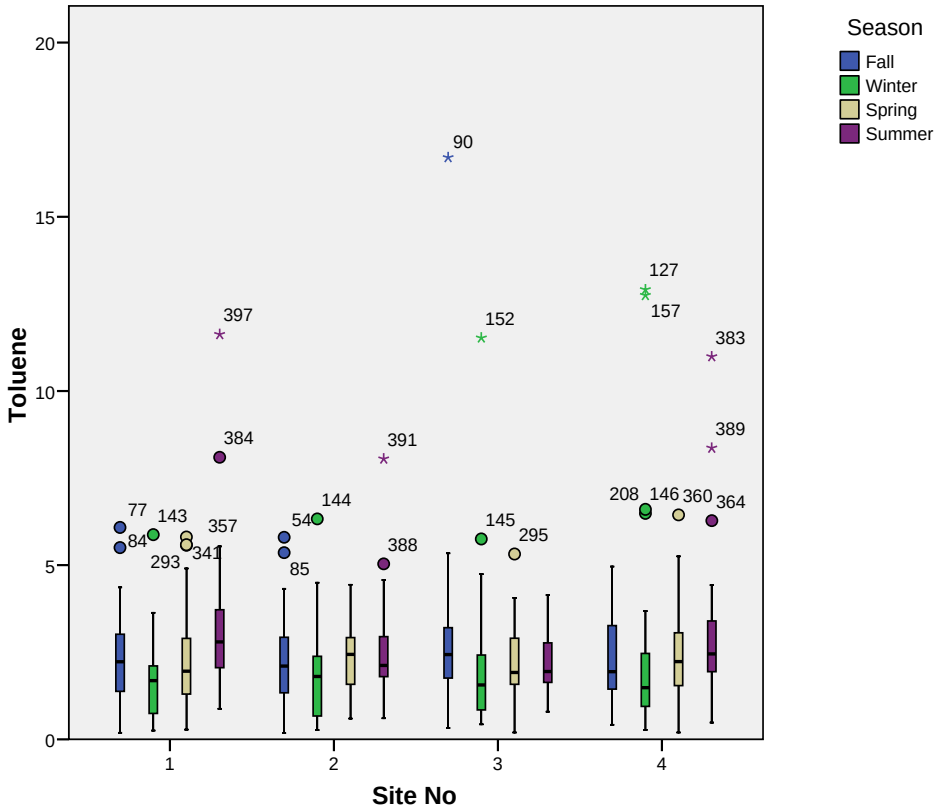


Figure 75. Box and whisker plot of toluene concentration (µg/m³) by site and season

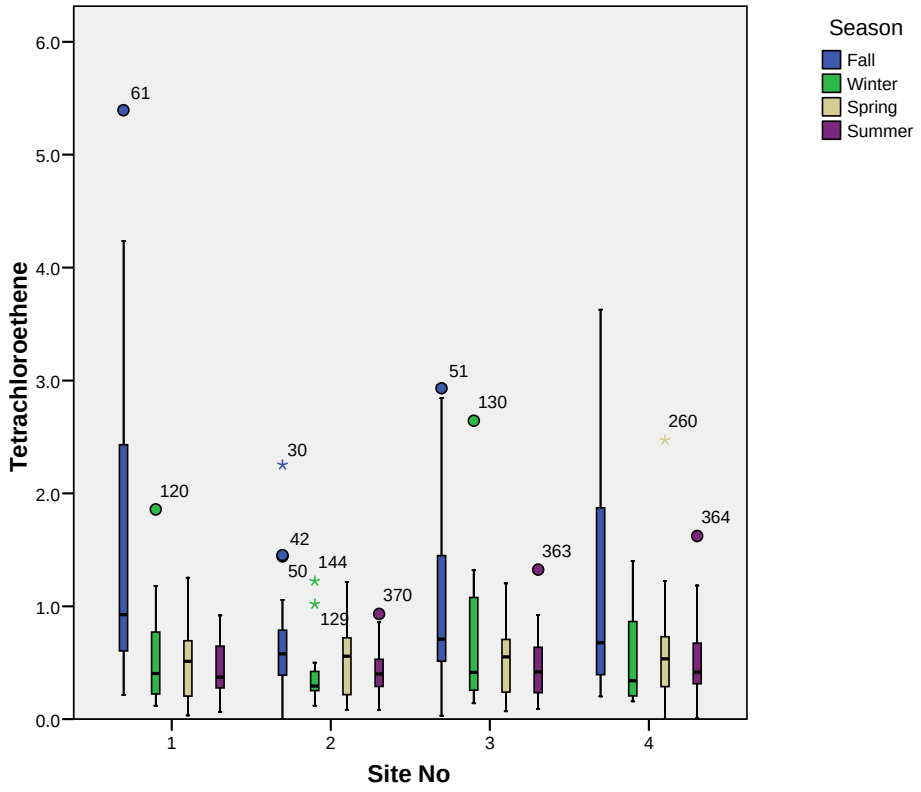


Figure 76. Box and whisker plot of tetrachloroethene concentration (µg/m^3) by site and season

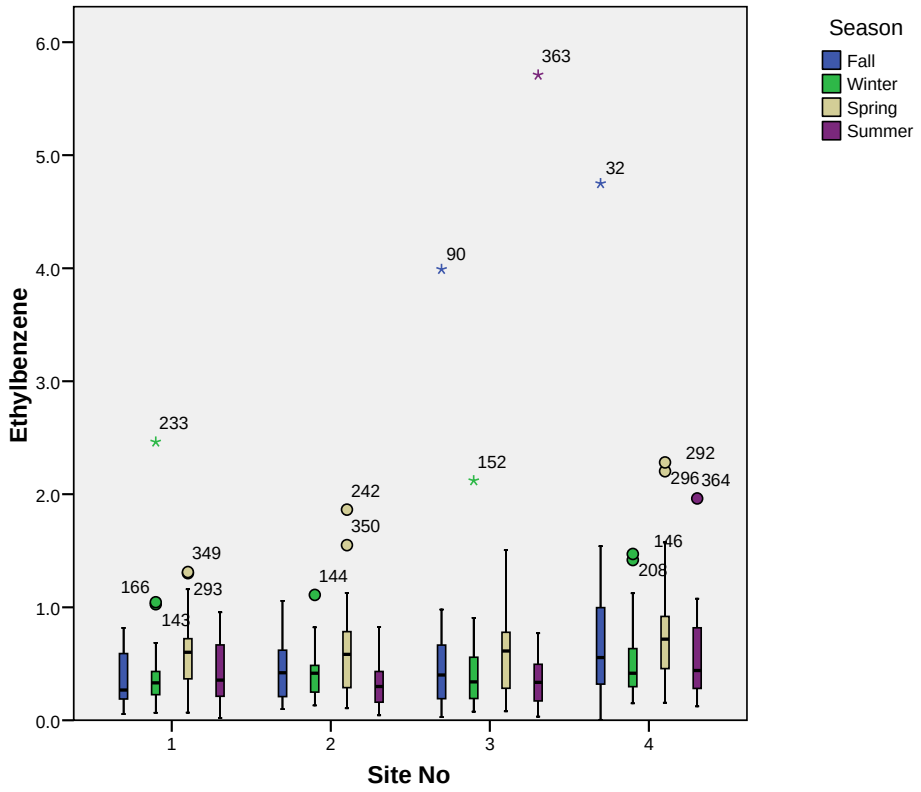
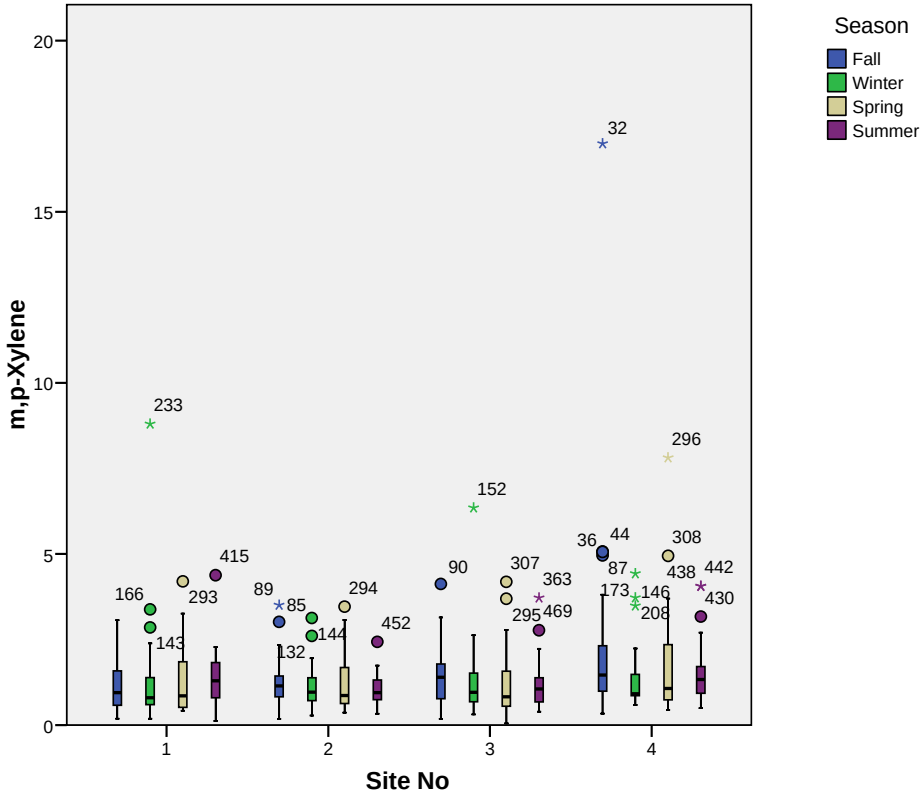


Figure 77. Box and whisker plot of ethylbenzene concentration (µg/m^3) by site and season



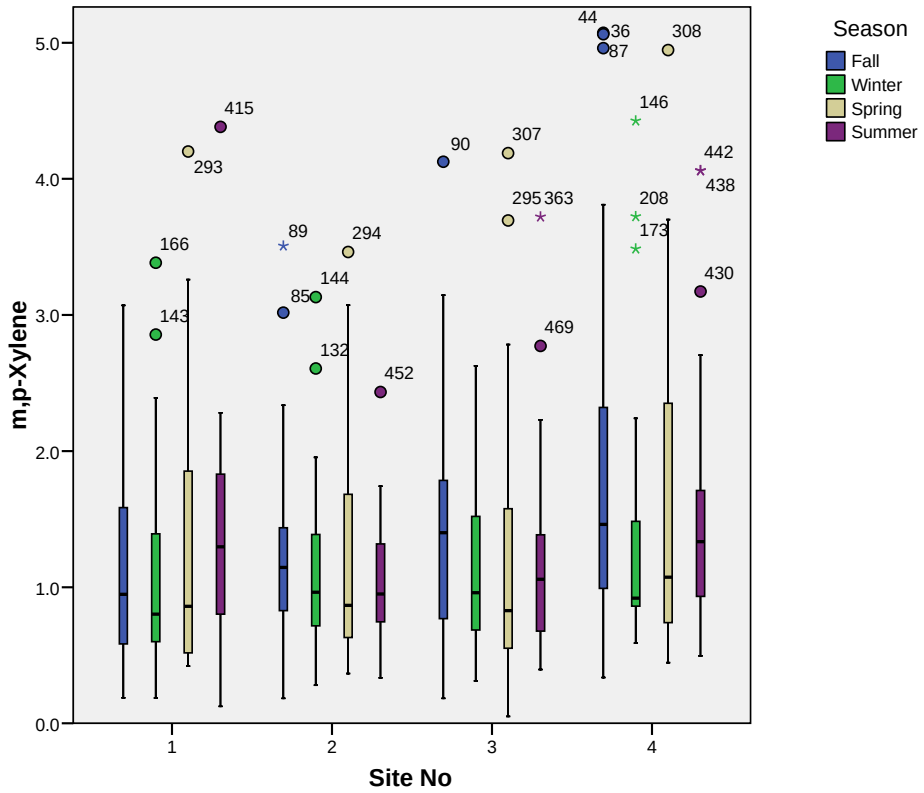
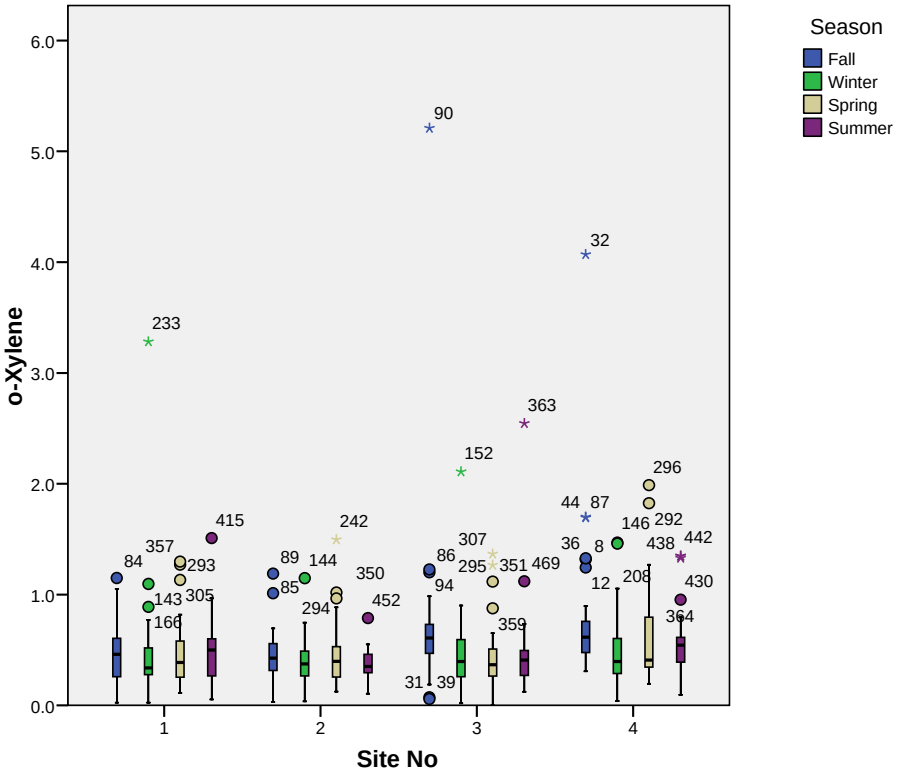


Figure 78. Box and whisker plot of *m,p* xylene concentration (µg/m^3) by site and season

(a)



(b)

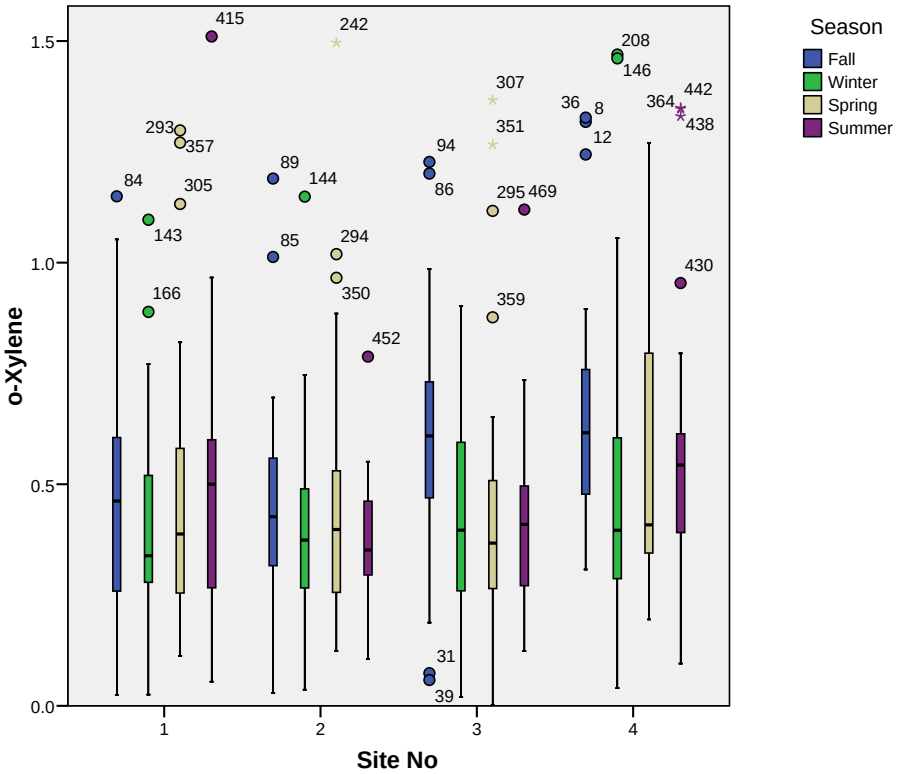


Figure 79. Box and whisker plot of *o* xylene concentration (µg/m³) by site and season

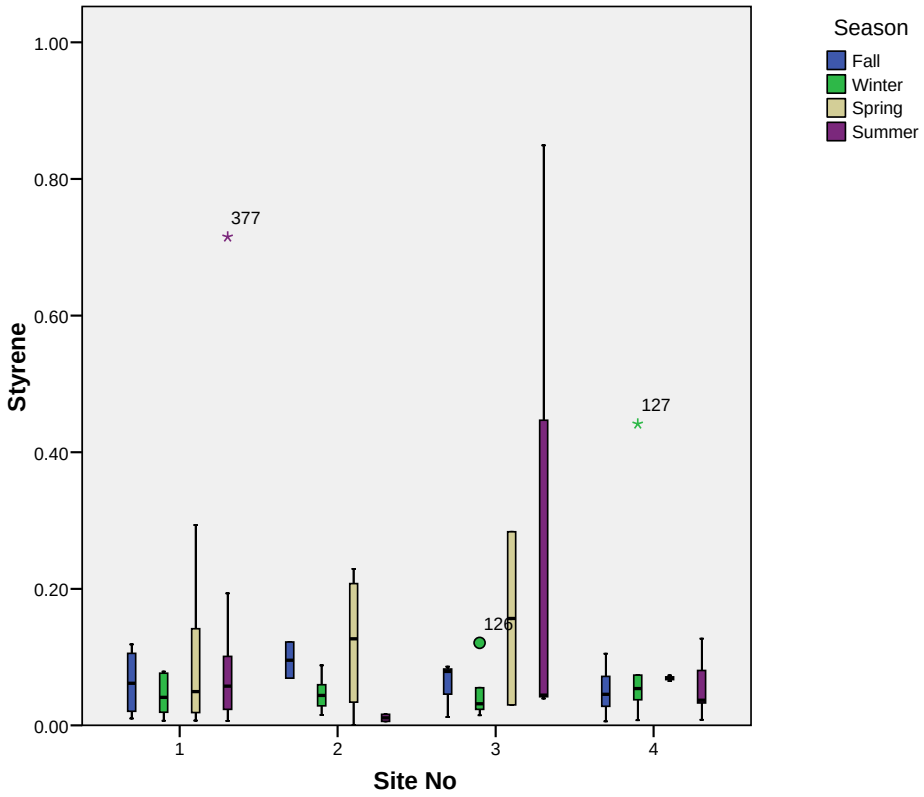


Figure 80. Temporal box and whisker plot of styrene concentration (µg/m^3) by site and season

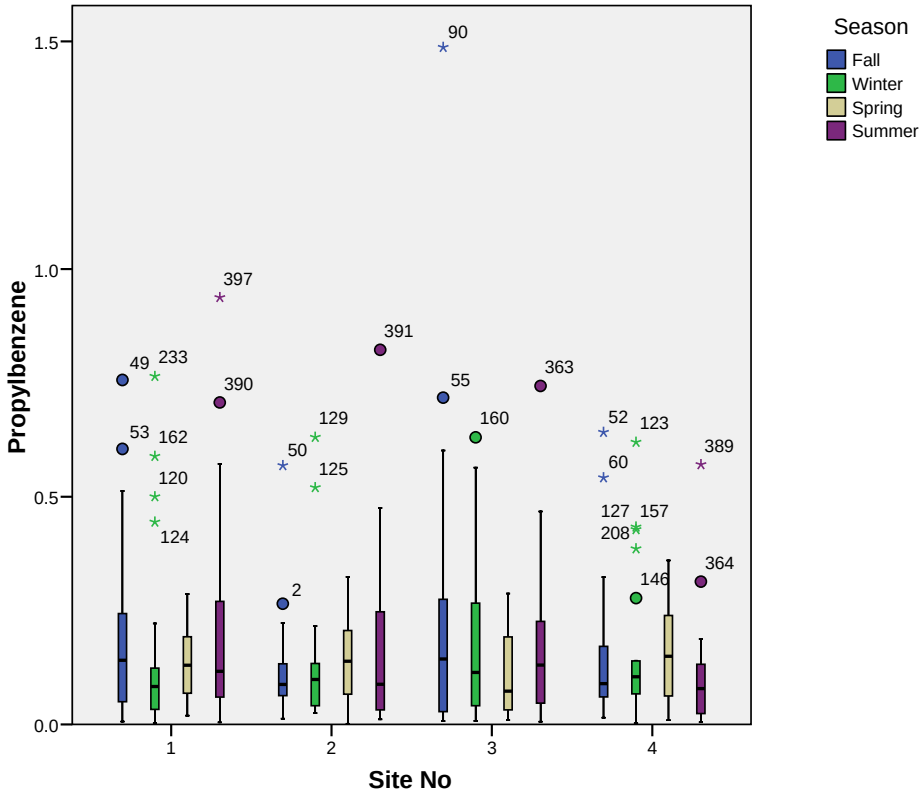


Figure 81. Box and whisker plot of propylbenzene concentration (µg/m^3) by site and season

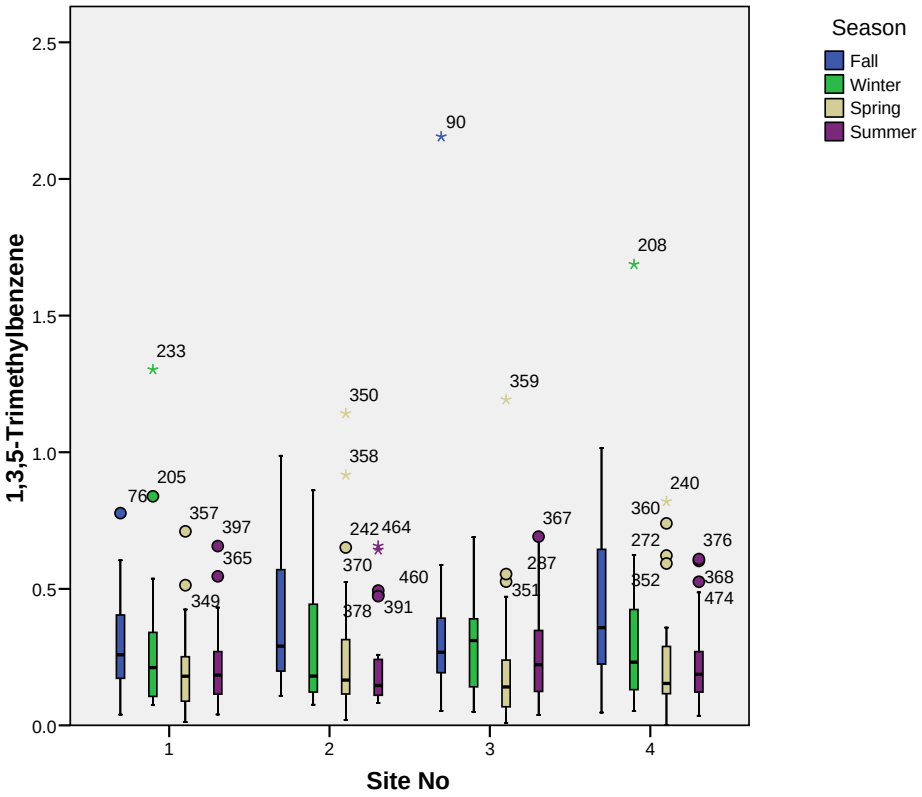


Figure 82. Box and whisker plot of 1,3,5 trimethylbenzene concentration (µg/m^3) by site and season

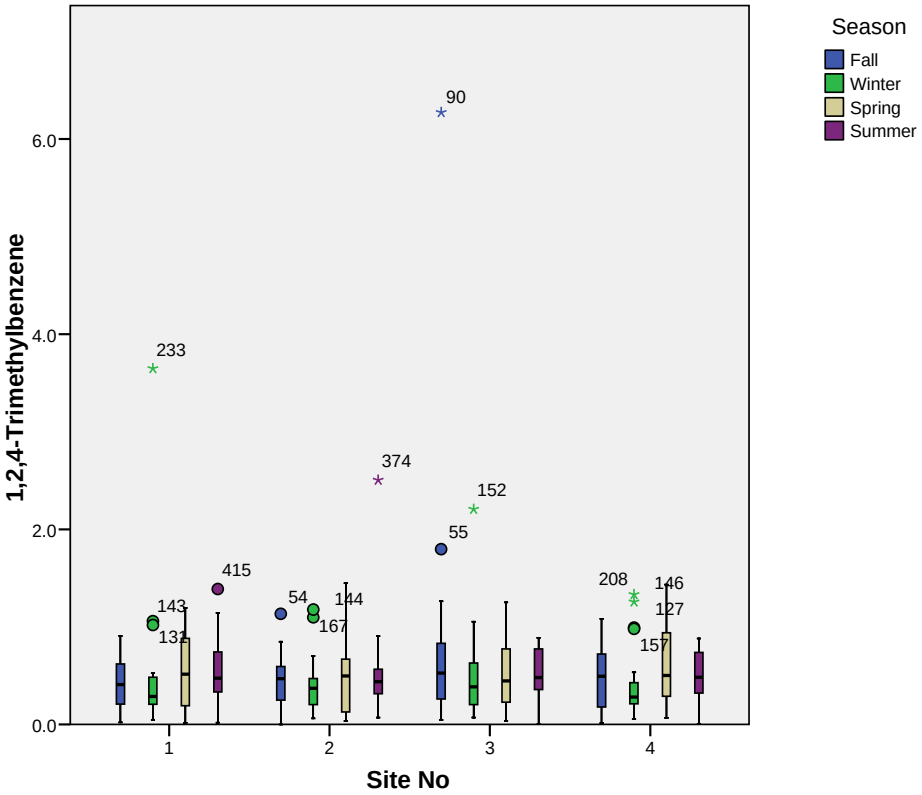


Figure 83. Box and whisker plot of 1,2,4 trimethylbenzene concentration (µg/m^3) by site and season

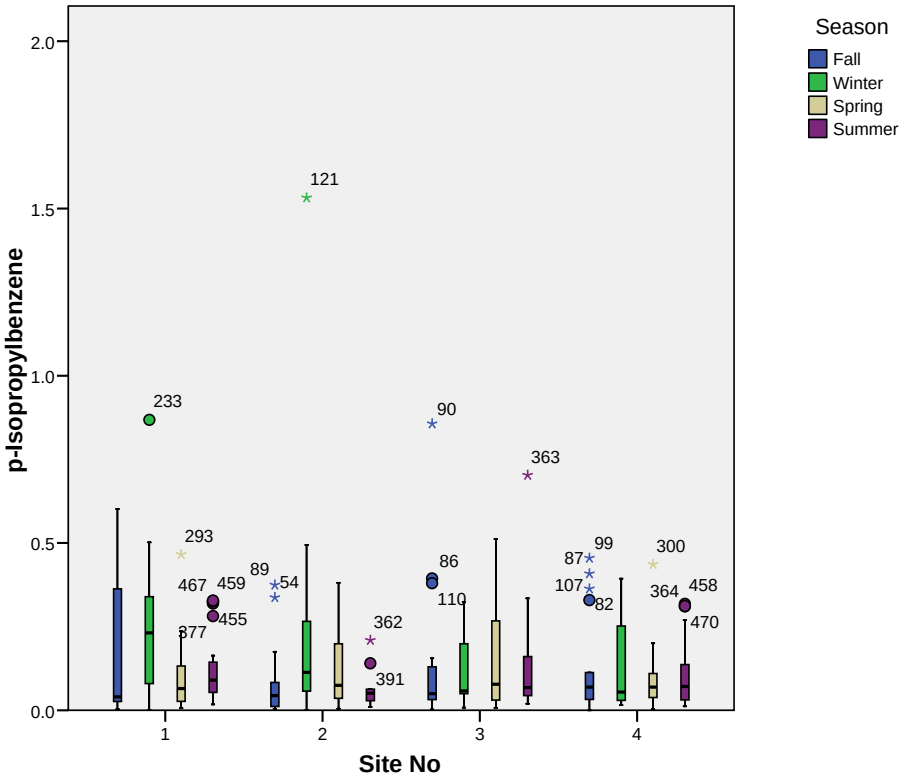


Figure 84. Box and whisker plot of p-Isopropylbenzene concentration (µg/m³) by site and season

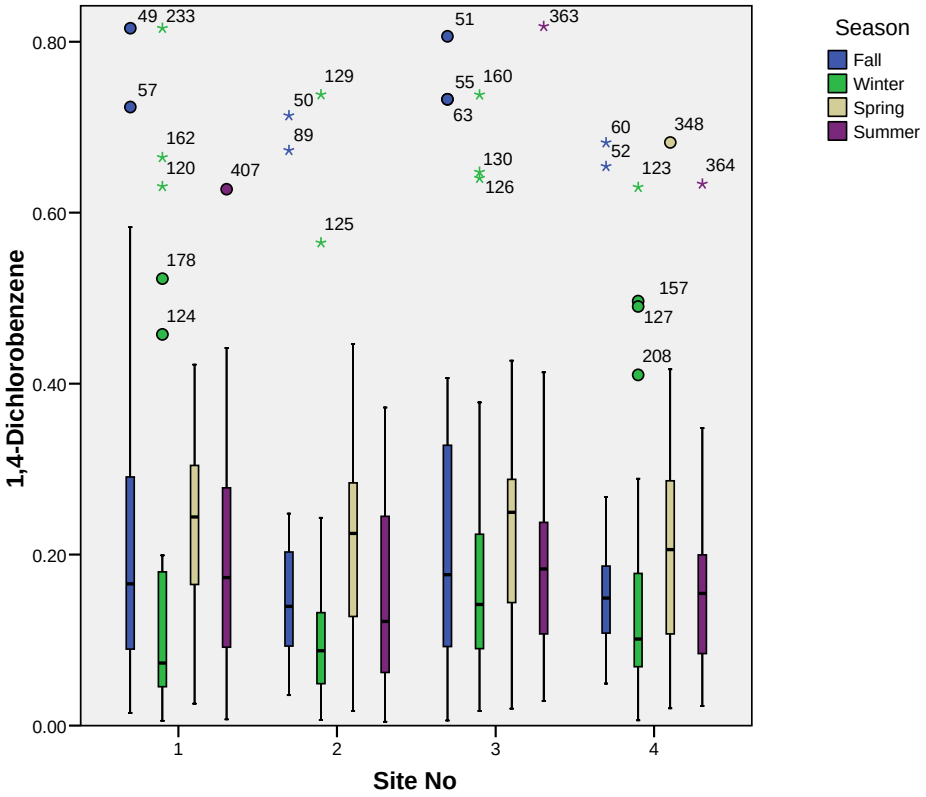


Figure 85. Box and whisker plot of 1,4 dichlorobenzene concentration (µg/m³) by site and season

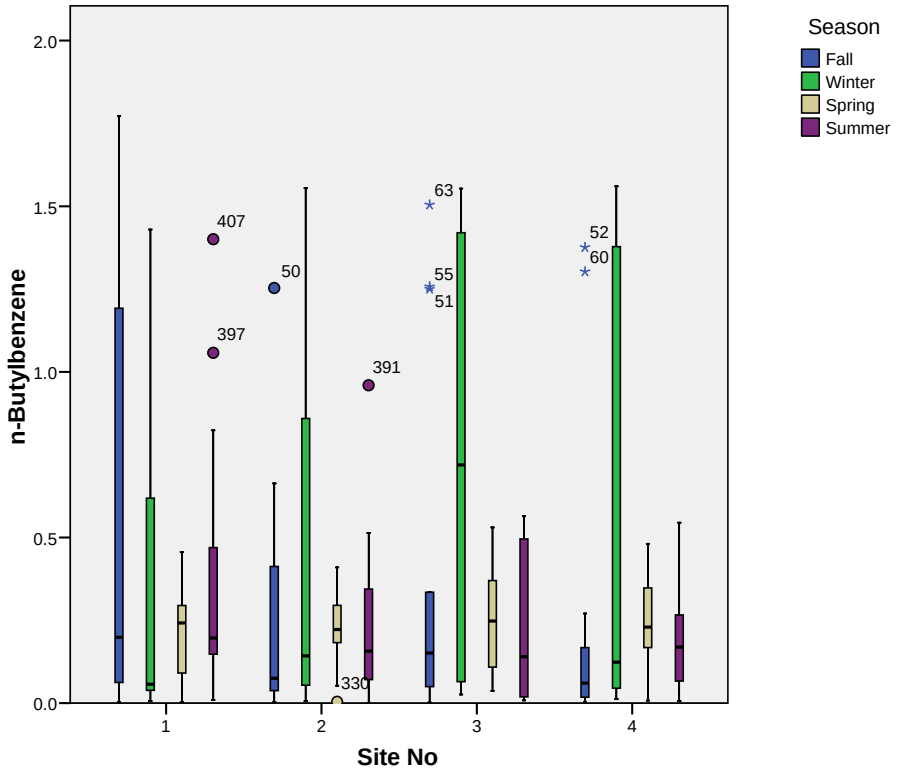


Figure 86. Box and whisker plot of n-butylbenzene concentration (µg/m^3) by site and season

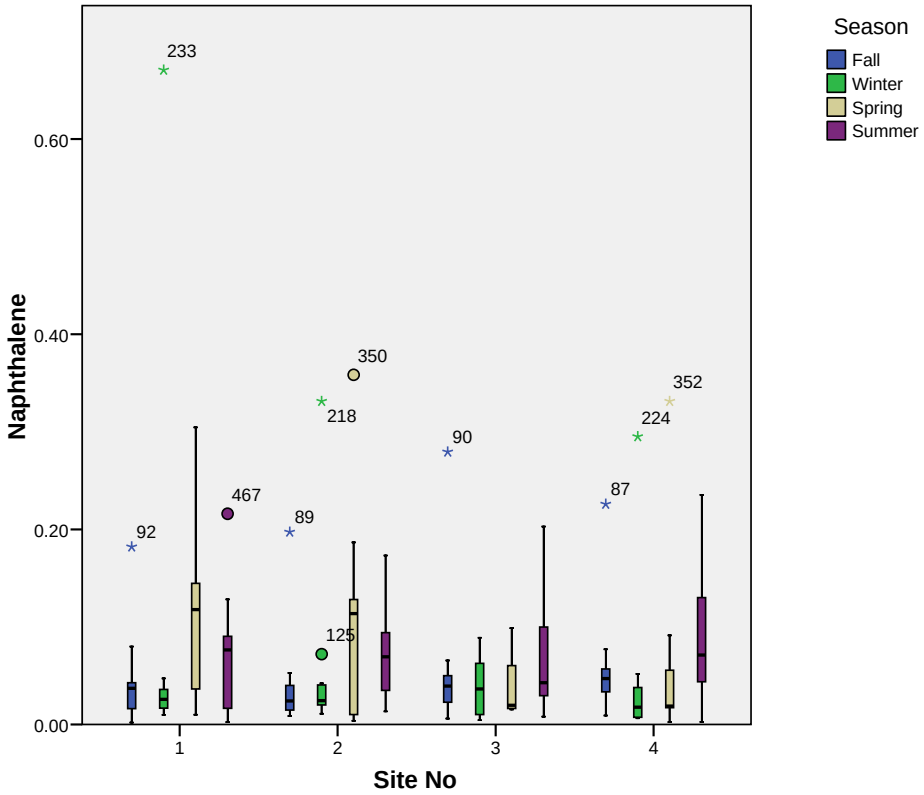


Figure 87. Box and whisker plot of napththalene concentration (µg/m^3) by site and season

1.3 Discussion

The data collected during the field study provide baseline air concentrations for the Meadowlands area and can be used to assess the impact of future development on the ambient air concentration. It also provides the database for evaluating the atmospheric models so that confidence can be achieved in the model's ability to predict how different development schemes will affect the air concentration in any future analyses. The overall concentrations were typical of the urban air background concentrations found in New Jersey and are consistent with transport of contaminants to the Meadowlands from the surrounding areas.

No major differences were observed between the two sites where PM was measured, since the mean total mass concentrations were nearly identical. However, the degree of overlap in the day-to-day variations in the concentrations showed some differences for individual species. Particulate OC is both emitted in particle form (primary) and formed in the atmosphere from the partitioning of low/semivolatile products of gas phase photochemical reactions (secondary). EC is a good tracer for primary combustion-generated OC. It is notable that median OC concentrations were higher in the summer, whereas median EC concentrations were highest in the fall and winter. The higher summertime OC concentrations cannot be explained by common origin with EC, and probably reflect the larger influence of secondary OC in the summertime. Both sites exist close to the major roadways in the area so it is not clear that difference in the EC can be explained by differential impact of the traffic. Site 2, Sports Complex, is near an area of active construction that includes diesel powered vehicles which may contribute to the 20% higher EC levels measured at that site. However, the NJMC Headquarters is also adjacent to an area where large diesel trucks frequent.

The mean artifact corrected OC during the Meadowlands study was 2.35 $\mu gC/m^3$. This is comparable to the Chemical Speciation Network (CSN) values for New Jersey (Camden, Elizabeth, Chester, New Brunswick, 2005 annual average filter-collected OC of 3-5 $\mu gC/m^3$ across sites). Note CSN network OC values are reported without any blank or artifact subtraction. Assuming a 30% adsorption artifact (which is typical for these types of locations and sampling parameters) artifact correction would bring the NJ CSN OC values to approximately 2.1 – 3.5 $\mu gC/m^3$ across the four sites. The Meadowlands average falls within this range. Meadowlands mean EC was 0.55 $\mu gC/m^3$. This is comparable to the 2005 annual average for the four NJ CSN sites (0.5 – 2 $\mu gC/m^3$ across sites).

Assuming an OM/OC ratio of 1.6 to 1.9 (to cover the range of average molecular weight per carbon weight expected for fresh to aged OC; (Turpin & Lim, 2001.), the average organic matter (OM) concentration during the Meadowlands study was 3.8 to 4.5 $\mu g/m^3$, or 35-40% of fine particle mass. EC was 5% of fine particle mass, on average. These percentages are consistent with expectations for the Northeastern US.

An "EC tracer approach" (Turpin & Huntzicker, 1995.) can be used to estimate the contributions of organic particulate matter that is emitted in particle form (primary) and formed in the atmosphere (secondary). In this method, time periods that are expected to be influenced little by photochemistry are identified and used to construct a relationship between primary OC and EC, recognizing that EC is a tracer for primary combustion generated EC. This approach works best with highly time-resolved data and tends to provide smaller secondary OC estimates for 24 or 48 h samples. Also the EC tracer approach has difficulty with primary combustion OC sources that (1) only occasionally impact the site and (2) have a much higher OC/EC ratio than the primary combustion sources that typically impact the site (e.g. woodsmoke/wild fires). OC and EC concentrations for the entire study are shown in Figure 88.

In this work, samples collected from November through April were considered likely to be dominated by primary OC. OC and EC concentrations for these samples are shown in Figure 89. The regression of OC on EC for Figure 89 provides the following equation describing primary OC:

$$OCpri = 2.25EC + 0.94. \quad (1)$$

This equation is considered an estimate of primary combustion-generated and primary non-combustion OC. It must be recognized that the primary OC/EC ratio does vary with source mix and that will create some scatter around a primary OC regression line. In the EC tracer method, primary OC is calculated from Equation 1 on a point-by-point basis, with the requirement that primary OC cannot exceed total measured OC. Secondary OC is then the difference between total OC and primary OC. Measurements with the lowest 20th percentile values of OC/EC are plotted in Figure 90. The regression of these OC values on EC provides a lower bound estimate for primary OC:

$$OCpri = 1.91EC + 0.07. \quad (2)$$

Averaged over the whole study (all seasons) this analysis suggests that secondary OC was about 23% of total OC (OCpri from Equation 1) and not more than 54% of total OC (OCpri from Equation 2). The contribution of secondary OC was substantially greater in the summer, as expected. The highest 48 h secondary OC estimate (3.6 $\mu gC/m^3$, 62% was for July 4-6 (OCpri from Equation 1); secondary OC exceeded primary OC for 5 samples. As an upper bound (equation 2), the highest secondary OC estimate is 4.7 $\mu gC/m^3$ on July 10-12; the highest percentage secondary is 85% on June 21-23 and secondary OC exceeded primary OC on 36 days (May-Oct).

As noted above, the EC tracer approach has difficulty with primary combustion OC sources that (1) only occasionally impact the site and (2) have a much higher OC/EC ratio than the primary combustion sources that typically impact the site (e.g. woodsmoke/wild fires). It should be noted that the sample collected on Dec 24 – 26 contained 3 $\mu gC/m^3$ of OC that was identified by the EC tracer method as secondary OC (the largest value for the winter). We do not expect large secondary OC contributions in the winter. The large difference between total OC and primary OC in this sample is more likely from woodsmoke.

The trace elemental concentrations for As, Co, Cd, Pb, Mn and V were about 20% higher at Site 1 than at Site 2. This would suggest a localized source of these metals in the Meadowlands. One possible source is the bare ground that is adjacent to the NJMC Headquarters area which had active digging taking place at the time of the study as well as, resuspension of the dirt by the movement of truck traffic through the area. However, the mean difference, while statistically significant is of a relative small magnitude. There were individual days when only one of the sites was elevated for some metals suggesting a unique emission on that day. None of the levels exceeded a few tens of ng/m^3 with the exception of magnesium which is a common component of soil. The next highest concentrations were for nickel and copper which are present in steel and other scrap metal. Lead was typically below 10 ng/m^3 but occasional exceeded that value but were still well below the NAAQS of 1.5 $\mu g/m^3$ for 3 month average.

The VOCs did not show a truly consistent concentration trend either across the sites or across seasonal. Typically, the aromatic compounds vary together as their primary source to the atmosphere is mobile source emissions. The air concentrations of these compounds are expected to increase in the winter because of the reduced combustion efficiency during the cold weather and the greater stability of the atmosphere during the winter increasing the air concentration from local emissions. These patterns were not clearly evident. The chlorinated compounds might have been expected to increase in the summer since their concentration, if local sources are important, is a function of evaporation which increases during the summer. One reason that this might not occur is the presence of an industrial or commercial source that releases the compounds more frequently during a different

season. As discussed above, no single site was always higher than the others which would suggest a single dominant source type for all of the compounds. However, Site 4 was higher for the xylenes and ethyl benzene (but lower for benzene) than the other sites indicating a greater local mobile source impact there. Site 4 is somewhat closer to the major roadways than the other site, though the influence of the height of the roadways needs to be considered in evaluating the influence on ambient levels. A vast majority of the days had very similar VOC concentrations across all sites implying that regional air concentrations and region emissions dominate the levels usually observed in the Meadowlands and those levels were consistent with concentrations measured elsewhere in NJ. However, on individual days differences were observed which is best explained by a local source within the Meadowlands.

1.3.1 Comparison to Ambient Air in New Jersey

The ambient air concentrations measured at the long term fixed sites in the Meadowlands were compared to air concentrations measured at NJ DEP monitoring sites at four locations in New Jersey, Camden, Rider College, Cook Campus Rutgers University New Brunswick and NJ Turnpike Interchange Exit 13/14 (Figure 91) (US EPA AIRES Database access January 2008 http://www.epa.gov/aqspubl1/annual_summary.html) and in samples collected during 2000-2002 outside residences in Elizabeth, NJ, an urban center (Tables 1-PM Mass, 4-OC and EC, 7-Metals and 10-VOCs). The ranges in mean ambient air concentrations measured for 2006 are presented for the four NJDEP monitoring sites. Only PM mass selected trace metals and VOCs air concentrations were available from the NJDEP monitoring sites while the data collected in Elizabeth included PM mass and trace metals, organic carbon and elemental carbon and several of the VOCs. The highest concentrations for the NJDEP samples for aromatic hydrocarbons were measured at the site near the NJ Turnpike Interchange. In contrast, Camden, an urban center, tended to be higher for the chlorinated compounds. The average PM mass (Table 1), organic and elemental carbon (Table 4) and metals (except cobalt and nickel) (Table 7) air concentrations in the Meadowlands were lower than the mean values measured in Elizabeth, NJ and the PM mass was slightly lower than measured across the NJDEP monitoring sites. The air concentration of several of the metals: cadmium, copper, lead, manganese and vanadium, were at least 50% lower than the mean value measured in Elizabeth, NJ and similar to the NJDEP concentration except for cadmium which was much higher at the NJDEP sites. The average air concentration of VOCs across the four sites were also consistently lower, often by a factor of two, compared to the values in Elizabeth, NJ (Table 10). The air concentrations of the aromatic compounds were also lower at the Meadowlands than the upper end of the range of values measured at the NJDEP monitoring site, which was adjacent to a NJ Turnpike interchange. This is consistent with the sampling sites in the Meadowlands being impacted by mobile source emissions from the NJ Turnpike and Route 3, but they are not as close to those roadways as a NJDEP site located at an interchange near an exit. The air concentration of styrene, trichloroethene, tetrachloroethene, and 1,4 dichlorobenzene were all much lower at the Meadowlands sites than in the Elizabeth study. However, when compared to the DEP sites, this was only true for styrene. Carbon tetrachloride, 1,1,1 trichloroethane, and 1,4 dichlorobenzene, which do not have large commercial or industrial sources in the state of NJ, had similar mean air concentrations at both the Meadowlands Site and the NJDEP sites. The similarity in concentration suggests a general background air concentration for these compounds for much of the highly populated areas of New Jersey. The mean ambient air concentration of tetrachloroethene and trichloroethene were higher at the Meadowlands site than reported at the NJDEP sites, likely because of the sources within or immediately adjacent to the Meadowlands, as reported in the modeling section of this report (Appendix D).

1.3.2 Summary and Conclusions for Long Term Fixed Sampling

- The fixed station sampling were able to measure $PM_{2.5}$ mass, organic carbon, elemental carbon, a suite of metals and a suite of aromatic and chlorinated hydrocarbons that are hazardous air pollutants to provide baseline air concentrations for future comparison as development of the Meadowlands proceeds.

- The sample to sample temporal variability in ambient air concentrations spanned more than an order of magnitude for individual elements and compounds. However, only some of these air pollutants showed average seasonal differences, indicating the day to day changes are due to the daily meteorological conditions on the daily air concentration for pollutants with sources in the region and with variability in their emission rates. However, seasonal differences were of a more limited magnitude than the day to day changes, within a factor of two, as is expected due the effect of averaging. Not all air pollutants showed temporal variations. The seasonal differences likely reflect variations in source emissions over the course of a year. Such variations are not captured in current emission inventories and increase the uncertainty in the modeling values, particularly for predictions of peak air concentrations on specific days or for compounds that only have seasonal uses.

- Overall the spatial differences were smaller that the temporal differences, though some were identified for individual metals and VOCs. These spatial differences are likely due to variability in the proximity of sources to the different sites. For example the sites closest to the Jersey Turnpike would be impacted more for aromatic hydrocarbons resulting in higher air concentrations at those sites. Specific local activities associated with construction could resuspend dust containing individual metals that could lead to some of the spatial and seasonal differences observed.

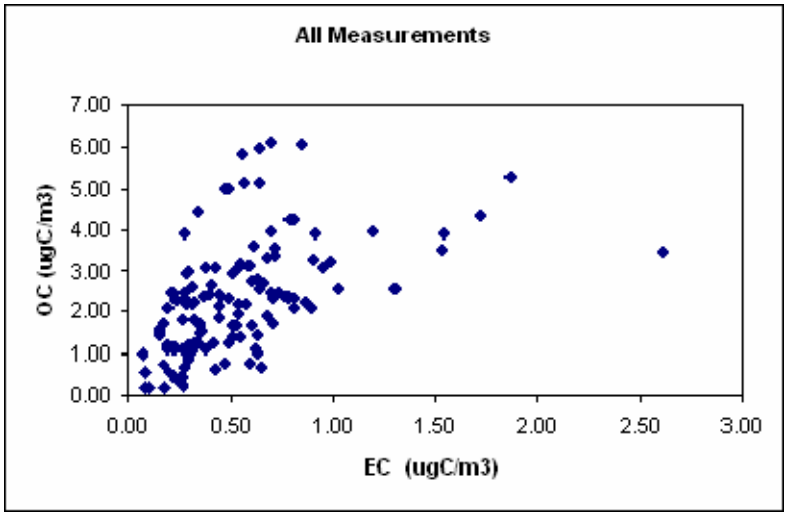


Figure 88. Artifact corrected particulate organic carbon (OC, μgC/m^3) and elemental carbon (EC, μgC/m^3), all days.

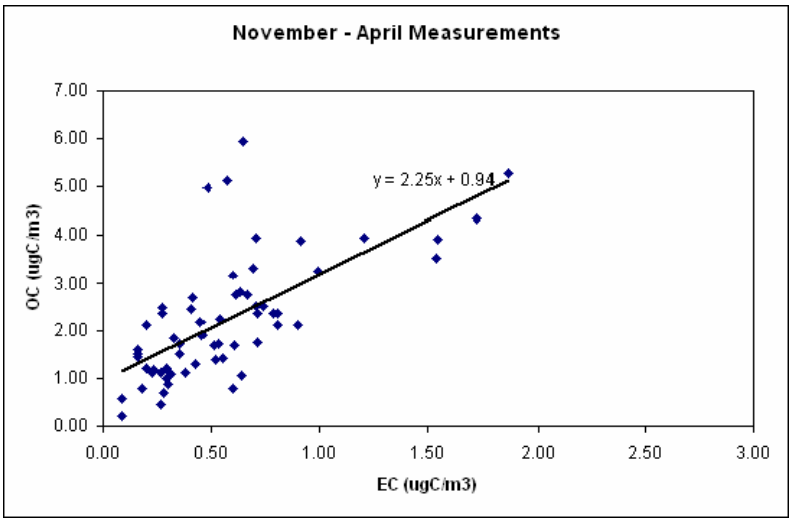


Figure 89. Artifact corrected particulate organic carbon (OC, μgC/m^3) and elemental carbon (EC, μgC/m^3), November - April.

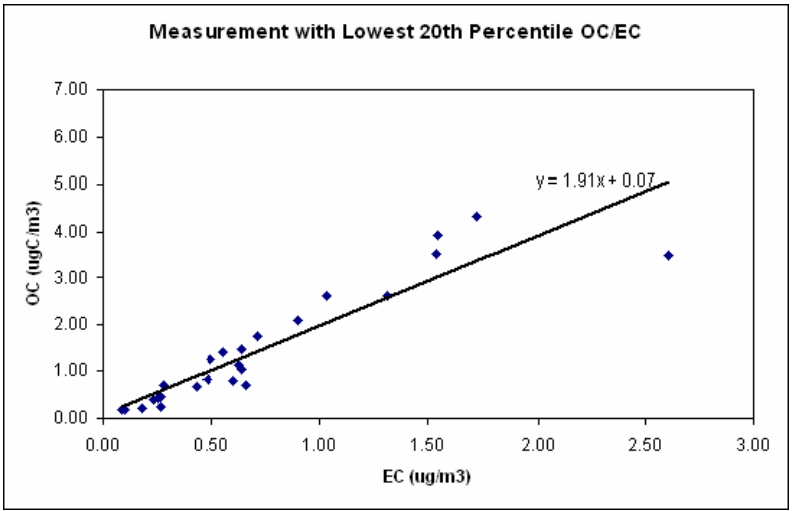


Figure 90. Artifact corrected particulate organic carbon (OC, μgC/m^3) and elemental carbon (EC, μgC/m^3), measurements with the lowest 20th percentile OC/EC.

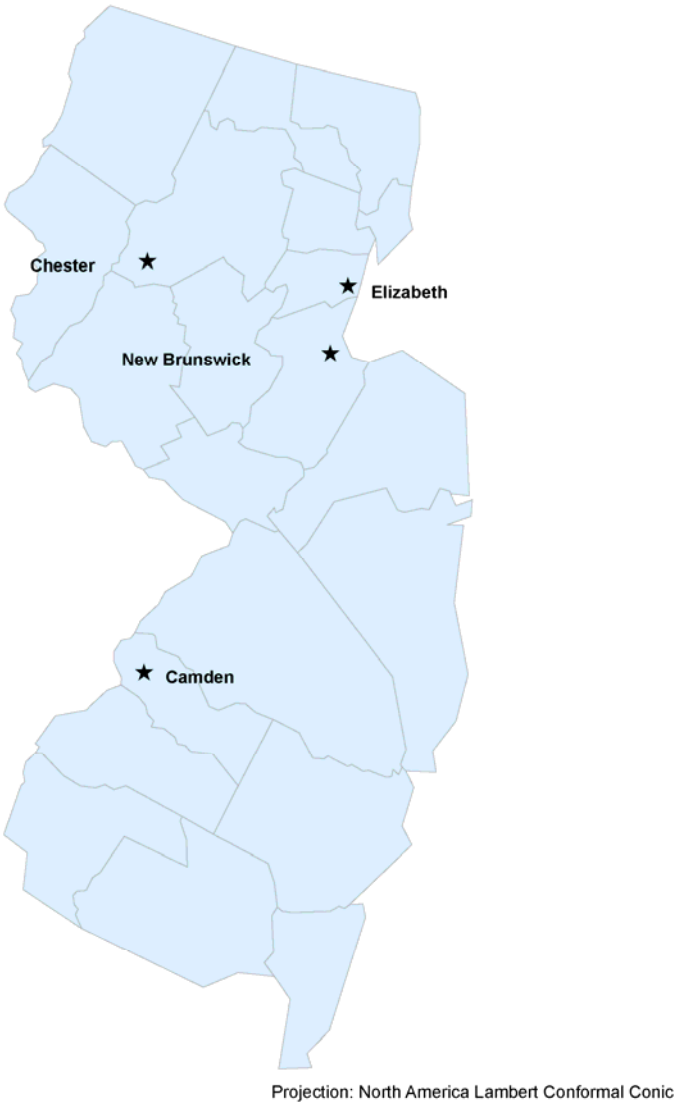


Figure 91. Location of NJDEP monitoring sites used for comparison to concentrations measured in the Meadowlands (Source NJ DEP web site on air toxics in New Jersey)

1.4 Intensive Sampling - Implementation and Results

1.4.1 Results of Intensive Sampling

Personal air samples were collected along four different walking paths, which included trails at Dekorte Park, which also houses the NJMC Headquarters; and in Secaucus (Mills Creek and Little Ferry), a residential community within the Hackensack Meadowlands District, and on a closed landfill near the NJMC Headquarters (Figure 92) within the Meadowlands area during three different time periods during three years, November-December 2004; July-September 2005 and October-November 2006. The walks lasted for two to three hours and were alternated between the morning and afternoon hours. Only days without precipitation were selected since the purpose of this sampling was to ascertain the potential exposure levels for people hiking in the area which occurs more on days without precipitation. Sampling was done for volatile organic compounds (VOCs) using adsorbent traps packed with Tenax TA and Carboxen X (obtained from Supelco Corporation) connected to a BGI air sampling pump operated at between 25 and 35 cc/min with the exact flow rate recorded. This resulted in the collection of air volumes of 3 to 4 liters. The adsorbent traps were thermally desorbed using a Perkin Elmer ATD400 coupled to an Hewlett Packard GC/MS 5890/5971A. The samples were collected by the staff from EOHSI. In addition to the walking trails one set of samples was collected on a boat trip which include measurement of gaseous mercury in addition to VOCs to evaluate the potential exposure from mercury contaminated sediment.

Twenty VOCs were detected in at least one sample (chloroform, bromodichloromethane, toluene, benzene, ethylbenzene, *m/p* xylene, styrene, *o*-xylene, isopropylbenzene, n-propylbenzene, tetrachloroethene, 2-chlorotoluene, 1,2,4-trimethylbenzene, tert-butylbenzene, 4-isopropyltoluene, n-butylbenzene, sec-butylbenzene, 1,4-dichlorobenzene, trichlorofluoromethane (Freon), methylene chloride, carbon tetrachloride, bromochloromethane, 1,1,1-trichloroethane, trichloroethene, chlorobenzene, bromobenzene, 1,2-dichlorobenzene, naphthalene) but many of those compounds were only detected in a very limited number of samples. The summary statistics for those compounds presented in (Table 33). Compounds which were not detected in any samples at detection limits of ~0.5µg/m^3 include: bromodichloromethane, bromoform, dichlorobromomethane, 1,3-dichloropropane, 1,1,2-trichloroethane, 1,1-dichloroethene, *c*-1,2-dichloroethene, 1,1-dichloroethane, 2,2-dichloropropane, 1,2 dichloropropene, 1,2-dichloroethane, 1,2-dichloropropane, dibromoethane, *cis*-1,2-dichloropropene, *trans*-1,3-dichloropropene, 1,1,2-trichloroethane, 1,3-dichloropropane, dibromochloromethane, 1,2-dibromoethane, 1,1,2,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, bromobenzene, 4-chlorotoluene, 1,2-dibromo-3-chloropropane, 1,2,4-trichlorobenzene, and 1,2,3-trichlorobenzene. As was the case for the long term sampling more compounds were present in the commercially purchased standard mixture for evaluating contaminated environmental samples by GC/MS analysis than is normally expected to be in ambient air. Thus, it is not surprising that many of the compounds in the standard were not detected in the ambient air in the Meadowlands.

1.4.2 Results of Intensive Sampling

The variation in the air concentrations with wind speed (actual values and log transformed concentrations) of the eleven compounds with at least 10 values above the MDL are shown (Figure 93 – Figure 103) for each of the three separate sampling periods. Most of the detected compounds were aromatics which are emitted from mobile sources. For those compounds a trend of decreasing concentration with wind speed was observed during the Winter ’04 and Fall ’06. The log transformed air concentrations for benzene - Figure 94 , toluene - Figure 93 , ethyl benzene - Figure 95 , *m/*p xylene - Figure 96 , o xylene Figure 97 were evaluated for variations with wind speed, and

the association had R^2 values that ranged from .4 to .6 and .2 to .5, for Winter '04 and Fall '06, respectively. However, for the samples collected during the Summer '05 the air concentration were not correlated with wind speed. Pollutants with constant source strengths emitted in a region, as might be expected for pollutants emitted by mobile sources during weekdays in areas near major roadways, will typically show and inverse relationship between wind speed and air concentration. This phenomenon was evident for both the Winter '04 and Fall '06 sample sets. The reasons for the lack of an association between wind speed and air concentration during the Summer '05 samples are unknown.

Five chlorinated compounds were above detection in sufficient number of samples to examine the relationship between their air concentrations and wind speed. Tetrachloroethene (Figure 98) was present predominantly during the Summer '05, with a couple of samples having measurable concentrations during the Winter '04. No trend in air concentration with wind speed was observed, suggesting a variable source strength for this compound. This compound is used as a common industrial solvent and is the primary solvent currently used in dry cleaning of clothing. The air concentration of 2-chlorotoluene (Figure 99), a compound that is used as a solvent and intermediate in the synthesis of organic chemicals, dyes, pharmaceuticals, and synthetic rubber compounds, was present during the Winter '04 and its air concentration was inversely related to wind speed, suggesting a constant local emission source. The air concentration of trichlorofluoromethane (Freon) (Figure 101) also had its highest concentration during the Winter '04 and was inversely related to the wind speed. The air concentration of carbon tetrachloride (Figure 103), which was measurable in most samples, appeared to be independent of wind speed. This is consistent with its concentration being controlled by background levels rather than local sources.

The mean concentration of the three samples collected at each site during each sample time are displayed using box and whisker plots in Figure 104 to Figure 127. The means values were calculated using the uncensored data for all peaks observed (actual calculated concentrations even when the value was below the method detection limit if a peak was present) and one half the MDL when a compound was not present in the chromatogram. Therefore, a dash in the figure implies that all values were not detected and the value displayed is one half the MDL. These figures provide a qualitative assessment of seasonal or site differences and guided where statistical analyses should be done.

A similar pattern is observed across the compounds whose dominate source in the region is mobile source emissions, with the exception of benzene (Figure 107). The highest mean air concentrations were generally in the samples collected during Winter '04 at the Dekorte and Little Ferry sites compared to samples collected at the Mill Creek or Landfill sites. During the Fall '06 the mean air concentrations in the samples collected at the Little Ferry Site were higher than measured at the other sites, even exceeding the levels in the Winter '04 for some of the compounds This was due to the high concentration of toluene (Figure 106), ethyl benzene (Figure 108) and xylenes (Figure 109 and Figure 111) in the sample collected on the morning of November 7, 2006. The lowest air concentrations were measured in the Summer '05 samples, with the Little Ferry site again having the highest air concentrations. The likely explanation for the observed spatial pattern is the closer proximity of the trails in Little Ferry and Mill Creek to the New Jersey Turnpike and Route 3 along with the greater number of local roadways near those trails than near Dekorte Park and the path taken within the Landfill. In addition, 1,2,4 trimethylbenzene (Figure 115) and tert-butylbenzene (Figure 117) substituted aromatic compounds, showed similar patterns consistent with contributions from mobile sources. As indicated above, benzene, although a minor component of mobile source emission, had a different pattern. While the benzene air concentrations in samples collected in the Winter '04 and Fall '06 look similar to the air concentration for the other aromatic hydrocarbons, the benzene levels during the Summer '05 were considerably higher. A similar pattern was observed for sec-butyl benzene (Figure 119), with measurable values during the

Summer ’05 but not in the majority of the samples collect during the other time periods. The reason for the higher benzene concentration levels during the Summer ’05 and its lack of similarity to the patterns observed for the other aromatic compounds measured is not known. Two possible explanations are a unique benzene source in the area and laboratory contamination. No large benzene sources are known to be within the Meadowlands though all of the material that was dumped in the landfill has not been characterized and greater evaporation of solvents in the ground would occur in the Summer. While no QA flags for benzene were found since the blanks were not higher than other sampling periods, and the benzene response to external standards were valid during this time period, several samples collected simultaneously using a different adsorbent evaluated during that time period did show variability for benzene and different amounts of benzene were present on those samples.

To examine if the trends reached statistically significant differences, a One-Way ANOVA in SPSS was run on the log transformed concentrations to: (1) examine the seasonal comparisons for all compounds, were compared by combining all the data across each site (Table 34) and (2) compare spatial variability by combining the data across all seasons (Table 35). These combinations were used because only three samples were collected at each site during each time period, which meant that there were too few measurements to compare individual days in a statistical analysis. It is recognized that the number of individual days when samples were collected represent snapshots of potential personal exposure, so any actual temporal trends should only be evaluated using the long term samples which were collected every week from four sites. The only two compounds that showed a statistical difference ($p<.05$) with collection period were benzene and 1,2,4 trimethylbenzene, and with o xylene approach statistical significance (p value of .093). The post hoc test indicated that for benzene the concentrations measured during the Fall ’06 were statistically lower than the other two seasons; however, in the Summer ’05 benzene appeared to be an anomaly (as discussed above) and the Winter ’04 benzene was higher than the values measured during the other two time periods. The air levels for o-xylene were also lowest in the Summer of ’05. None of the sites were statistically different from each other at a $p>.05$, though toluene and o xylene had p values of 0.056 and 0.073, suggesting if a larger n was available these compounds might show statistically significant differences.

Many of the chlorinated and substituted aromatic compounds were only found in a few samples; therefore, comparisons across season and sites cannot be done. These included bromochloromethane (Figure 105), styrene (Figure 110), isopropylbenzene (Figure 112), n-propylbenzene (Figure 113), n butylbenzene (Figure 118), chlorobenzene (Figure 35), bromobenzene (Figure 126) and naphthalene (Figure 127). For those compounds that were measurable in multiple samples most displayed no obvious temporal or spatial trends (Freon (Figure 120), methylene chloride (Figure 121), carbon tetrachloride (Figure 123), and bromochloromethane (Figure 125) suggesting that these compounds were from regional sources or emitted from industrial or commercial sources throughout the year that were not located near any of the specific trails. Two compounds were present predominantly during the summer, chloroform (Figure 104) and tetrachloroethene (Figure 114). One possible explanation for this was temperature dependent evaporation from sources within the area. The cause for the temporal pattern for 2-chlorotoluene (Figure 115) is not known.

A special study was done to evaluate exposure to gaseous elemental mercury while traveling on a boat on Berry’s Creek where sediments had been contaminated with mercury. Gaseous elemental mercury was measured in the breathing (inlet was ~1.5 meters above the boat) height zone of a boat while it traversed Berry’s Creek. Measurable air concentrations exceeding background air levels for mercury were detected, but the overall levels were still low, 20 to 50 ng/m^3. The air levels measured were highest near the location where the greatest sediment contamination exists (i.e. the tidal gates in Figure 128).

1.4.3 Comparison to Ambient Urban Air in New Jersey

A number of the VOCs, particularly the aromatic hydrocarbons and one and two carbon substituted chlorinated compounds have been measured in urban locations in New Jersey. The air concentrations measured in Elizabeth, NJ in 2002 during the RIOPA Study (Turpin et al., 2007; Weisel et al., 2005a; Weisel et al., 2005b) and from the monitoring data collected by NJ DEP at the following four locations Camden, Rider College, Cook Campus Rutgers University New Brunswick and NJ Turnpike Interchange Exit 13/14 (Figure 91) (source USEPA AIRS Database access January 2008 http://www.epa.gov/aqspubl1/annual_summary.html) were used for comparison with the Meadowland District data. The concentrations of the aromatic compounds emitted from mobile sources, except benzene, were similar to those measured in Elizabeth, NJ and were at the higher end of the range measured at the NJDEP monitoring sites, which included the site located near the NJ Turnpike. This location was similar to the surroundings that exist for two of the trails used in the study. The chlorinated hydrocarbons measured along the Meadowland trails were similar to the values measured in Elizabeth, but above that of the NJDEP monitoring site for chloroform, methylene chloride, and carbon tetrachloride. The values were similar to that at the NJDEP monitoring site but below that measured in Elizabeth (where measured) for tetrachloroethene, 1,4 dichlorobenzene, trichloroethene, 1,1,1-trichloroethane and chlorobenzene.

1.4.4 Summary and Conclusions for Intensive Sampling

The VOC air concentrations measured along the trails in the Meadowlands generally were two to three times higher than the concentrations measured at the monitoring stations established during this project for the aromatic compounds but were similar for the halogenated compounds. VOC exposures for individuals using these trails are similar to exposures that occur in typical urban settings for volatile organic compounds from mobile sources and some chlorinated compounds, but lower than the exposures that occur in urban settings for several other chlorinated compounds. The emissions from mobile sources from the surrounding major roadways in the region appear to be the major source of the exposures that occurred on the trails for the aromatic hydrocarbons. The chlorinated compounds do not show a strong increase in concentration during the summer as might have been expected if they were emitted from spills in the area nor as strong a relationship with wind speed as observed for the aromatic hydrocarbons. The results suggest that they are, for the most part, not emitted locally. These data imply that the current use of the trails within the Meadowlands do not present elevated VOC exposure to residents of NJ compared to exposure they may have already received elsewhere in the state. However, further evaluation of exposure along trails should be assessed as the development of the Meadowlands continues to assure that the exposure levels determined in this study are maintained or reduced by new control strategies.

1.4.5 Summary for Summer Intensive

- With the exception of benzene, the data are consistent with aromatic sources being primarily mobile emission while the halogenated compounds come from evaporative emissions. The air concentrations of aromatic compounds during the summer intensive campaign were lower than measured during the fall/winter. The halogenated compounds were higher during the summer.
- The air concentrations of the aromatic compounds, except benzene, were generally lower than background ambient levels measured at the NJDEP Camden site and the Elizabeth, NJ RIOPA outdoor, residential sampling sites collected during the same time of the year, while the halogenated compounds were at similar concentrations.
- Most compounds showed no consistent trends in concentration with wind speed and location suggesting variable sources for these compounds within or near the Meadowlands District during the summer.
- Mobile source emissions appear to dominant measured aromatic compounds concentrations.

Table 33. Summary statistics of all air concentrations (µg/m^3) combined from all personal samples for VOCs measured in the Meadowlands and comparison values

	chloroform	bromo-dichloro-methane	toluene	benzene	ethyl benzene	m,p-xylene	styrene	o-xylene	isopropyl benzene
Number of Samples	37	37	37	37	37	37	37	37	37
Number Above MDL	7	2	36	34	35	35	3	33	11
Mean	0.30	0.15	6.40	3.29	0.95	2.80	0.24	0.98	0.22
Median	0.30	0.15	3.61	2.69	0.52	0.89	0.20	0.41	0.20
Std. Deviation	0.06	0.07	10.49	2.94	1.68	8.59	0.14	1.67	0.10
Percentiles 25			1.91	1.05	0.34	0.31		0.30	0.20
50			3.61	2.69	0.52	0.89		0.41	0.20
75			6.37	4.56	0.79	1.85		0.74	0.20
Elizabeth RIOPA*	0.30±.99		6.77±5.75	1.44±1.57	1.34±2.75	3.23±4.30	0.53±3.48	1.70±6.53	
NJDEP 2006#	.02-.03		1.3-5.8	0.6-2.4	0.2-1.0	0.5-2.8	0.1-0.7	0.2-1.0	0.06-0.5

	n-propyl benzene	tetrachloro-ethene	2-chloro-toluene	1,2,4-trimethyl benzene	tert-butyl benzene	4-isopropyl toluene	n-butyl benzene	sec-butyl benzene	1,4-dichloro benzene
Number of Samples	37	37	37	37	37	37	37	37	37
Number Above MDL	5	11	22	32	8	6	2	12	1
Mean	0.42	0.21	0.40	0.58	0.20	0.23	0.16	0.21	0.10
Median	0.43	0.11	0.28	0.16	0.18	0.19	0.15	0.17	0.10
Std. Deviation	0.14	0.21	0.41	1.10	0.09	0.19		0.08	
Percentiles 25		0.11	0.20	0.12				0.17	
50		0.11	0.28	0.16				0.17	
75		0.24	0.43	0.54				0.24	
Elizabeth RIOPA*		1.05±3.09							3.77±26.9
NJDEP 2006#	.05-.14	.04-.11		.15-.99					.04-.2

	trichlorofluoromethane	methylene chloride	carbon tetrachloride	bromochloromethane	1,1,1-trichloro ethane	Trichloro ethene	chloro-benzene	Bromo benzene	1,2-dichloro benzene	Naphtha-lene
Number of Samples	37	37	37	37	37	37	37	37	37	37
Number Above MDL	28	24	29	17	1	4	1	3	3	4
Mean	1.35	1.48	0.46	0.30	0.17	0.19	0.09	0.25	0.24	0.12
Median	1.50	0.81	0.43	0.20	0.17	0.14	0.08	0.21	0.24	0.06
Std. Deviation	0.90	1.55	0.23	0.22		0.20		0.13	0.02	0.19
Percentiles 25	0.40	0.78	0.28	0.20						
50	1.50	0.81	0.43	0.20						
75	1.80	1.43	0.63	0.31						
Elizabeth RIOPA*		1.6±4.2	0.84±2.3			0.57±2.2				
NJDEP 2006#			.09-.1		.04-.05	.02-.16	.02-.17			

*Elizabeth, NJ RIOPA Data from Turpin et al., 2007; Weisel et al., 2005a; Weisel et al., 2005b
NJDEP 2006# Summary Data from NJ DEP Monitoring Sites for 2006 as reported http://www.epa.gov/aqspubl1/site.html

Table 34. Comparison of the VOC air concentrations for personal samples across the three different sampling periods by one-way ANOVA and the log transformed air concentrations

		Sum of Squares	df	Mean Square	F	Sig.
Logtoluene	Between Groups	.176	2	.088	.415	.664
	Within Groups	7.208	34	.212		
	Total	7.384	36			
logbenzene	Between Groups	3.123	2	1.562	10.023	.000
	Within Groups	5.297	34	.156		
	Total	8.421	36			
logethylbenzene	Between Groups	.336	2	.168	1.350	.273
	Within Groups	4.236	34	.125		
	Total	4.572	36			
logm,p-xylene	Between Groups	.039	2	.019	.052	.950
	Within Groups	12.311	33	.373		
	Total	12.349	35			
logo-xylene	Between Groups	.839	2	.420	2.551	.093
	Within Groups	5.593	34	.164		
	Total	6.432	36			
log1,2,4-trimethylbenzene	Between Groups	5.112	2	2.556	14.498	.000
	Within Groups	5.994	34	.176		
	Total	11.106	36			

logbenzene

Tukey HSD

	N	Subset for alpha = .05	
Season Code	1	2	1
3	13	-.0624	
1	12		.4217
2	12		.6226
Sig.		1.000	.425

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 12.316.
b The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

log1,2,4-trimethylbenzene

Tukey HSD

	N	Subset for alpha = .05	
Season Code	1	2	1
2	12	-1.0209	
3	13	-.7265	
1	12		-.1170
Sig.		.205	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 12.316.
b The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Table 35. Comparison of the VOC air concentrations for personal samples across the four different sampling trails by one-way ANOVA and the log transformed air concentrations

		Sum of Squares	df	Mean Square	F	Sig.
logtoluene	Between Groups	1.396	3	.465	2.563	.071
	Within Groups	5.988	33	.181		
	Total	7.384	36			
logbenzene	Between Groups	.071	3	.024	.093	.963
	Within Groups	8.350	33	.253		
	Total	8.421	36			
logethylbenzene	Between Groups	.549	3	.183	1.500	.233
	Within Groups	4.024	33	.122		
	Total	4.572	36			
logm,p-xylene	Between Groups	1.780	3	.593	1.796	.168
	Within Groups	10.570	32	.330		
	Total	12.349	35			
logo-xylene	Between Groups	1.302	3	.434	2.793	.056
	Within Groups	5.130	33	.155		
	Total	6.432	36			
log1,2,4-trimethylbenzene	Between Groups	1.479	3	.493	1.690	.188
	Within Groups	9.627	33	.292		
	Total	11.106	36			

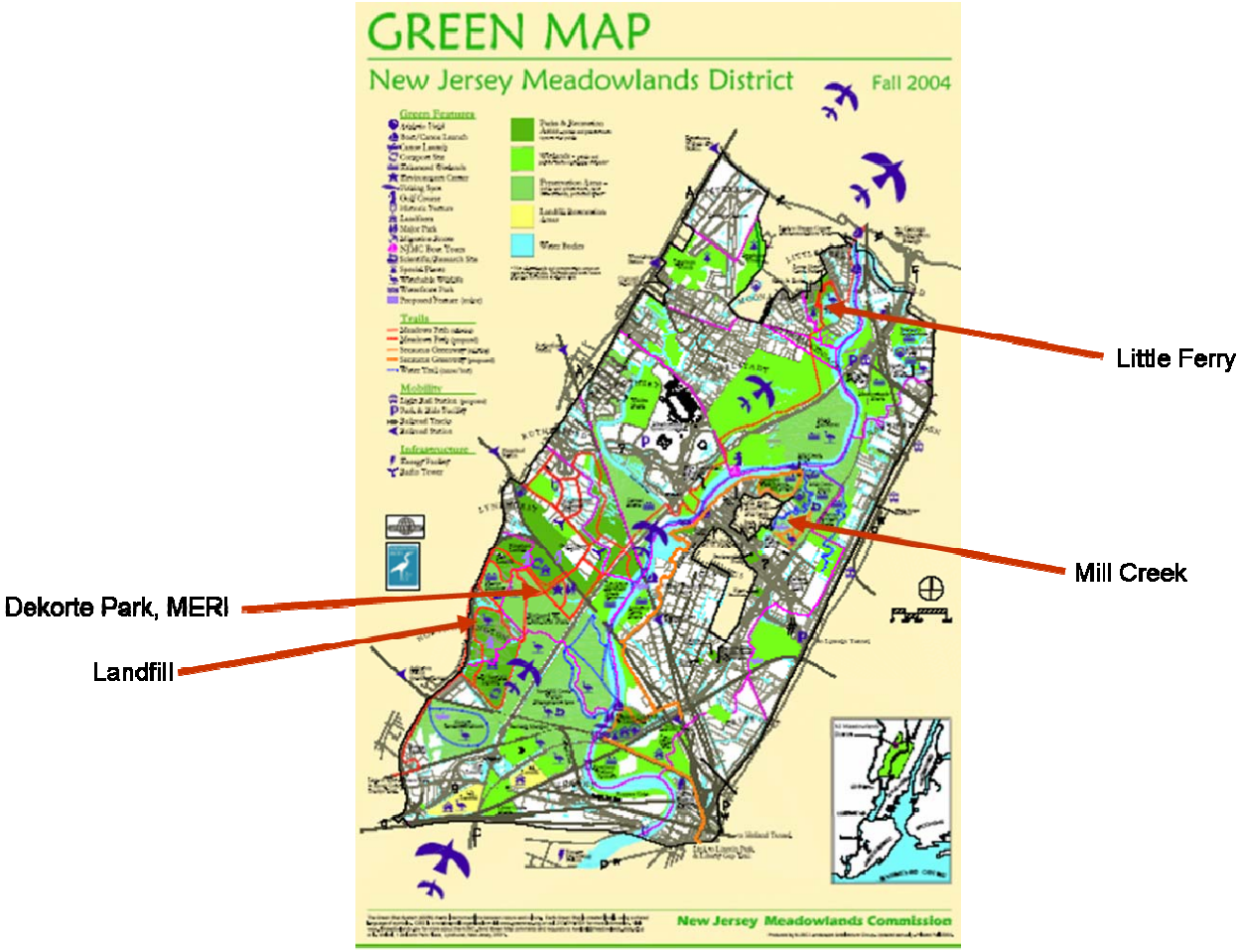


Figure 92. Locations of trails followed for intensive sampling

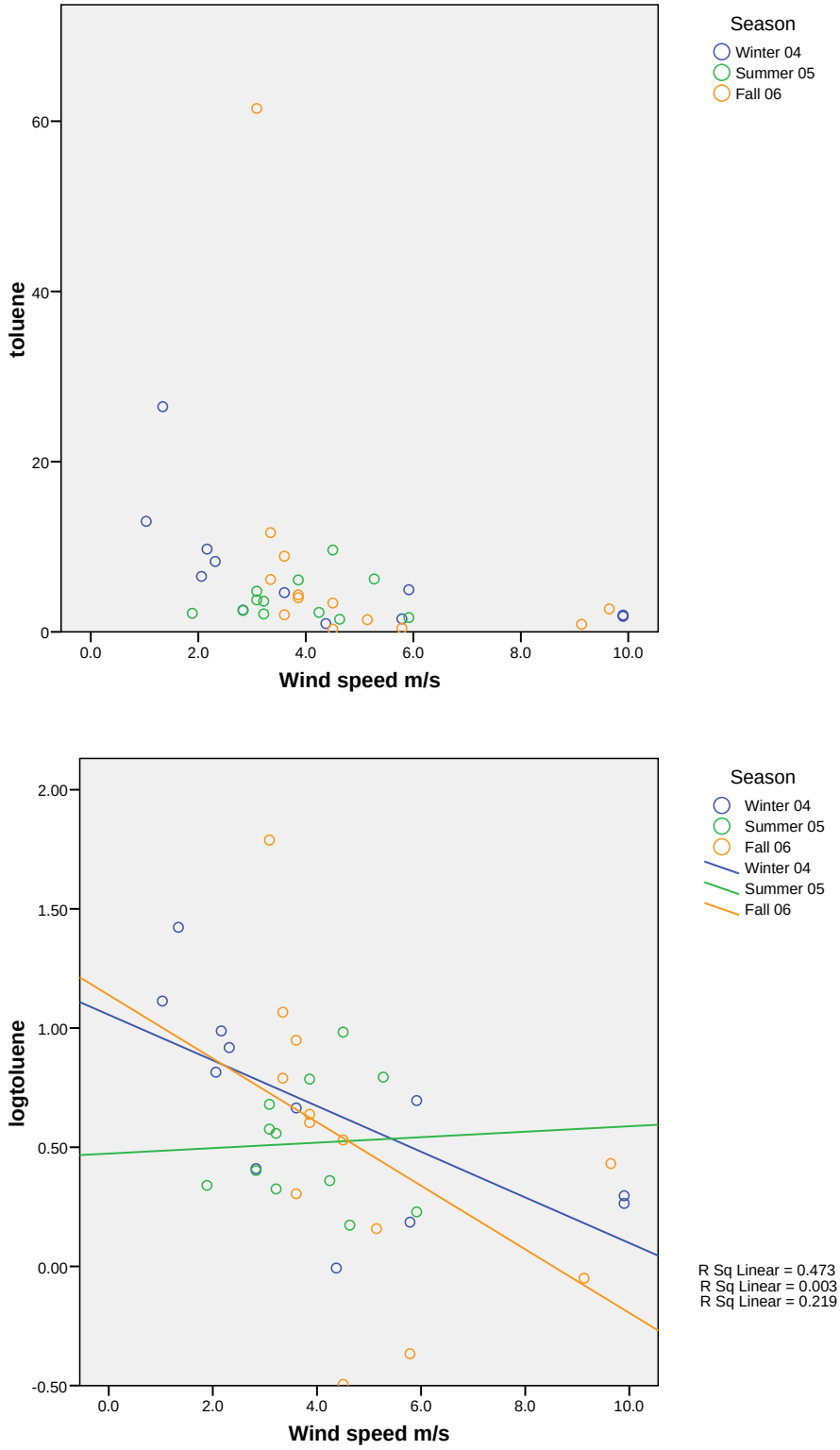
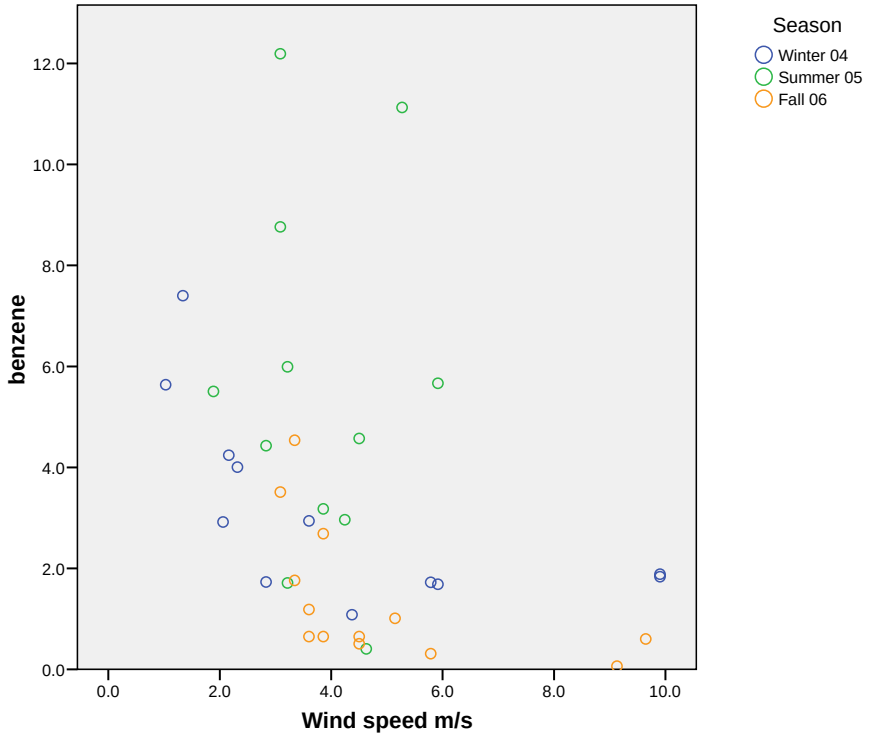


Figure 93. Air concentration (µg/m^3) (a) and log air concentration (b) of Toluene with wind speed (m/s) during Intensive sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted.



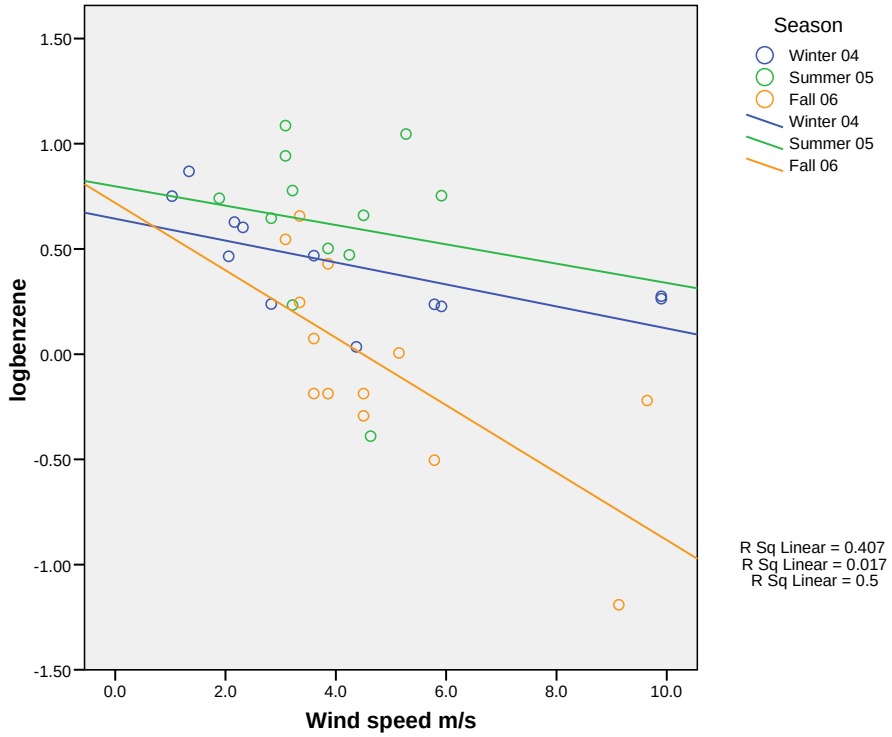
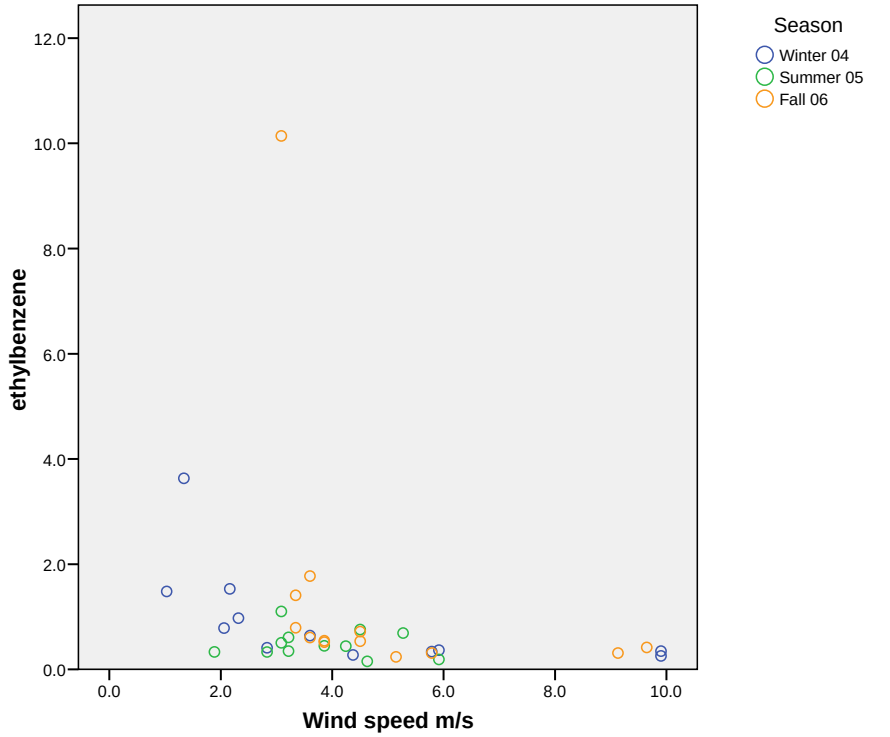


Figure 94. Air concentration (µg/m^3) (a) and log air concentration (b) of Benzene with wind speed (m/s) during Intensive sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted.



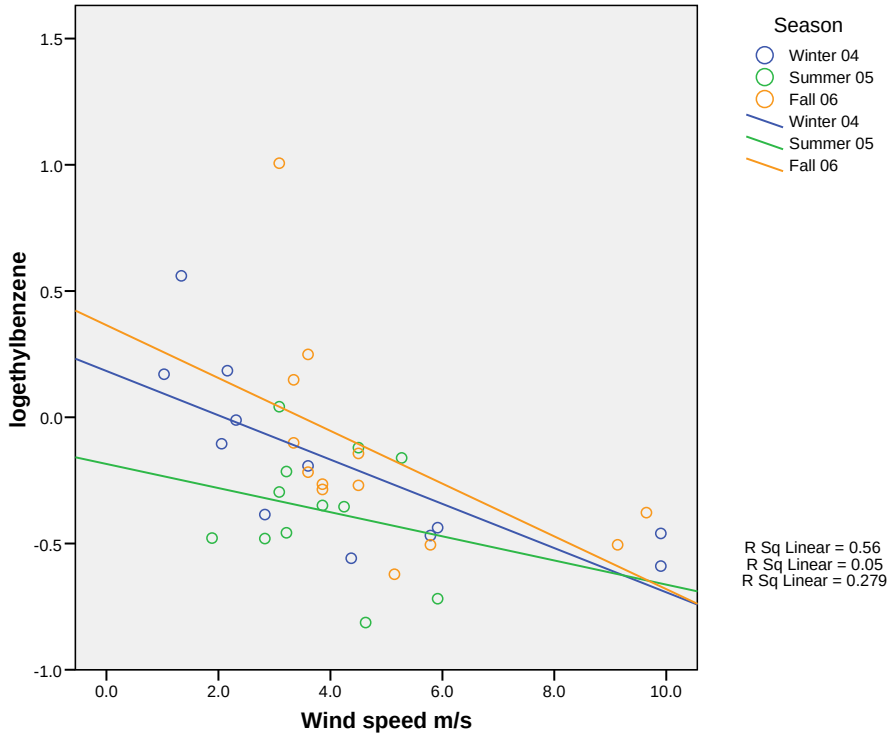
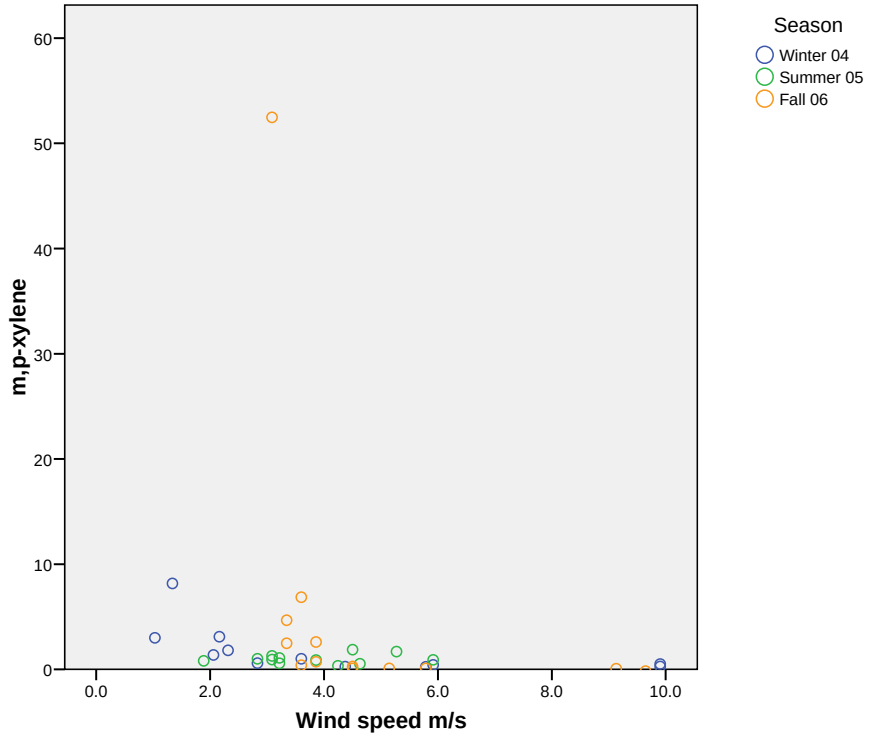


Figure 95. Air concentration (µg/m^3) (a) and log air concentration (b) of Ethyl benzene with wind speed (m/s) during Intensive sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted.



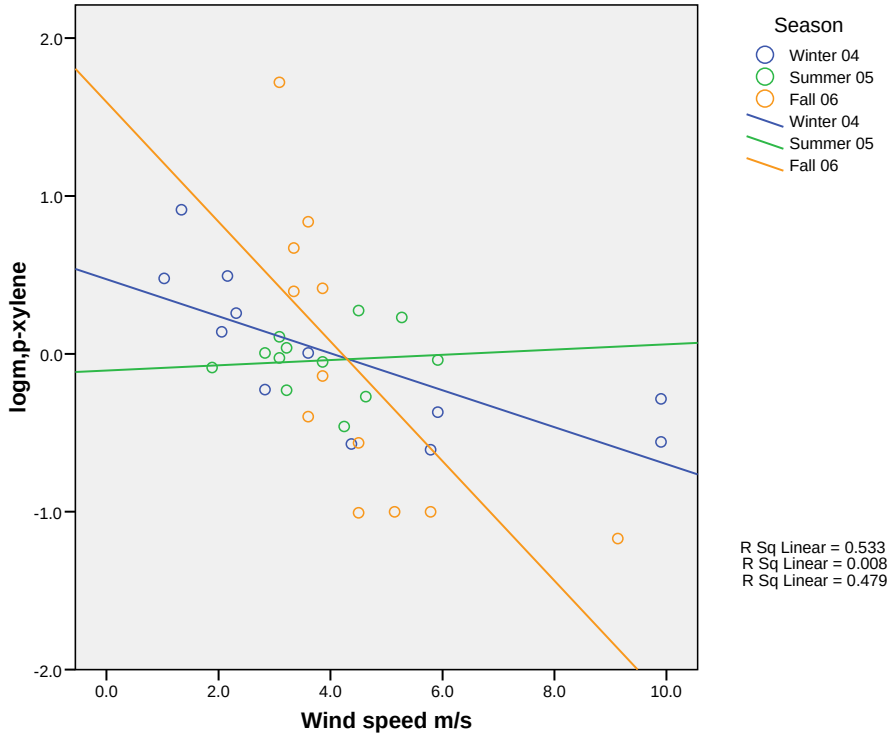
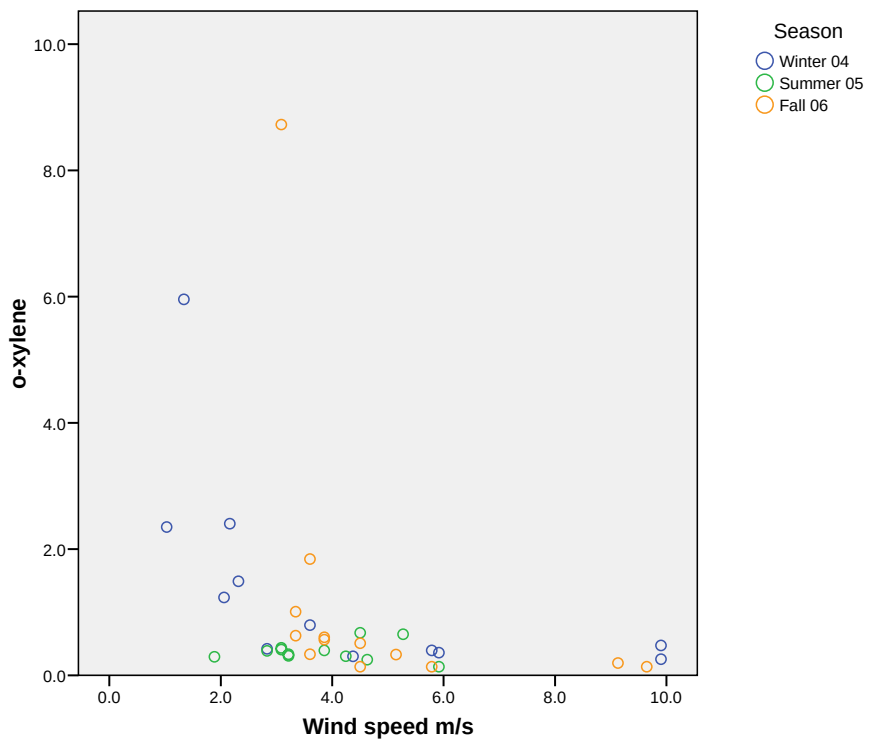


Figure 96. Air concentration (µg/m^3) (a) and log air concentration (b) of *m/*p Xylene with wind speed (m/s) during Intensive sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted.



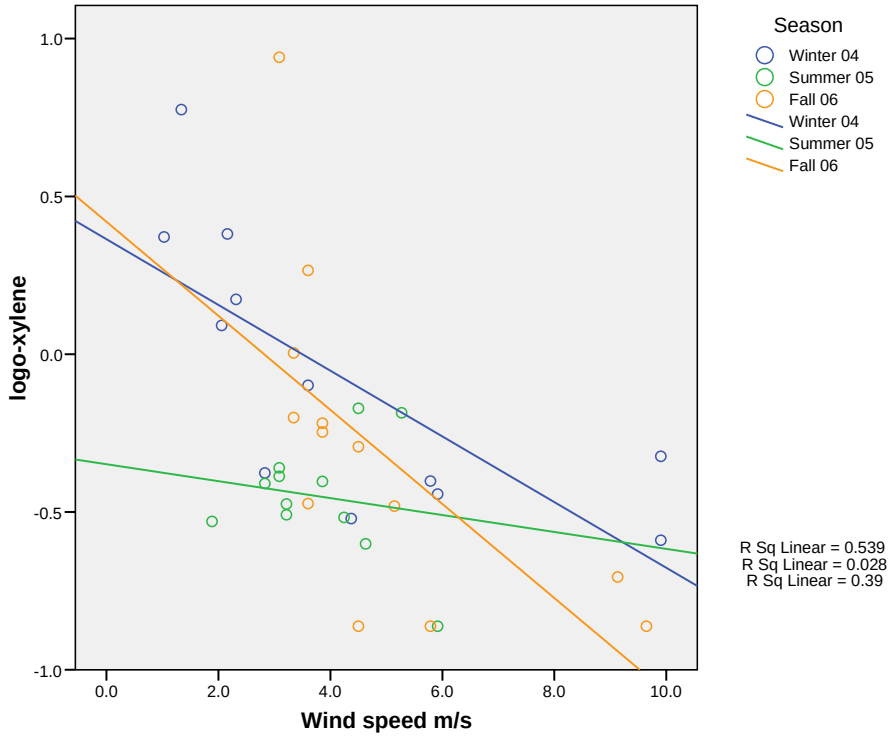
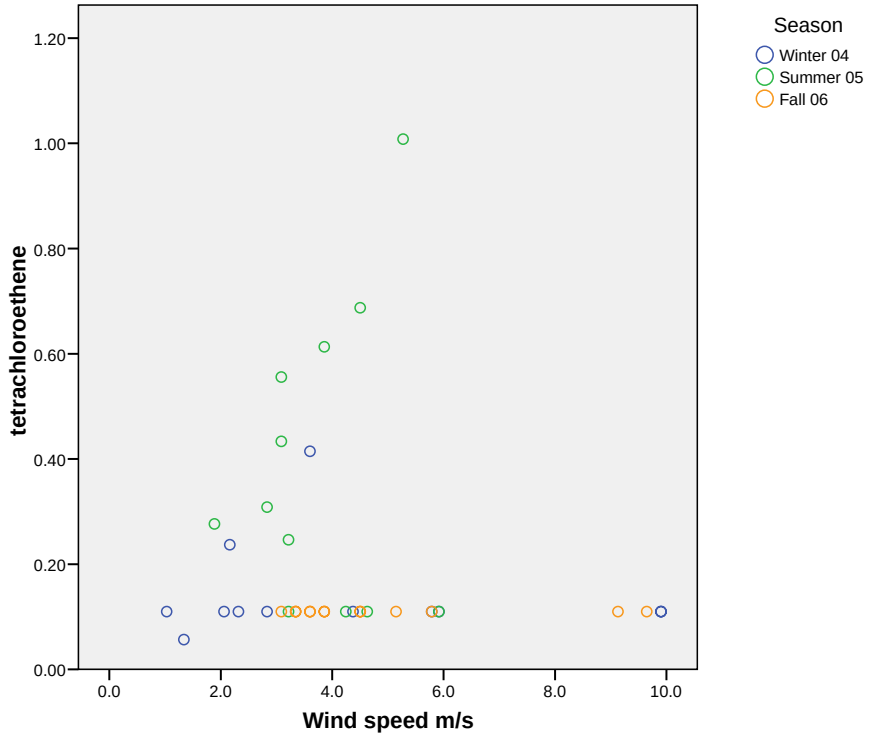


Figure 97. Air concentration (µg/m^3) (a) and log air concentration (b) of o Xylene with wind speed (m/s) during Intensive ampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted.



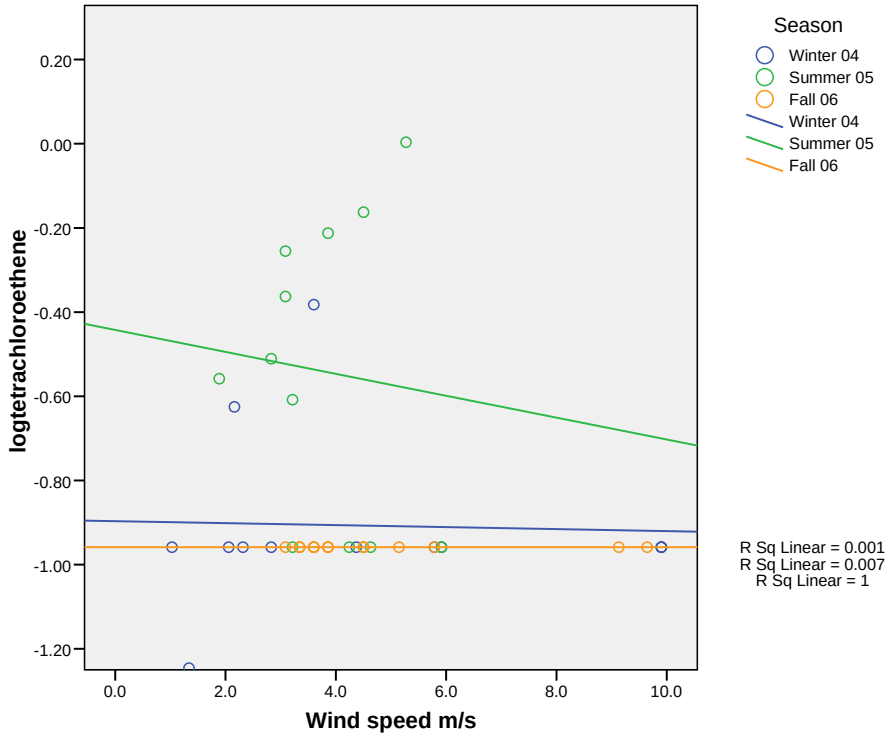
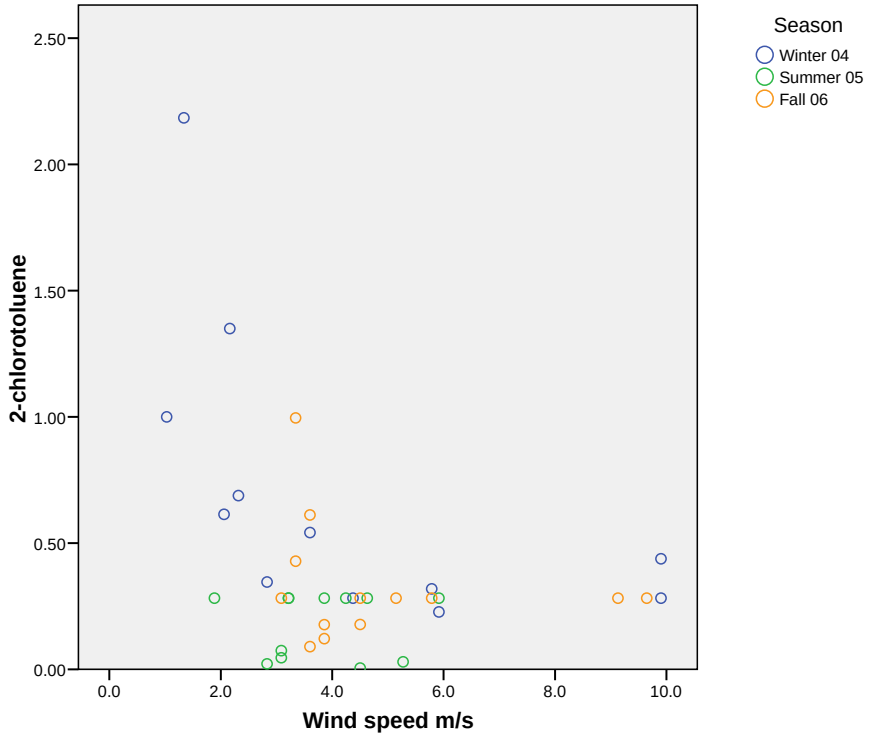


Figure 98. Air concentration (µg/m^3) (a) and log air concentration (b) of Tetrachloroethene with wind speed (m/s) during Intensive Sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted.



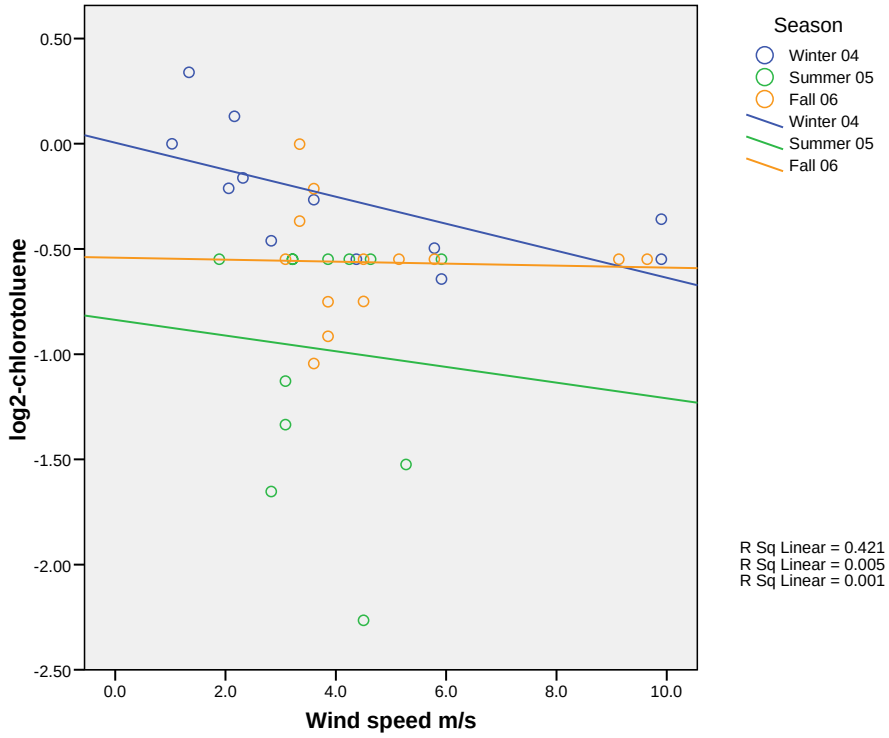
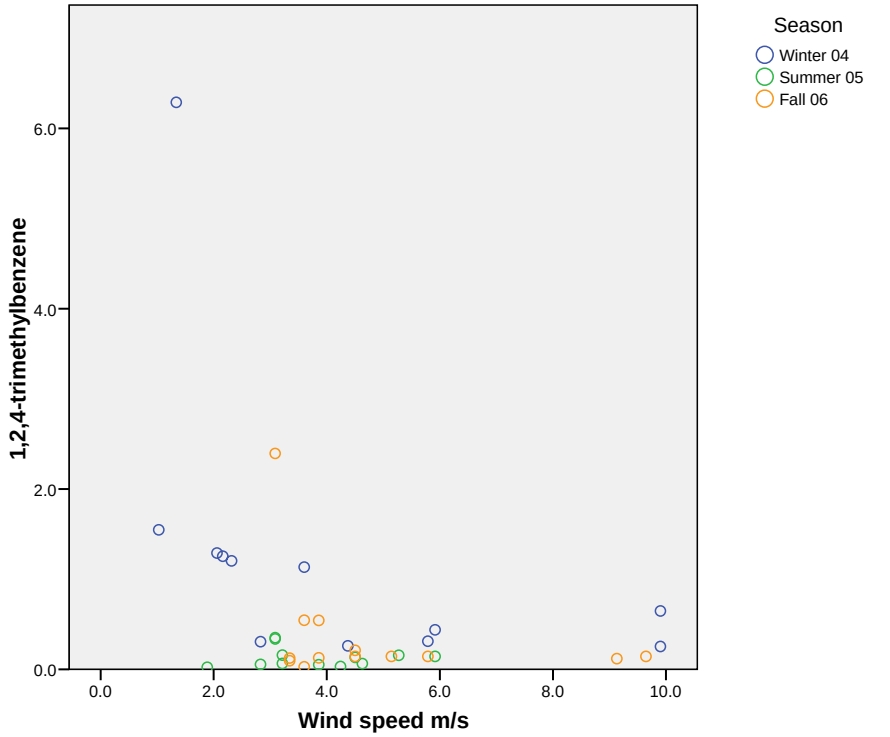


Figure 99. Air concentration (µg/m^3) (a) and log air concentration (b) of 2-chloroetoluene with wind speed (m/s) during Intensive Sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted.



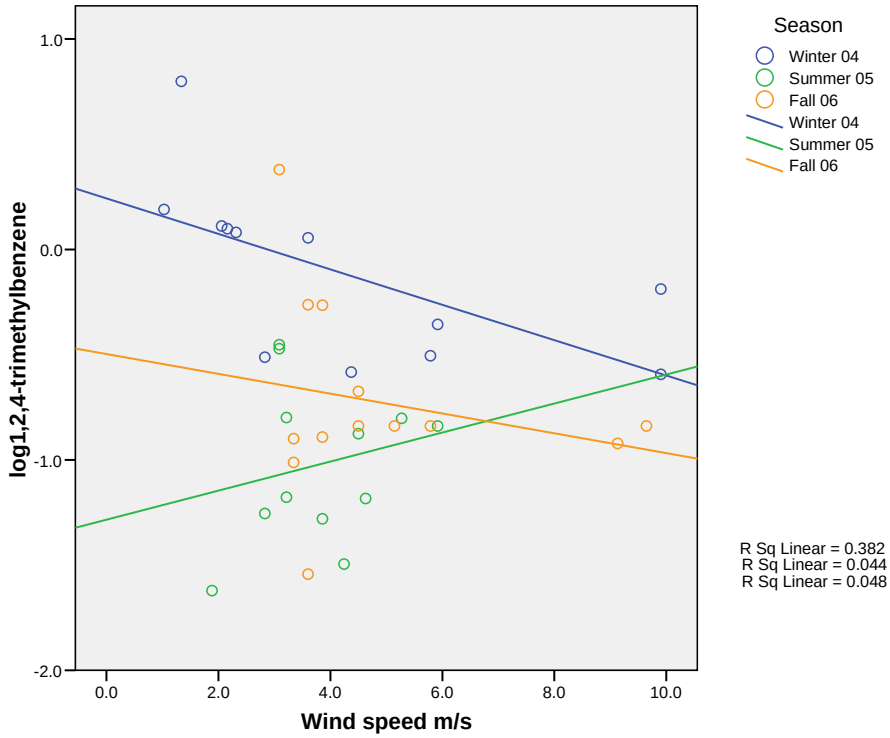
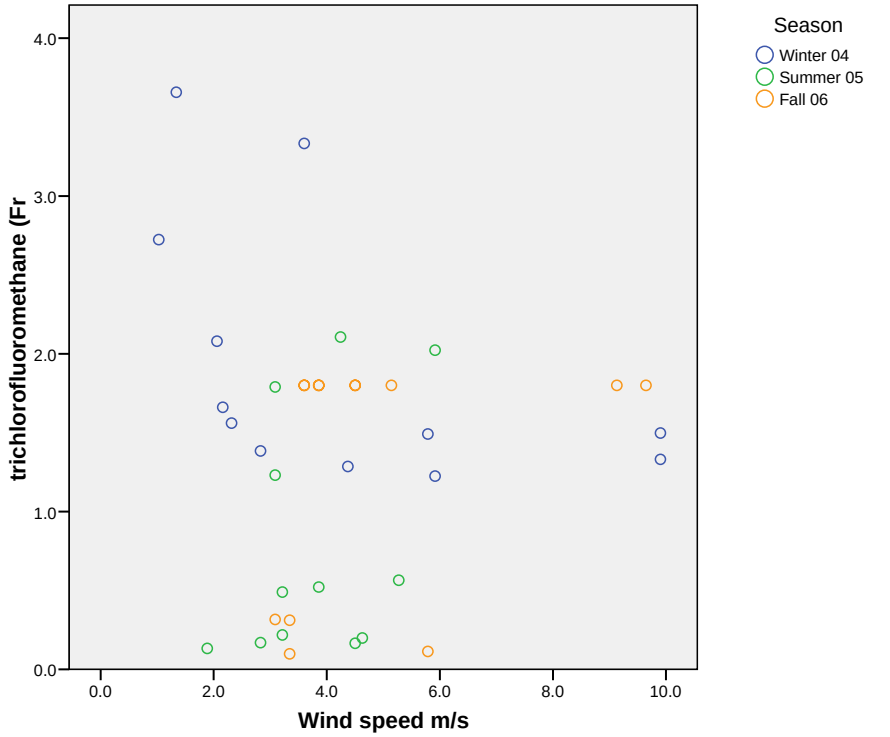


Figure 100. Air concentration (µg/m^3) (a) and log air concentration (b) of 1,2,4-trimethylbenzene with wind speed (m/s) during Intensive Sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted.



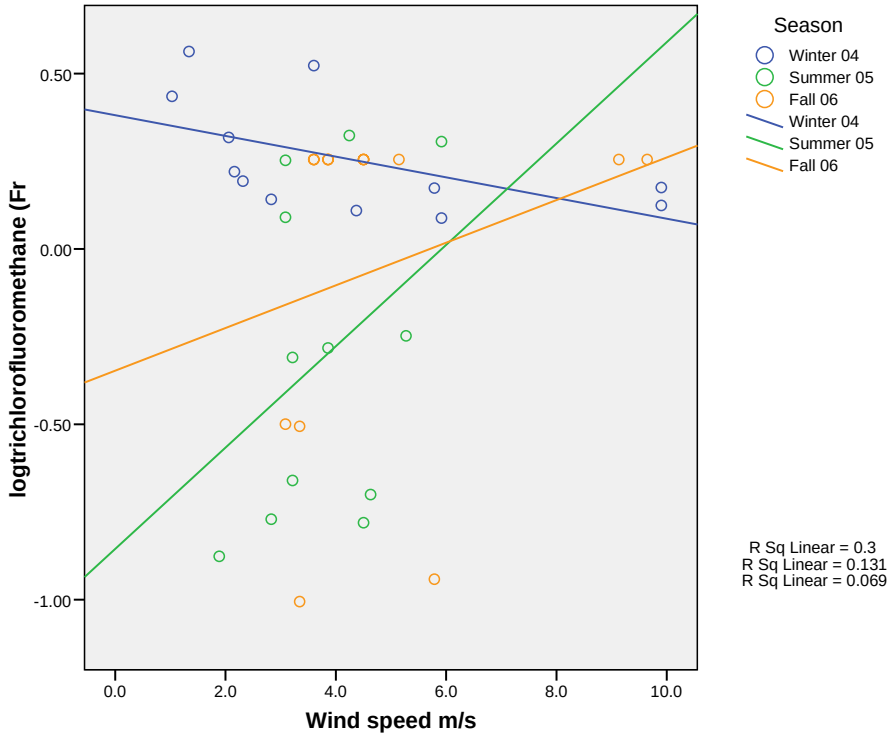
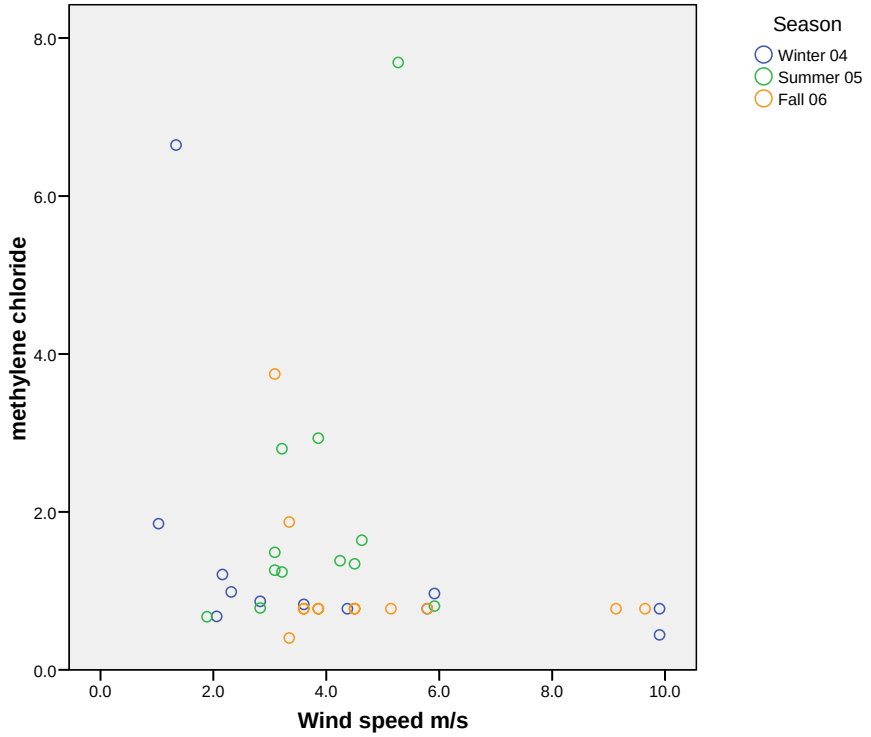


Figure 101. Air concentration (µg/m^3) (a) and log air concentration (b) of trichlorofluoromethane (Freon) with wind speed (m/s) during Intensive Sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted.



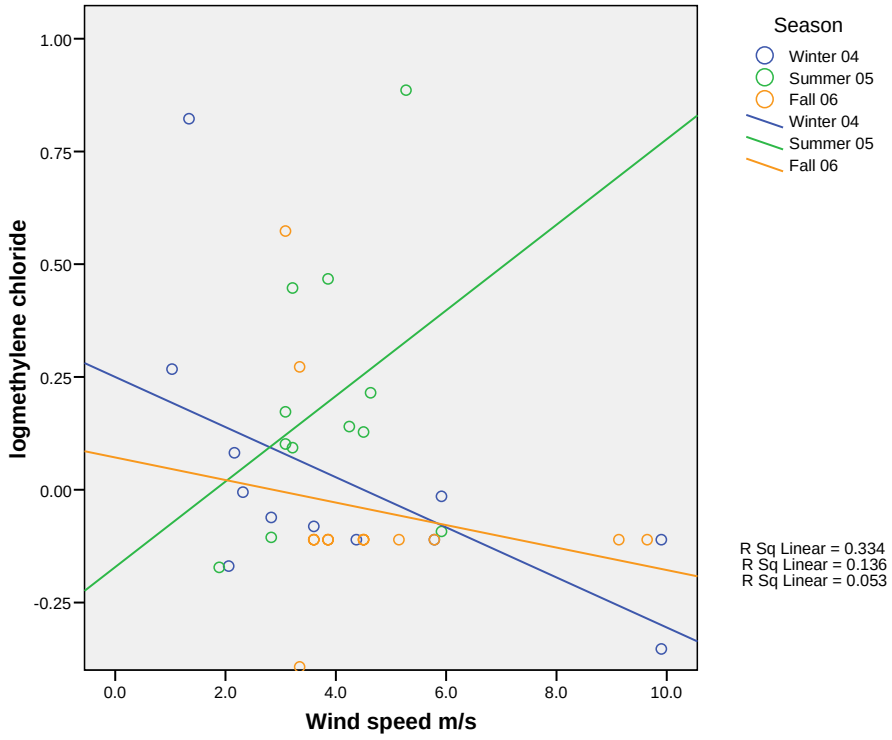
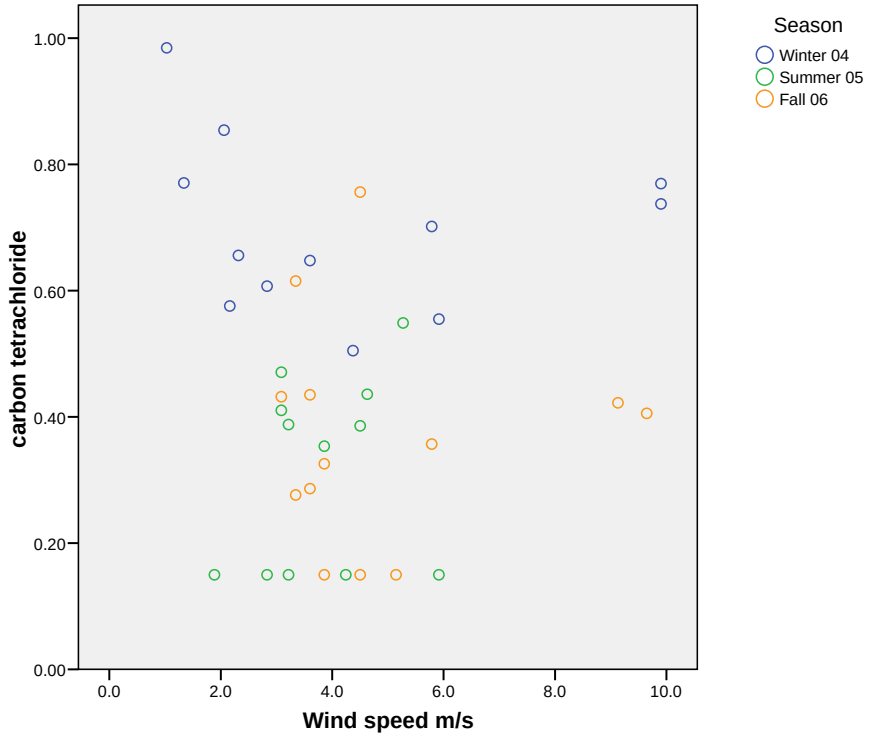


Figure 102. Air concentration (µg/m^3) (a) and log air concentration (b) of Methylene Chloroide with wind speed (m/s) during Intensive Sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted.



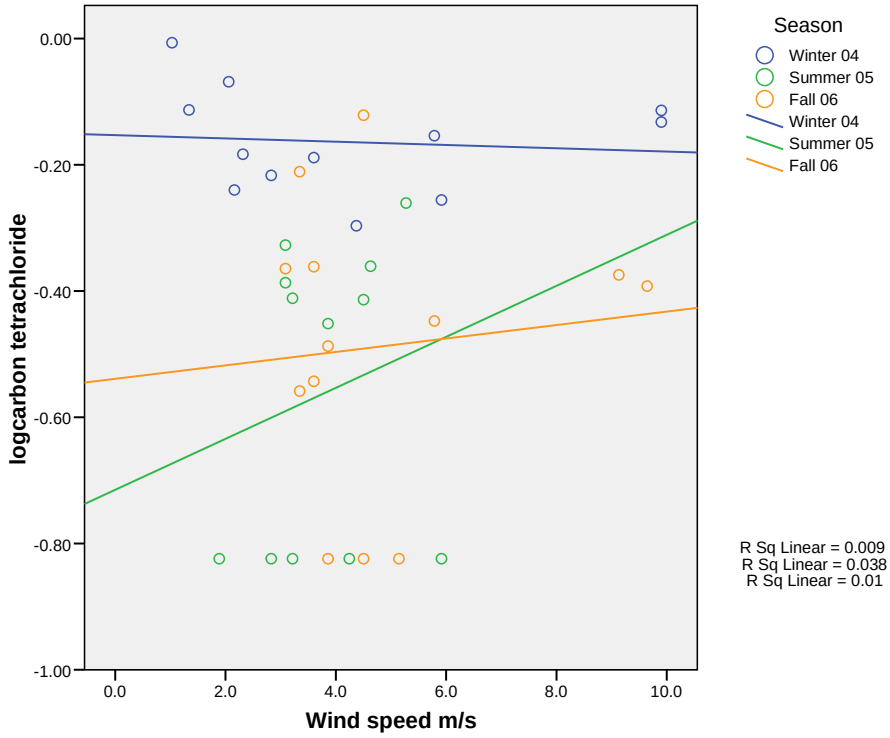


Figure 103. Air concentration (µg/m^3) (a) and log air concentration (b) of Carbon Tetrachloroide with wind speed (m/s) during Intensive Sampling Program. Time period of sampling as designated. Least Square Line and R^2 fit for log air concentration depicted.

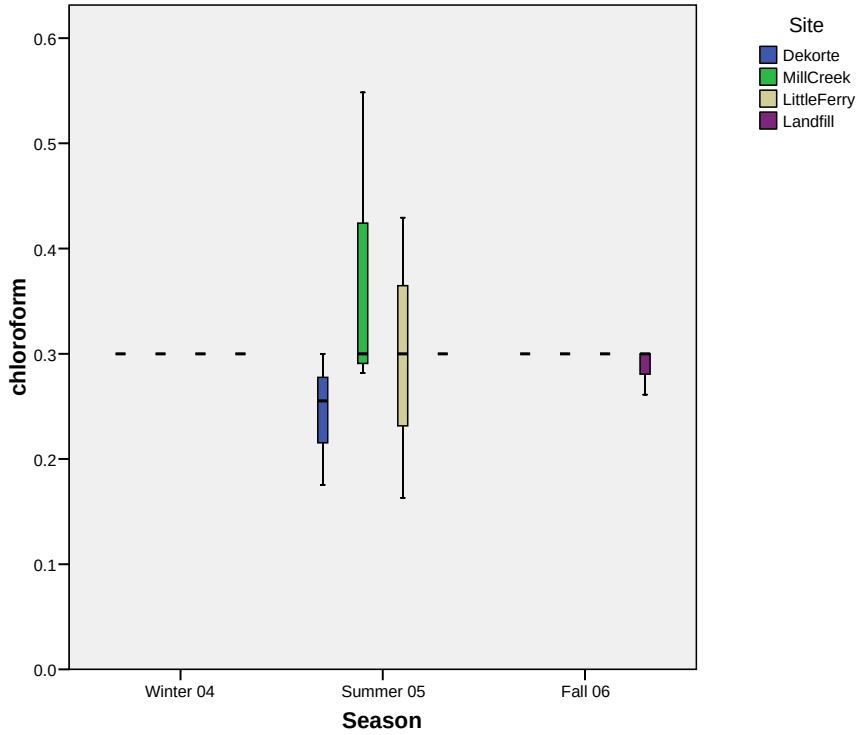


Figure 104. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of Chloroform by Sampling Time and Trail Location during Intensive Sampling Program.

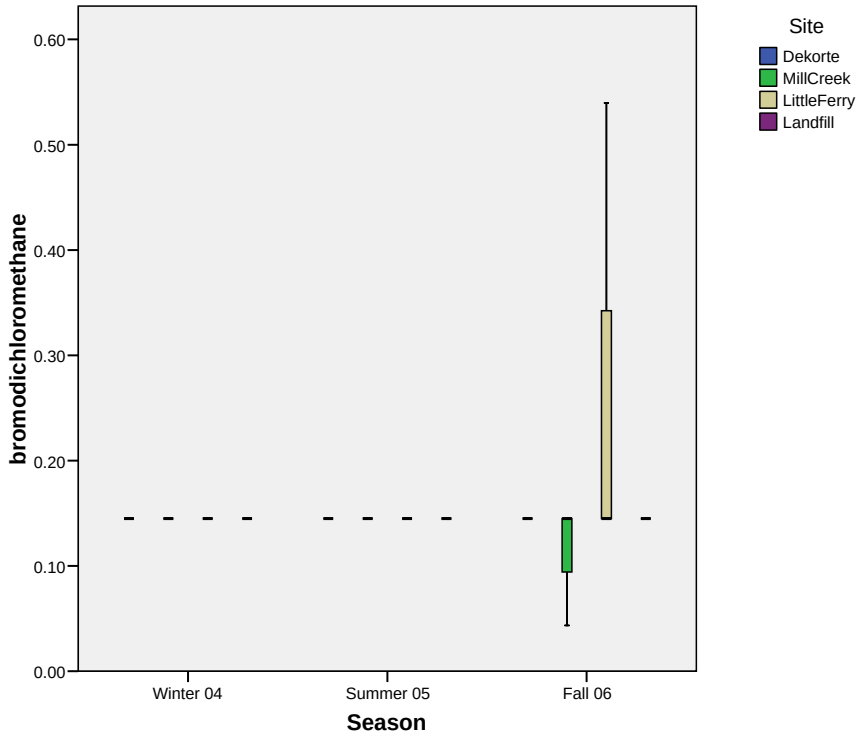


Figure 105. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of Bromovhloromethane by Sampling Time and Trail Location during Intensive Sampling Program.

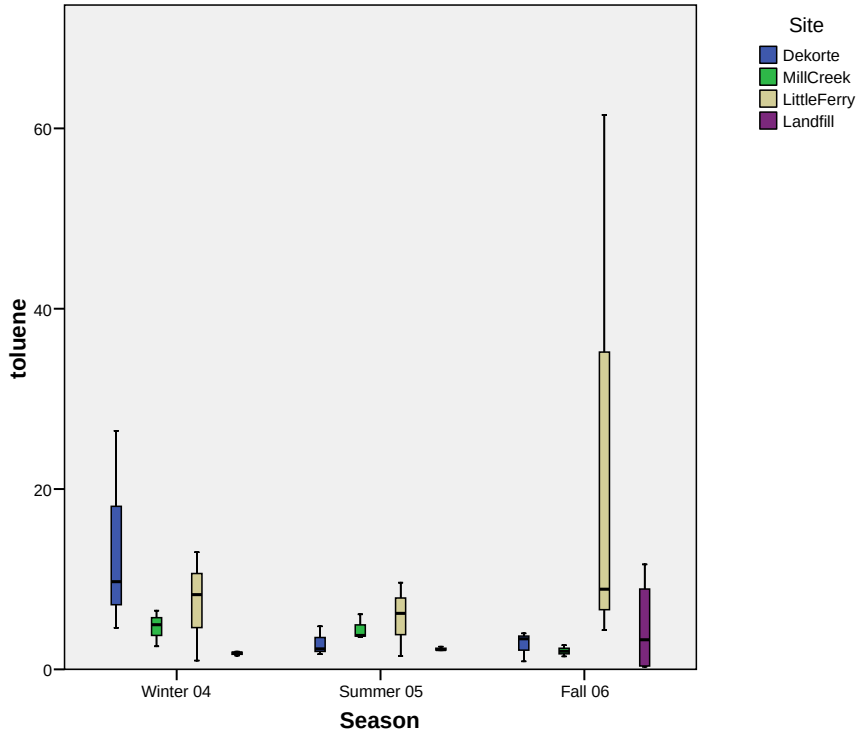


Figure 106. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of Toluene by Sampling Time and Trail Location during Intensive Sampling Program.

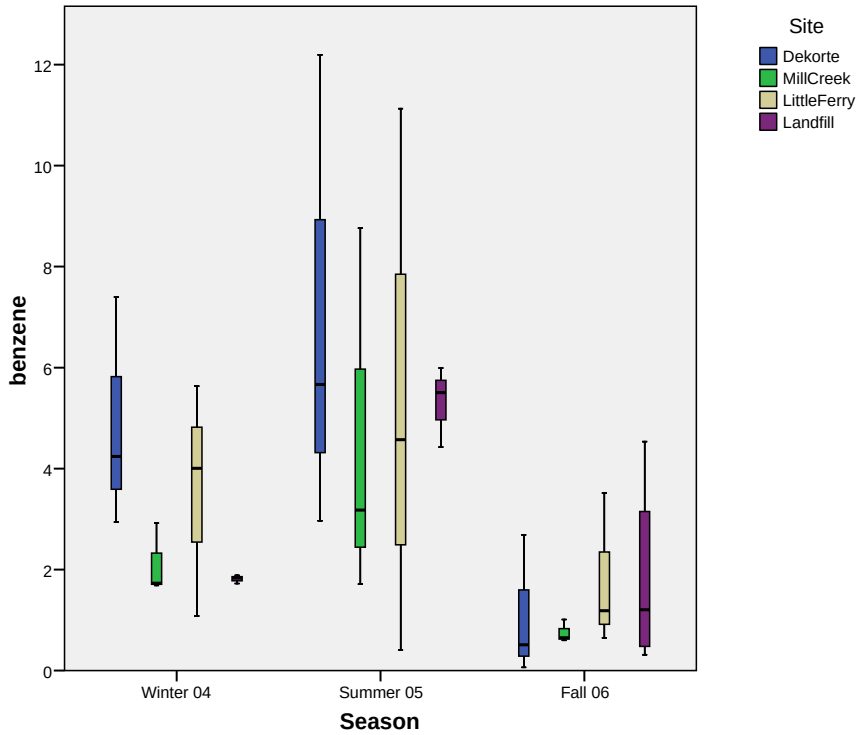


Figure 107. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of Benzene by Sampling Time and Trail Location during Intensive Sampling Program.

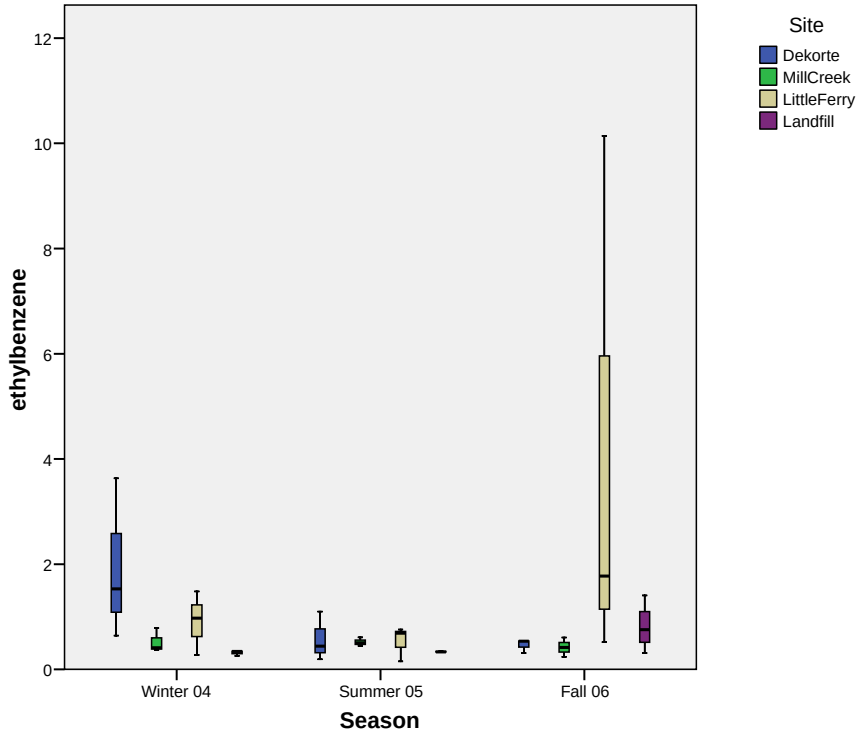


Figure 108. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of Ethybenzene by Sampling Time and Trail Location during Intensive Sampling Program.

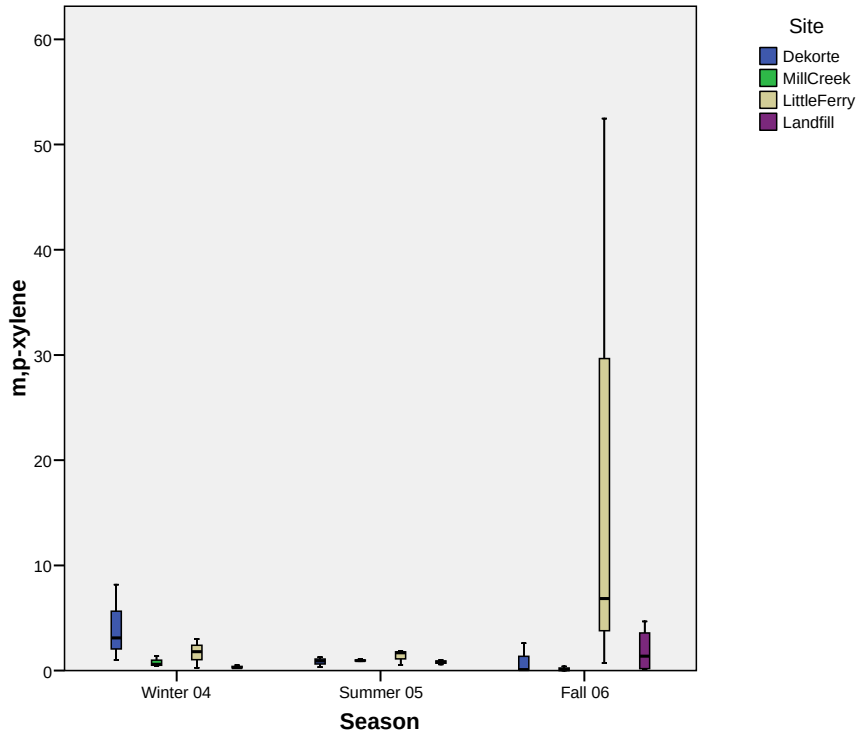


Figure 109. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of *m/*p Xylene by Sampling Time and Trail Location during Intensive Sampling Program.

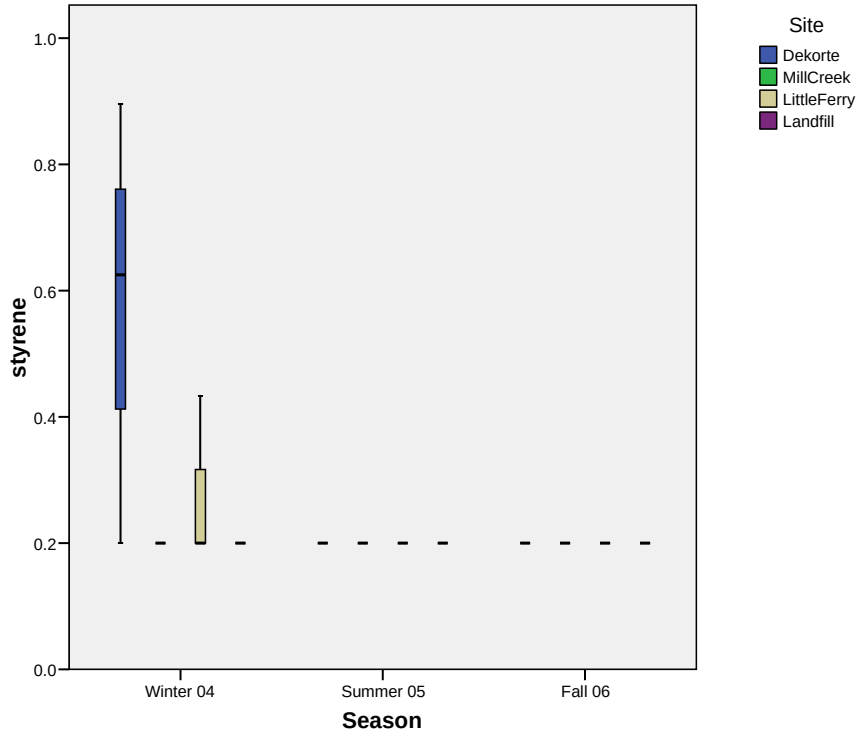


Figure 110. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of Styrene by Sampling Time and Trail Location during Intensive Sampling Program.

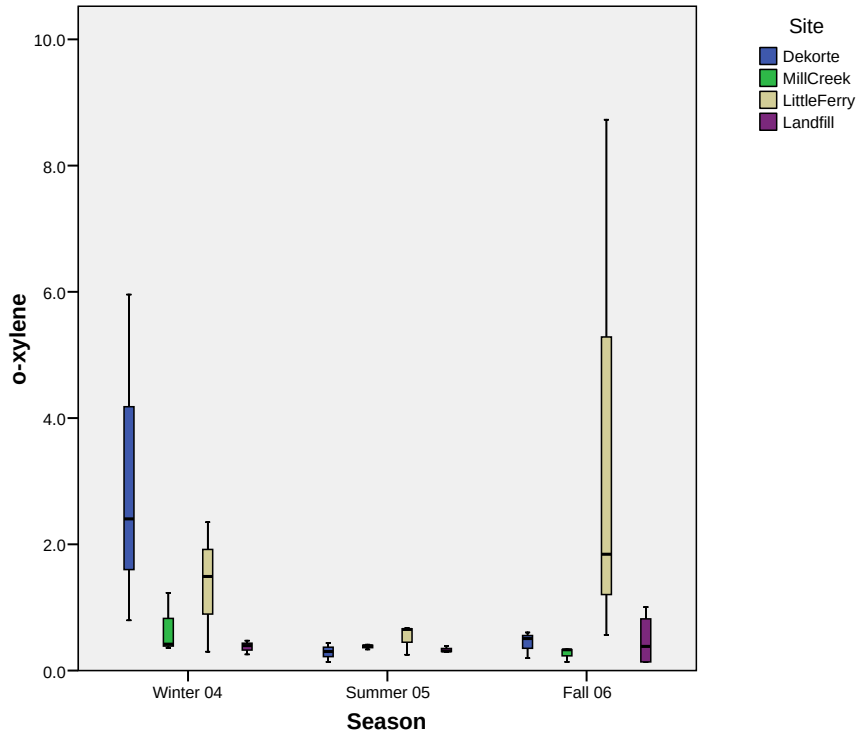


Figure 111. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of o-Xylene by Sampling Time and Trail Location during Intensive Sampling Program.

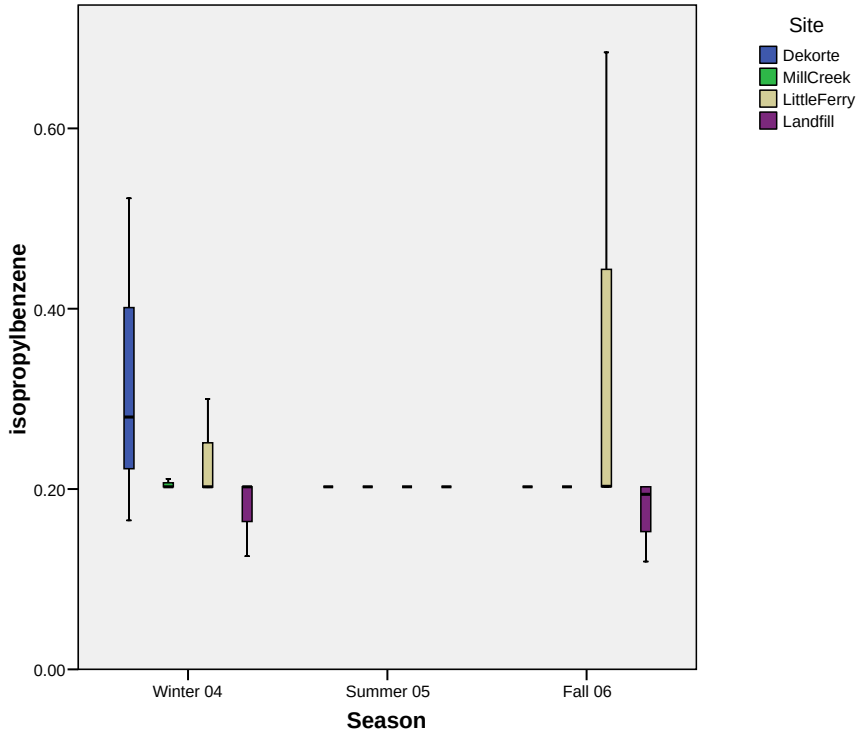


Figure 112. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of iso-Propylbenzene by Sampling Time and Trail Location during Intensive Sampling Program.

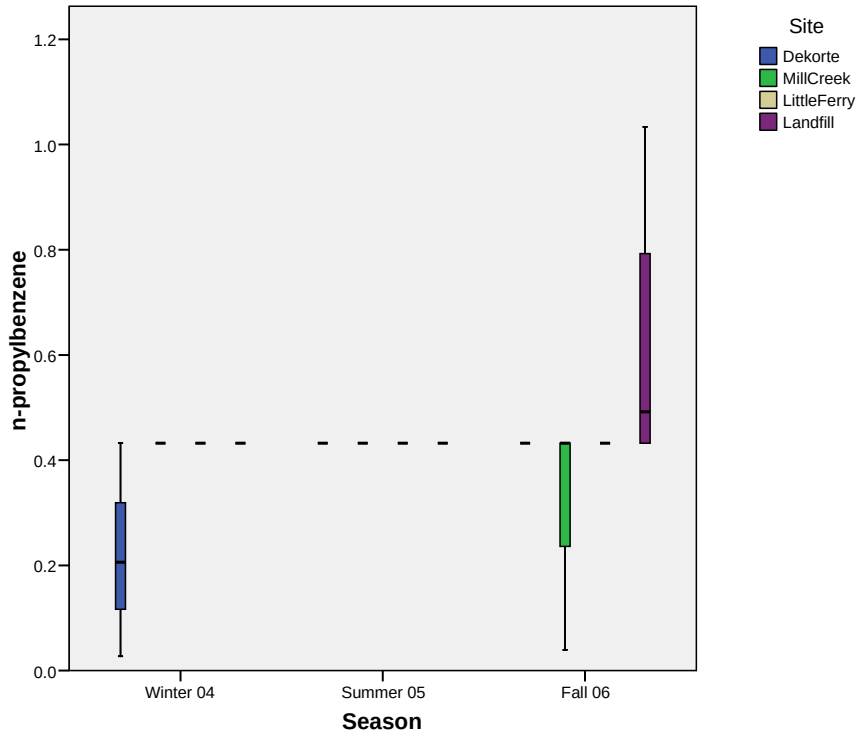


Figure 113. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of n-Propylbenzene by Sampling Time and Trail Location during Intensive Sampling Program.

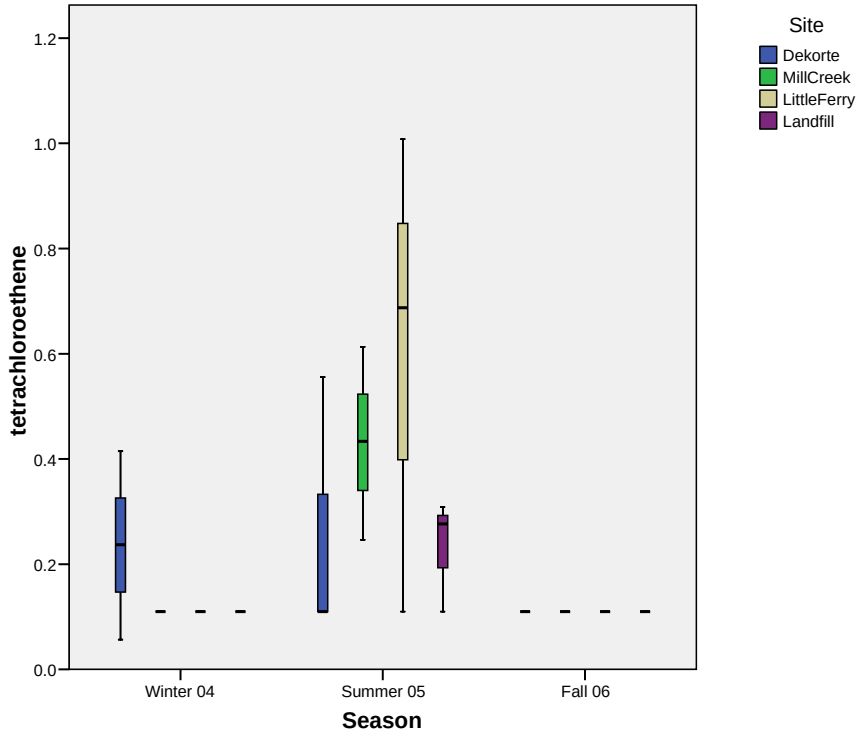


Figure 114. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of Tetrachloroethene by Sampling Time and Trail Location during Intensive Sampling Program.

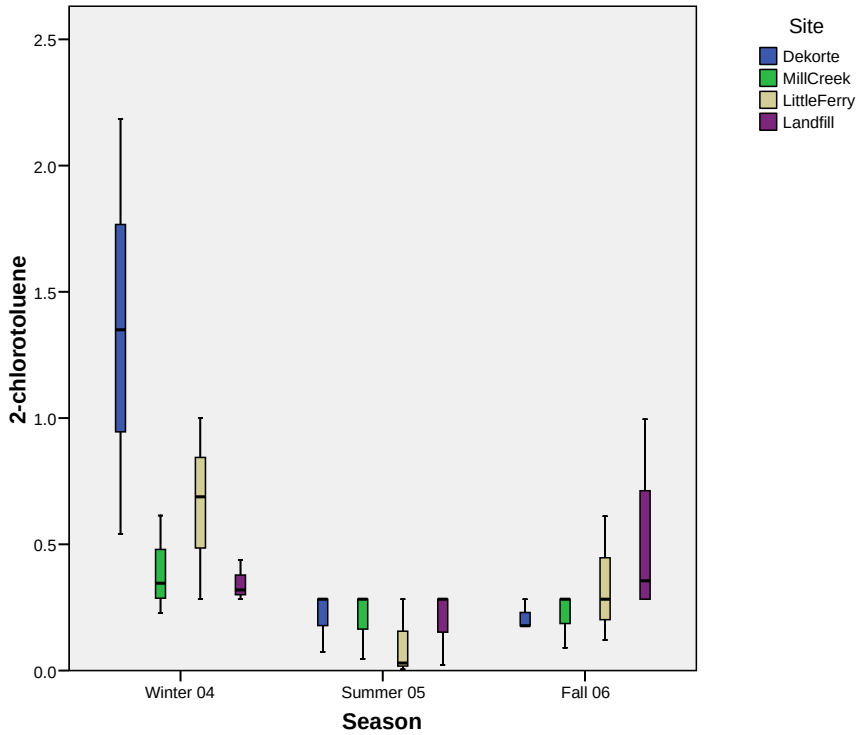


Figure 115. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of 2-Chlorotoluene by Sampling Time and Trail Location during Intensive Sampling Program.

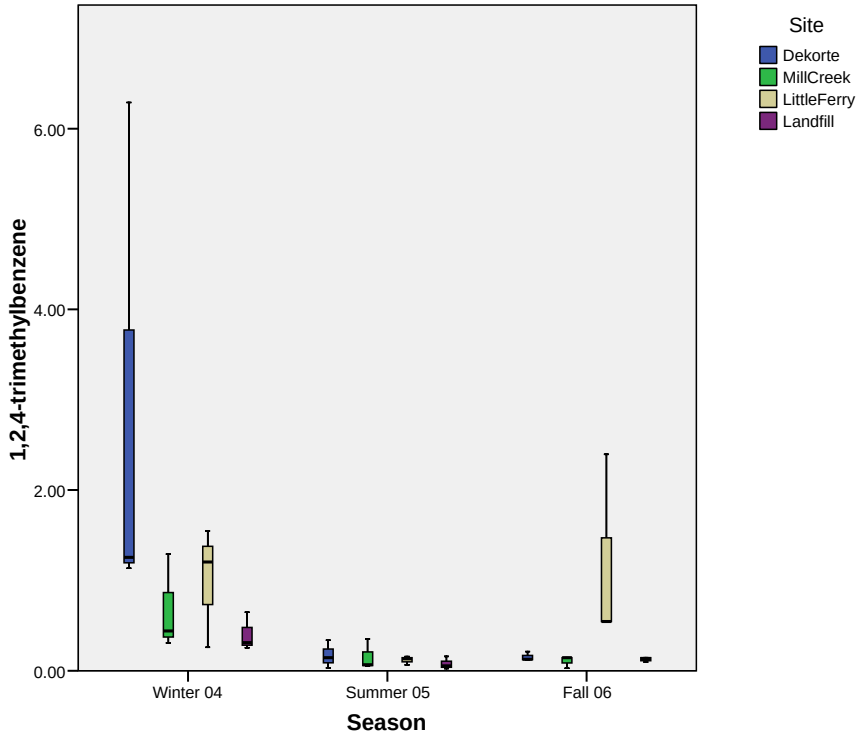


Figure 116. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of 1,2,4-Trimethylbenzene by Sampling Time and Trail Location during Intensive Sampling Program.

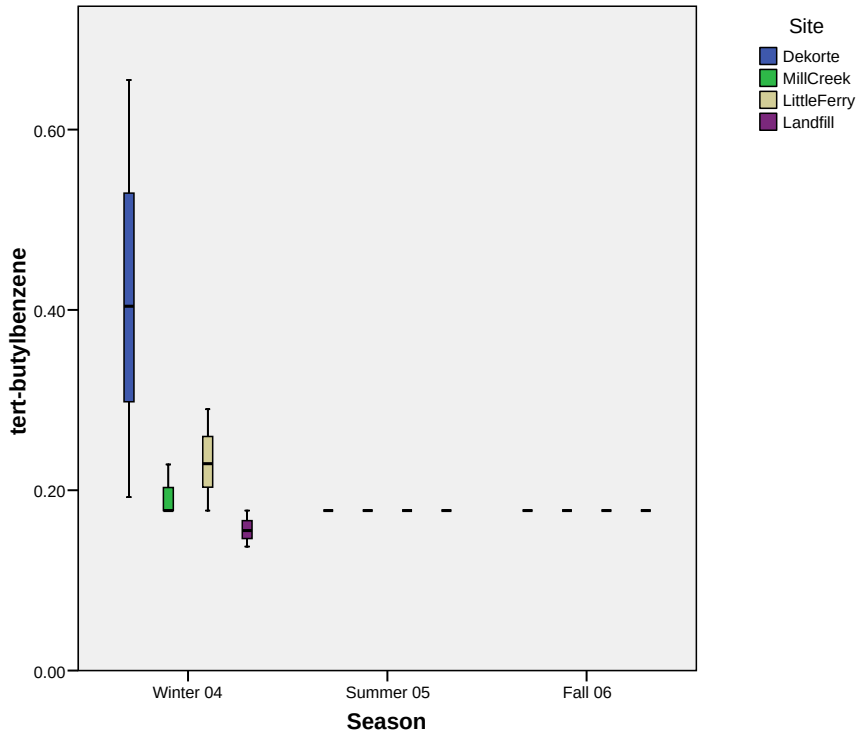


Figure 117. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of tert-Butylbenzene by Sampling Time and Trail Location during Intensive Sampling Program.

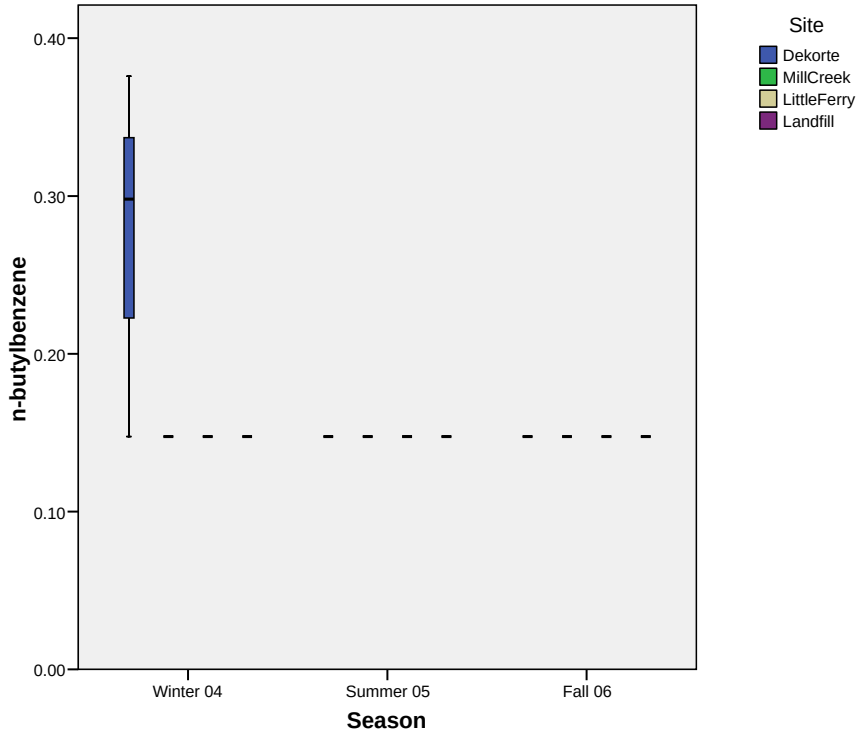


Figure 118. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of n-Butylbenzene by Sampling Time and Trail Location during Intensive Sampling Program.

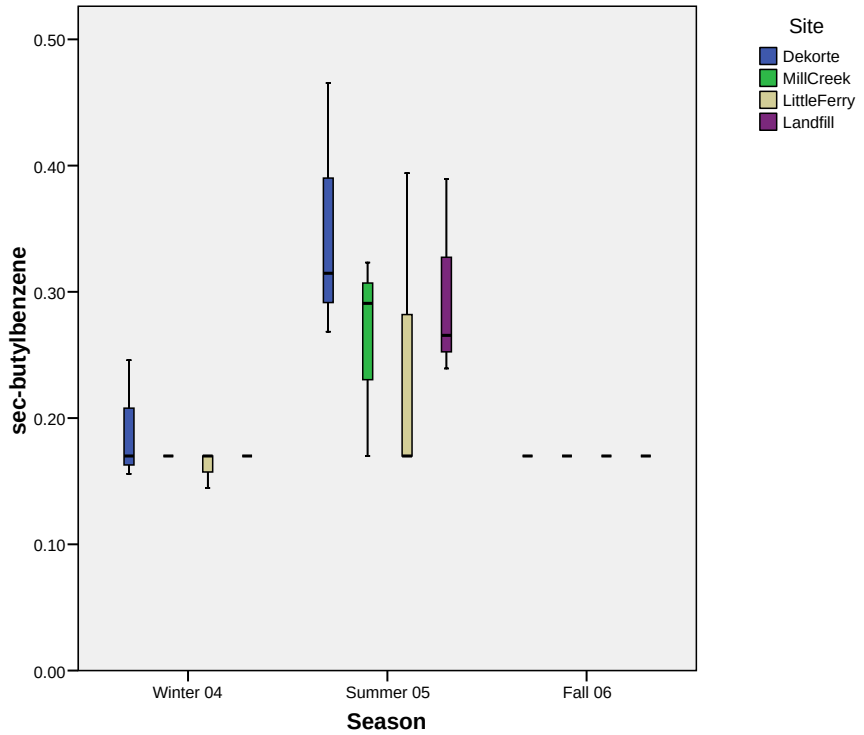


Figure 119. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of sec-Butylbenzene by Sampling Time and Trail Location during Intensive Sampling Program.

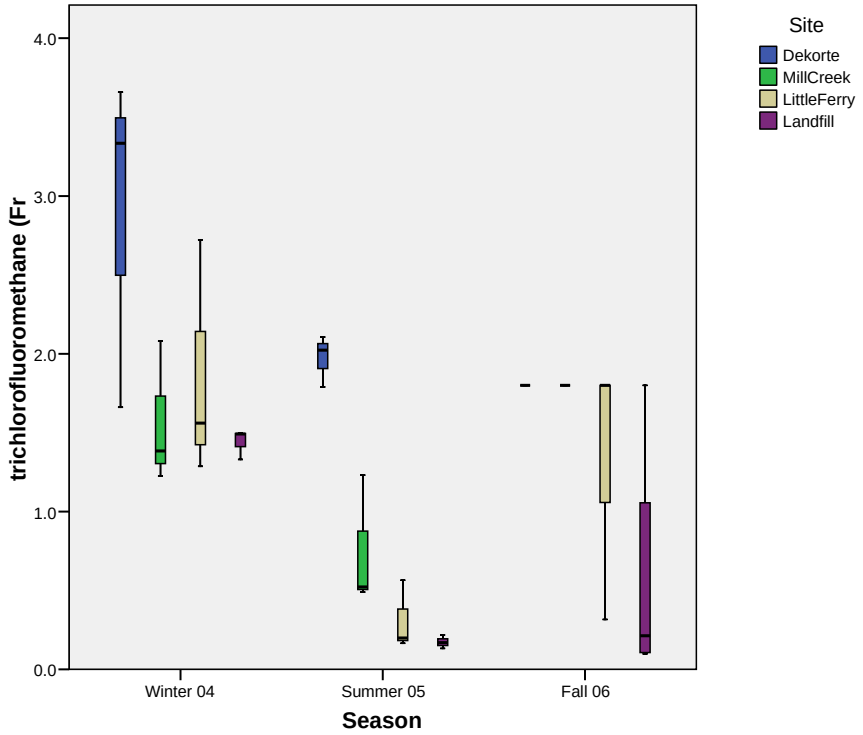


Figure 120. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of Trichloroflouromethane (Freon) by Sampling Time and Trail Location during Intensive Sampling Program.

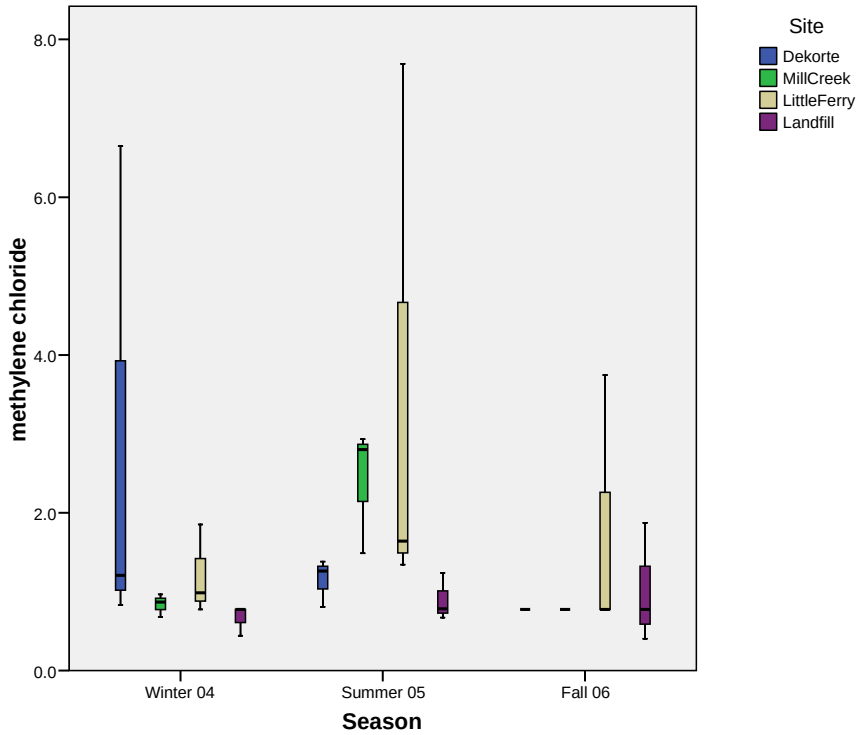


Figure 121. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of Methylene Chloride by Sampling Time and Trail Location during Intensive Sampling Program.

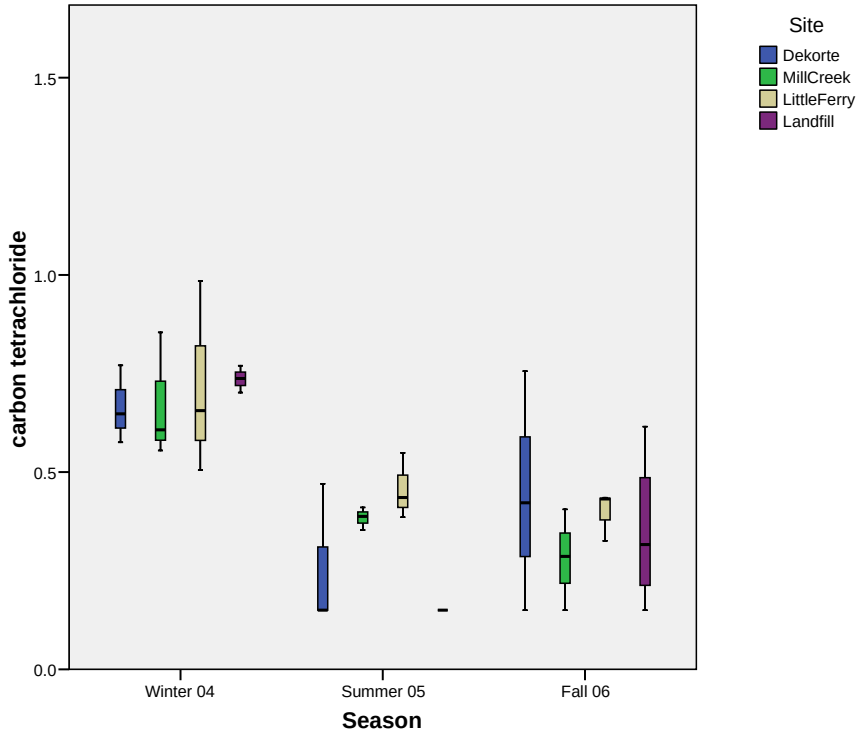


Figure 122. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of Carbon Tetrachloride by Sampling Time and Trail Location during Intensive Sampling Program.

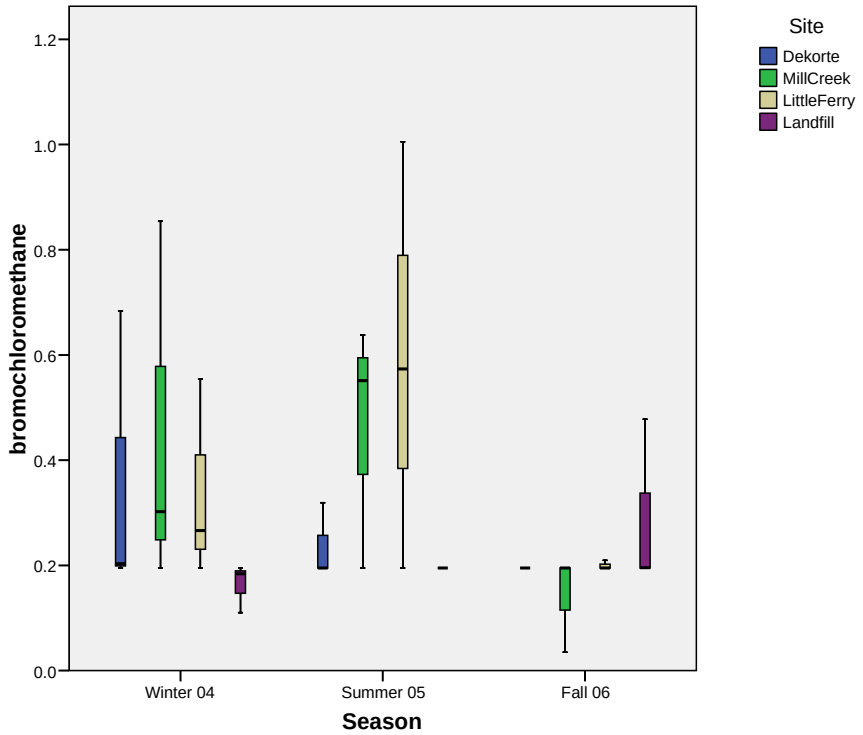


Figure 123. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of Bromochloromethane by Sampling Time and Trail Location during Intensive Sampling Program.

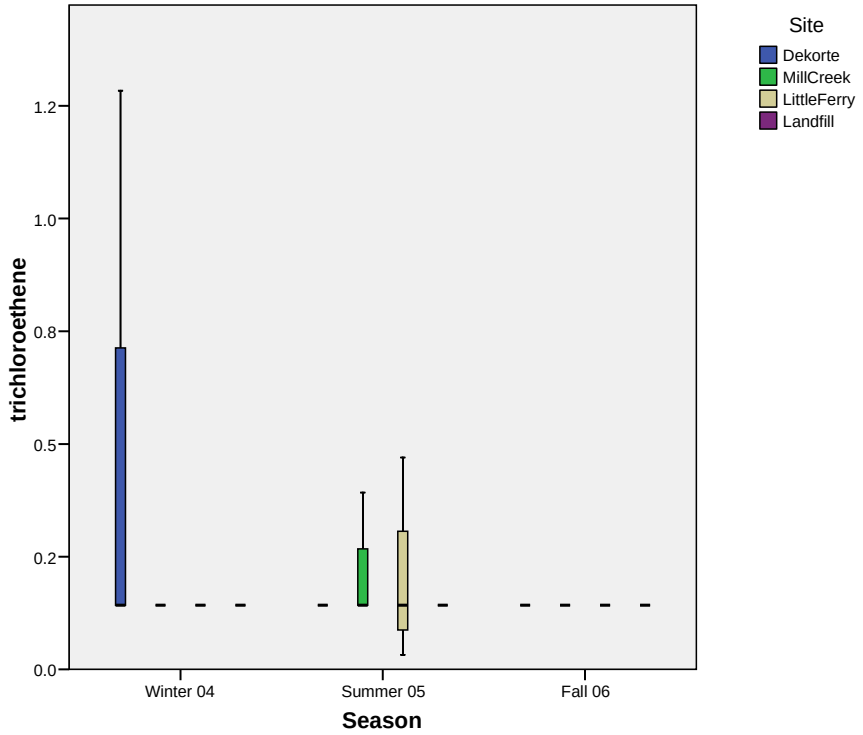


Figure 124. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of Trichloroethene by Sampling Time and Trail Location during Intensive Sampling Program.

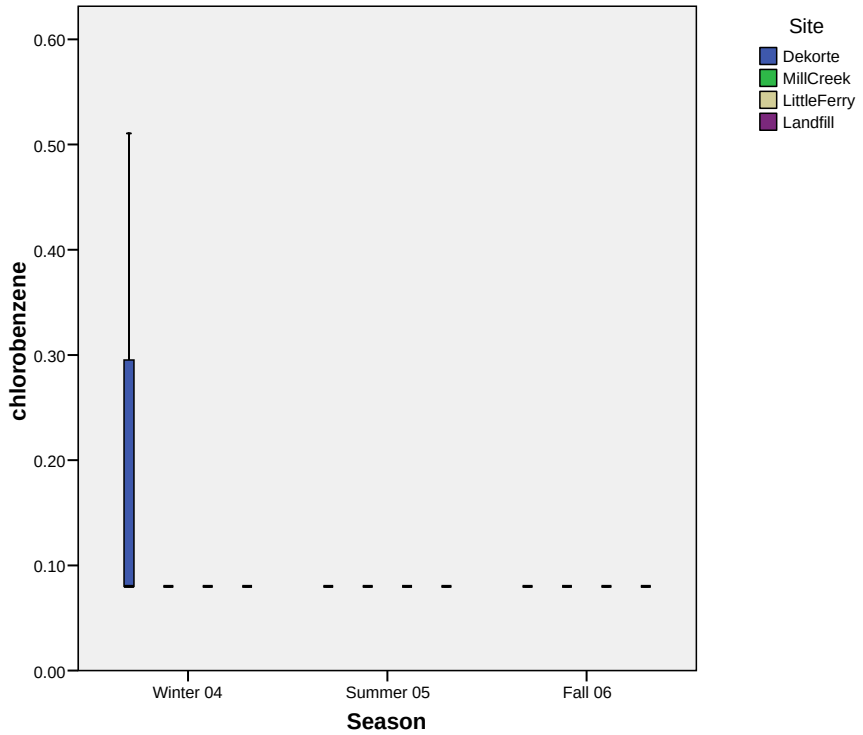


Figure 125. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of Chlorobenzene by Sampling Time and Trail Location during Intensive Sampling Program.

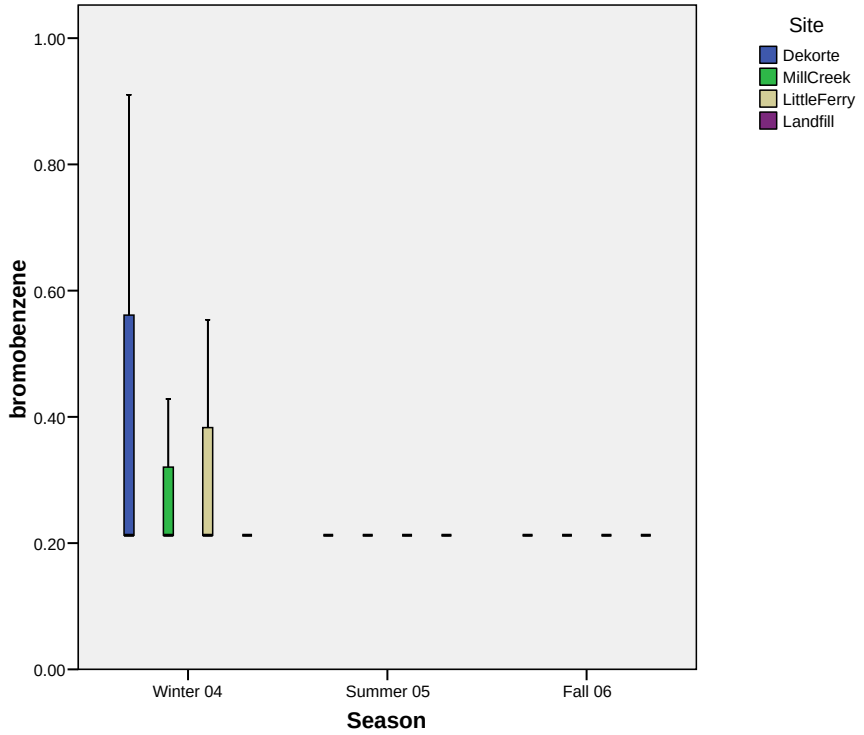


Figure 126. Box and Whisker Plot of the Mean Air concentration (µg/m^3) of Bromobenzene by Sampling Time and Trail Location during Intensive Sampling Program.

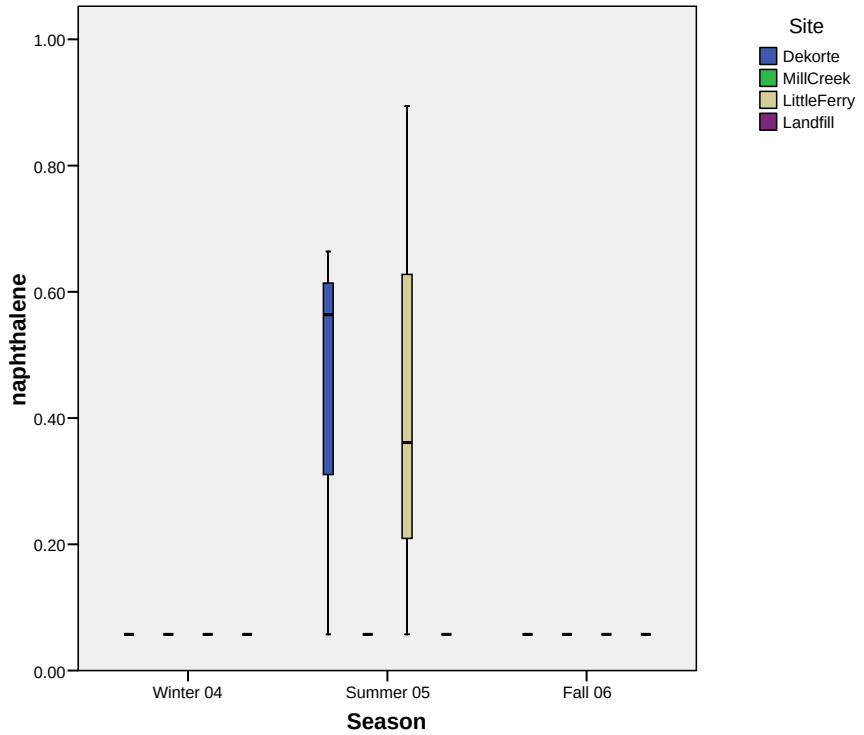
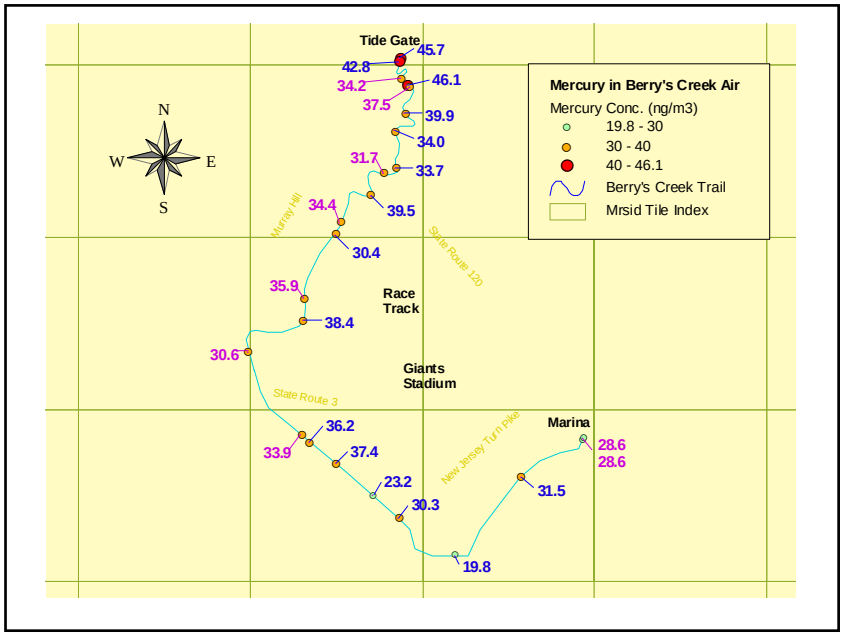


Figure 127. Box and Whisker Plot of the Mean Air concentration (µg/m3) of Naphthalene by Sampling Time and Trail Location during Intensive Sampling Program.



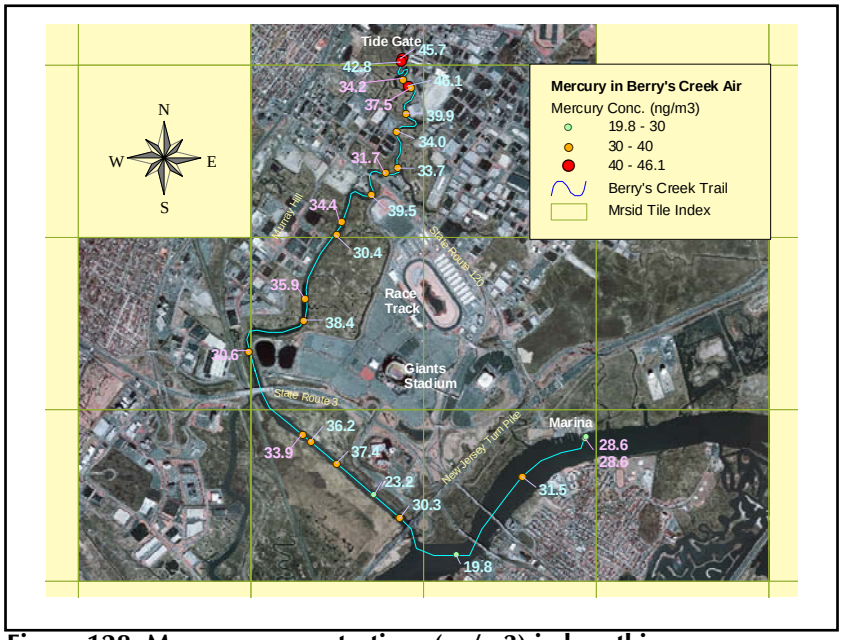


Figure 128. Mercury concentrations (ng/m3) in breathing zone measured on the Berry's Creek boat trail on July 21, 2005, 10:50 - 13:00. Blue numbers are Hg readings of trip from marina to tide gate, and purple numbers are readings of return trip from tide gate to marina; bottom image shows same concentrations overlaid on an aerial image of the location (aerial data from NJDEP)

1.5 Comparison of Intensive and Long Term VOC Concentrations

The samples collected for VOC during the intensive and long term sampling programs had a number of major differences: the collection techniques; the duration of sampling; the long term samples were collected every 6th day throughout the year while the intensive samples were collected over a few week period in different seasons; and the long term samples were at fixed sites while the intensive samplers were personnel monitors worn by individuals walking on trails. The intensive samples were collected on adsorbent traps using an active sampling approach with subsequent thermal desorption. The long term samples were collected using a passive sampling badge with solvent extraction. Both were analyzed with GC/MS. Comparison of active and passive methods have shown that overall there is good agreement between the two methods, within 20%, though individual compounds may have some greater bias (Jia et al., 2007). The shorter sample duration (~2 hours vs 48 hours) used for the intensive samples likely will result in more extremes in concentrations as longer sampling times tend to average out concentrations. The intensive samples were also collected during the daytime period, some during the weekday and some weekend days. Emission rates from mobile sources and most commercial or industrial sources are higher during the daytime hours than at night since cars are driven more during the day than at night and activities at commercial and industrial facilities are greater. Some of the intensive sampling time period overlapped with peak rush hour traffic, time periods of highest mobile source emissions. Thus, higher concentrations would be expected for the intensive samples than the long term samples, particularly for compounds emitted from mobile sources. The affect of the location of the samples on the concentration is harder to predict. Rather these two approaches represent complementary sampling designs with the intensive samples collected to evaluate actual exposure to individuals using the Meadowland Trails for recreational processes or near the home of residents while the long-term samples provides a robust evaluation of the baseline levels of air concentrations within the Meadowland region for future comparison as the region is developed.

A comparison of the aromatic compounds collected by the two sampling methods generally show that the mean concentrations were two to three times higher for the intensive sampling method while the median concentrations were closer, though still higher, than the long-term samples (Table 10 and Table 33). The chlorinated compounds were below detections in many of the samples collected by both methods and for the concentration that were above detection were closer, with the long term samples being somewhat higher than the intensive samples for some compounds by ~50% (for tetrachloroethlyene, carbon tetrachloride, 1,4 dichlorobenzene and trichloroethylene). Other compounds that were present in just a few samples: chloroform, 111 trichloroethane, methylene chloride, bromobenzene and 1,2 dichlorobenzene, were higher in the intensive samples. The higher mean levels of the aromatic compounds in the intensive samples reflect the shorter duration and the time of day the samples were collected as discussed above. It is also consistent with the typical observation that central site monitoring underestimates personal exposure, though those studies look at full exposure including indoor sources which are not relevant in this study (Ozkaynak et al., 2008). The smaller differences for the chlorinated compounds probably reflect the fewer sources in the immediate area of these compounds so in both cases more of a regional concentration was being examined.

As discussed in the individual sections describing each set of samples, the actual concentration for both the intensive and long term samples are consistent with other measurements made in New Jersey and the exposures and the results from these two sets of samples provide assurances about the exposure in the Meadowlands and the necessary information to interpret the impact of development on the area on both the background concentrations in the area as a whole and the levels that individuals using the hiking trail in the Meadowlands would be exposed to.

1.6 Overall Summary and Conclusions for the Field Sampling

- Baseline air concentrations were determined in the ambient air of the Meadowlands for $PM_{2.5}$ mass, organic and element carbon, and a suite of hazardous air pollutants that included particulate metals and volatile organic compounds. Baseline air concentrations for volatile organic compounds were also determined along hiking trails. These baseline air concentrations can be used for evaluating how future development of the Meadowlands might positively or adversely affect the air quality in the region and potential exposures to residents living near or individuals using the resources of the area.
- For most species, the air concentrations at the ambient sites were consistently lower than levels measured outside homes in Elizabeth, NJ, an urban center in NJ, and within upper portion of the range measured at NJDEP monitoring sites at different locations in the state, for those pollutant for which comparison data are available. The results suggest that for most air pollutants the current air quality in the Meadowlands reflects the general background for northern/central eastern NJ, though some individual exceptions were identified.
- The VOC air concentrations measured along the trails in the Meadowlands for aromatic compounds and some halogenated hydrocarbons were generally elevated compared to the fixed site samples, closer to the concentrations present in Elizabeth, NJ. The higher concentration on the trails is likely due to those samples being collected for only two to three hours during the day when there are more emissions, particularly from automobiles and trucks along the New Jersey Turnpike, compared to emissions and air concentrations at night. The ambient samples were 48 hour average values. Thus, VOC exposures to individuals using the Meadowlands for recreational purposes are similar to what the average concentration in urban centers due to the proximity of the daytime emissions in the area.

2 MODELING COMPONENTS

P.G. Georgopoulos, Team Leader

2.1 Introduction – Objectives and Background

2.1.1 Objectives

The objective of the modeling[1] component of the Meadowlands project was to simulate and define the baseline ambient air quality in the vicinity of the Meadowlands District. This was accomplished using various available emissions, land-use, and meteorological, etc. databases, along with the results of the field measurement study. Further, the efforts were made to demonstrate how the modeling analysis can be employed prospectively to assess future contributions based upon the anticipated "end-states", i.e. conditions corresponding to implementation of development plans, projected for the District. The report provides a description of the completed modeling analysis, focusing on the implementation of local-scale dispersion modeling and model performance evaluation using data collected from the field measurements.

2.1.2 Specific Aims

The specific aims of the modeling study were:

- To model local and regional specific air toxics emissions impacting the Meadowlands District
- To model air quality in the Meadowlands District identifying contributions from different types of local and regional sources
- To evaluate emissions and dispersion modeling using field data for specific compounds and refine an air quality modeling system for the Meadowlands District.

2.1.3 Background - The Meadowlands District Region

The NJ Meadowlands District (geographic center: 40.79°N, 74.07°W) is a mixed-use district that includes land-use categories that span from wetlands, commercial, industrial, residential, and transportation use. This district is physically continuous with other cities in the region (see map in Figure 129). Within and in communities adjacent to the Meadowlands District, there is a multitude of ambient air toxic sources including industrial emission sources from an industrial complex and an incinerator, numerous commercial sources (e.g., gasoline stations, dry cleaners, refinishing shops, and small factories), and mobile sources (cars and trucks) from a number of congested local streets and major highways going through the community. A local airport, the Teterboro airport, is located within the Meadowlands District, and a major New York metropolitan area airport, the Newark International Airport, is about seven miles to the south of the Meadowlands District.

2.1.4 Modeling study attributes

<u>Emission sources and their modeling domain</u>

The emission sources included in the ambient air quality modeling for a region within a 25 km radius of the centroid of the Meadowlands District (this zone is highlighted in Figure 129). The

[1] As per Table 1, modeling (utilizing emissions estimates and atmospheric dispersion calculations) and air monitoring are complementary activities, and both are generally needed to assess an environmental problem. In this case modeling is used to provide a consistent framework for analyzing air quality issues in the Meadowlands District; this framework can be utilized and expanded in future modeling and monitoring studies.

emission source categories include area, mobile, non-road[2], point, aircraft emissions, and landfill emissions.

Receptor modeling domain

The area covered is within a 10 km radius from the geographic center of the Meadowlands District (this zone is highlighted in Figure 129).

Modeling time period

The modeling time period is selected to match the time period of the long-term air sampling study (results in previous section) from March 17th, 2005 to March 13th, 2007.

Air toxics considered in the modeling study

Target air toxics[3] modeled, including both volatile organic compounds and heavy metals, are identified as follows: Benzene, Toluene, Ethylbenzene, Xylenes, Trichloroethylene (TCE), Tetrachloroethylene (PERC), 1,4-Dichlorobenzene (PDB), Arsenic, Lead, and Mercury. CAS numbers and toxicological properties of these air toxics are listed in Table 37.

[2] The non-road mobile sources include aircraft, commercial marine vessels, locomotives, and other non-road engines (USEPA, 2007)

[3] The initial set of target air toxics considered the following chemicals: Benzene, Formaldehyde, TCE, PERC, Arsenic, Lead, and Mercury. This list of target air toxics was modified by adding Toluene, Ethylbenzene, Xylenes, 1,4-Dichlorobenzene and removing Formaldehyde, which was not measured in the field study.

Table 36. Air quality monitoring and emissions estimation combined with air dispersion modeling (these are complementary approaches) (adapted from Vanderbilt & Lowe, 2003)

Approach	Advantages	Disadvantages
Air Monitoring	• Can capture actual variability in ambient concentrations (with changes in emissions rates and meteorological conditions), with appropriate design and sufficient (temporal and spatial) data collection	• Provides information on concentrations only for specific averaging times and only at sampled locations • Data collection is expensive • Difficult to distinguish source contributions for common pollutants (i.e. benzene)
Emissions Estimation Combined with Air Transport/Fate Modeling	• Can predict concentrations for a wide range of locations and averaging times • Can isolate the contribution of specific emissions sources to ambient concentrations – useful in evaluating/designing mitigation measures	• Uncertainties in emissions estimates and meteorological features create uncertainties in modeled concentrations in air • Provides an extremely large volume of results which can be difficult to make comprehensible for decision-makers

2.2 Approach and Methods[4]

The main focus of the analysis was a systematic evaluation and refinement of emissions used for an air quality modeling system defined for the Meadowlands District. The performance of the modeling system was tested by completing comparison with field data results discussed in Section 1 of this report. The steps used for the local-scale air quality dispersion modeling application are briefly reviewed. The approach to refining the emissions (for mobile on-road sources) and the model performance evaluation procedures of calculating quantitative performance metrics are described in detail in the following sections.

2.2.1 Estimation of background levels of air toxics

The background levels of the ten air toxics were estimated using the simulation results from the 1999 NATA study for the census tracts associated with our four field sampling sites. The background values are shown in Table 38. There is no information available on the background values for six selected of the air toxic, i.e. Toluene, Ethylbenzene, 1,4-Dichlorobenzene, As, Pb, and Hg, in the 1999 NATA study.

2.2.2 Preprocessing of emission inventories for use in local-scale air quality models

All of the source categories (including point, area, mobile on-road, and mobile non-road emissions) data were extracted from the 2002 National Emissions Inventory (NEI-2002) (USEPA, 2006b) for the ten selected air toxics according to the emission modeling domain shown in Figure 129. The NEI-2002 data were processed through the Emissions Modeling System for Hazardous Air Pollutants Version 3 (EMS-HAPv3.0) (Strum et al., 2004) for fine-scale spatial and temporal allocations that are necessary for the dispersion modeling to simulate their impacts in neighborhood-scale associated with the Meadowlands District.

2.2.2.1 <u>Refinement of spatial allocation for mobile on-road emissions</u>

The county total emissions, including mobile and area emissions, were initially spatially apportioned into the census tracts within each county based on the default spatial allocation factors

[4] A more detailed description of modeling approaches and methods is provided in Appendix B.

in EMS-HAP. These factors were derived from data on the geographic distributions of various spatial surrogates, which have similar geographic variations to the emissions from various source categories. Mobile on-road emissions were allocated into census tracts using the default Spatial Allocation Factors (SAFs) developed from geographic distribution of roadway miles.

The studies of Pratt et al., 2004 and Cohen et al., 2005 recommended treating mobile sources on major roadways as line sources rather than area sources distributed at census tracts for better characterization of the impact of mobile on-road emissions on the nearby receptor location. Therefore, in addition to the spatial allocation of the county level mobile on-road emissions into census tracts (the standard default approach), these emissions were also allocated to roadway links to provide an improved spatial allocation.

There were three major refinements made to create a newly developed SAFs for use with mobile source emissions which were more appropriate for the Meadowlands District. First, the new SAFs provided recently updated information of roadway locations in the vicinity of the Meadowlands District (see Figure 130). The default SAFs for mobile on-road emissions in EMS-HAP were developed from the TIGER (Topologically Integrated Geographic Encoding and Referencing) 2000 Census Feature Class Code (CFCC) roadway database (USCB, 2004), which was relatively out-dated (see Figure 131). In contrast, the new SAFs were based on the NJDOT 2007 FCC roadway database (NJDOT, 2007), which has the most recent updated information of roadway locations. Further, the default SAFs do not take into account the impact of local traffic volumes on the source strengths of mobile on-road emissions. The new SAFs incorporated the spatial variability of local traffic volumes through the approach of using the surrogate of population density to adjust the magnitudes of mobile on-road emissions locally. The most important aspect of the new SAFs was that they allocated the mobile on-road emissions to the road segments instead of the census tract centroids, which were the case for the default SAFs. These SAFs are a valuable tool for defining contributions to mobile source emissions in the Meadowlands District since the contributors and the location of mobile sources (new roads) will change with future development.

2.2.3 Preprocessing of local meteorology information

Important meteorological variables for atmospheric dispersion modeling include hourly surface data such as wind speed, wind direction, and temperature, as well as the upper air data such as mixing height and upper air soundings. The hourly surface meteorological data were taken from both the Newark Airport and the MERI meteorological station. The upper air data were downloaded from the NOAA's READY and ROAB databases. These data were processed through the meteorological preprocessors of PCRAMMET (USEPA, 1999) and AERMET (USEPA, 2004a) to generate the meteorological inputs for ISCST3 and AERMOD, respectively. Figure 132 presented the wind rose plot of the Newark Airport meteorological data for the modeling period from March 17th, 2005 to March 13th, 2007.

2.2.4 Applications of local-scale air quality models

Both the ISCST3 (USEPA, 1995) and AERMOD (USEPA, 2004b) models were used to calculate ambient concentrations of the ten selected air toxics at the four receptor locations, corresponding to the four field sampling sites. Three sets of sensitivity simulations of local-scale dispersion modeling were conducted identified the best modeling options for the model performance evaluations with the actual Meadowlands field measurements:

- The first set was conducted for 6 air toxics (Benzene, PERC, TCE, As, Pb, and Hg) for the time period of March 17th, 2005 to November 6th, 2005 (the first year of field measurements) with the 8 combinations of modeling options (listed in Table 39) with respect to the choices of dispersion models (ISCST3 vs. AERMOD), emissions inputs (NEI-1999 vs. NEI-2002), and meteorology inputs (Newark Airport vs. MERI).

- The second set was designed to reveal the impact of using the new spatial allocation factors (SAFs) of mobile on-road emissions on the predicted ambient concentrations of the 4 mobile source related air toxics benzene, toluene, ethylbenzene, and xylenes. The emission inputs of NEI-2002 and the meteorology inputs of Newark Airport data were used. The simulations were conducted for the time period of March 17th, 2005 to March 13th, 2007 (included the entire two year period of field measurement) with the 6 combinations of modeling options (listed in Table 40).
- The third set was designed to characterize the impact of using the two different meteorology inputs (Newark Airport data vs. MERI data) for the time period from June 10, 2006 to March 13, 2007, where the MERI meteorological data were more reliable.

2.2.5 Evaluating performance of local-scale air quality modeling

The hourly predictions made using the ISCST3 and AERMOD models were processed to generate the 48-hour average ambient concentrations of the ten air toxics. These were then matched in space and time with the actual field measurements, reported in the previous section, obtained over the 2 year sampling period. The performance of both ISCST3 and AERMOD modeling were evaluated by both the graphical forms (through time-series plots and box-plots of model-to-measurement ratios) and the quantitative model performance metrics. These metrics include mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error (MFE). The definitions of these 6 metrics were given as follows:

$$MB = \frac{1}{N}\sum_{1}^{N}(Cm - Co) \qquad (1)$$

$$ME = \frac{1}{N}\sum_{1}^{N}\left|Cm - Co\right| \qquad (2)$$

$$MNB = \frac{1}{N}\sum_{1}^{N}\left(\frac{Cm - Co}{Co}\right) \qquad (3)$$

$$MNE = \frac{1}{N}\sum_{1}^{N}\left|\frac{Cm - Co}{Co}\right| \qquad (4)$$

$$MFB = \frac{1}{N}\sum_{1}^{N}\frac{(Cm - Co)}{\left(\frac{Cm + Co}{2}\right)} \qquad (5)$$

$$MFE = \frac{1}{N}\sum_{1}^{N}\frac{|\,Cm - Co\,|}{\left(\frac{Cm + Co}{2}\right)} \qquad (6)$$

where N is the number of measurements, Cm is the modeled concentration, and Co is the measured concentration.

Mean bias provides the direction of model predictions (i.e. positive for overestimation and negative for underestimation of concentrations). Mean error provides the magnitude of deviation of the model predictions from the field measurements. However, both mean bias and mean error are sensitive to outliers. Further, comparing mean bias and mean error across different chemicals is difficult for providing useful information of model performance, since the measured concentrations of different chemicals have different magnitudes which affect the magnitudes of mean bias and mean error.

Mean normalized bias provides the direction of model predictions as mean bias, but can overcome the difficulty of different measurement scales through normalization. Mean normalized bias needs to be used with caution; however, since bias can be positive or negative, averaging positive bias and negative bias would result in a seemingly good agreement with measurements. Thus, mean normalized bias can only show how far the overall trend of the modeled concentrations differs from the observed concentrations. For the factor of 2 agreement between model predictions and measurements, the mean normalized bias will be in the range from +100% to -50%. Mean normalized error is better metric of model performance than mean normalized error for representing the average deviation of model predictions from measurements. Therefore, the combination of both metrics (mean normalized error and mean normalized bias) will provide better evaluation of model performance.

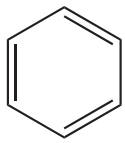
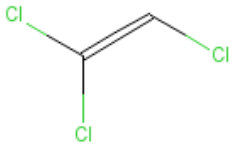
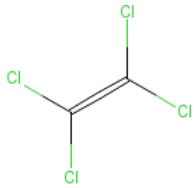
Fractional bias and fractional error are introduced to incorporate the uncertainty of measurements. The bias and error are normalized by the average of measured concentrations and modeled concentrations. The range of fractional bias is between -2 (extreme underestimation) to +2(extreme overestimation). For the factor of 2 agreement between model predictions and measurements, fractional bias will be in the range from +0.67 to -0.67, an EPA criterion for acceptance (USEPA, 1992).

2.2.6 Geodatabase development

Geo-databases of local and regional emissions and aerometric information utilizing existing inventories and standard modeling approaches were developed to facilitate the investigation and quantification of baseline ambient air quality in the vicinity of the Meadowlands District. Databases from the following sources were included: NTI (1996), NEI (1999, 2002), TRI (2002, 2003), HazDat (2003), CERCLIS, KCS-NJ (2001), NWS, ASOS, AQS, NJDEP, MERI operations and meteorological data[5].

[5] The detailed results of the geodatabases development are presented in Appendix C.

Table 37. Final set of air toxics considered in this study

			Chronic Inhalation				
			Non-Cancer		Cancer		
VOCs							
Chemical Name	**CAS #**	**Structure/ Formula**	**µg/m³**	**Source**	**EPA WOE**	**1/(µg/m³)**	**Source**
Benzene	71-43-2	C_6H_6 	30.0	IRIS	CH	0.13	IRIS
Toluene	108883		400.0	IRIS	D		
Ethylbenzene	100414		1000.0	IRIS	D		
Xylenes (mixed)	1330207		100.0	IRIS			
Trichloroethylene (TCE)	79-01-6	C_2HCl_3 	600.00	CAL	B2-C	0.5	CAL
Tetrachloroethylene (Perc)	127-18-4	C_2Cl_4 	35.0	CAL	B2-C	0.17	CAL
p-Dichlorobenzene	106467		800.0	IRIS	C	0.000011	CAL
Metals							
Arsenic	7440-38-2	As	0.03	CAL	A	0.00023	IRIS
Lead	7439-92-1	Pb	--	--	B2	0.083	CAL
Mercury	7439-97-6	Hg	0.3	IRIS	D	--	--

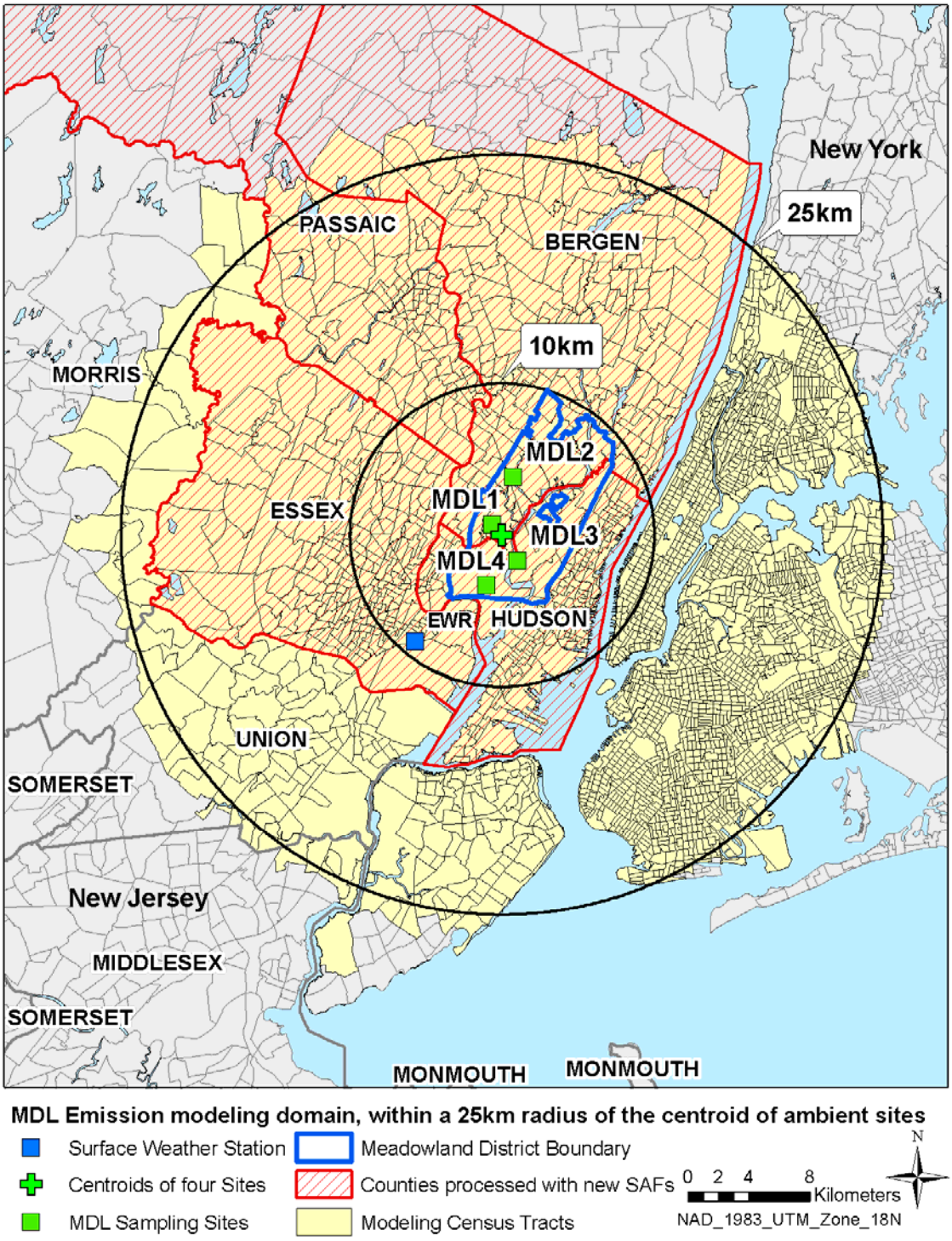


Figure 129. Area considered for emissions and dispersion modeling in assessing air toxics contamination in Meadowlands District

Table 38. Background concentrations (ug/m3) of the ten selected air toxics at the four receptor locations obtained from the 1999 NATA study (USEPA, 2006a).

chemical	MDL1	MDL2	MDL3	MDL4
Benzene	0.44	0.44	0.48	0.48
Toluene	0.00	0.00	0.00	0.00
Ethylbenzene	0.00	0.00	0.00	0.00
Xylenes	0.17	0.17	0.17	0.17
Tetrachloroethene	0.14	0.14	0.17	0.17
Trichloroethene	0.07	0.07	0.08	0.08
p-Dichlorobenzene	0.00	0.00	0.00	0.00
Arsenic (fine PM)	0.00	0.00	0.00	0.00
Mercury (fine PM)	0.00	0.00	0.00	0.00
Lead (fine PM)	0.00	0.00	0.00	0.00

Table 39. The 1st set of sensitivity simulations with 8 different combinations of dispersion models, emissions inputs, and meteorology inputs.

RunID	Dispersion model	Emission inputs	Meteorology inputs
ISCST3[1]	ISCST3	NEI-1999	Newark Airport
ISCST3[2]	ISCST3	NEI-1999	MERI station
ISCST3[3]	ISCST3	NEI-2002	Newark Airport
ISCST3[4]	ISCST3	NEI-2002	MERI station
AERMOD[1]	AERMOD	NEI-1999	Newark Airport
AERMOD[2]	AERMOD	NEI-1999	MERI station
AERMOD[3]	AERMOD	NEI-2002	Newark Airport
AERMOD[4]	AERMOD	NEI-2002	MERI station

Table 40. The 2nd set of sensitivity simulations for testing the sensitivity of using the mobile on-road emissions processed by different spatial allocation factors (Emission inputs: NEI-2002, Meteorology inputs: Newark Airport).

RunID	Dispersion model	SAFs	SAF attribute
I-TR	ISCST3	census tract-based	default
I-LKTR	ISCST3	road link-based	improved source strength only
I-LKRD	ISCST3	road link-based	improved source strength and location
A-TR	AERMOD	census tract-based	default
A-LKTR	AERMOD	road link-based	improved source strength only
A-LKRD	AERMOD	road link-based	improved source strength and location

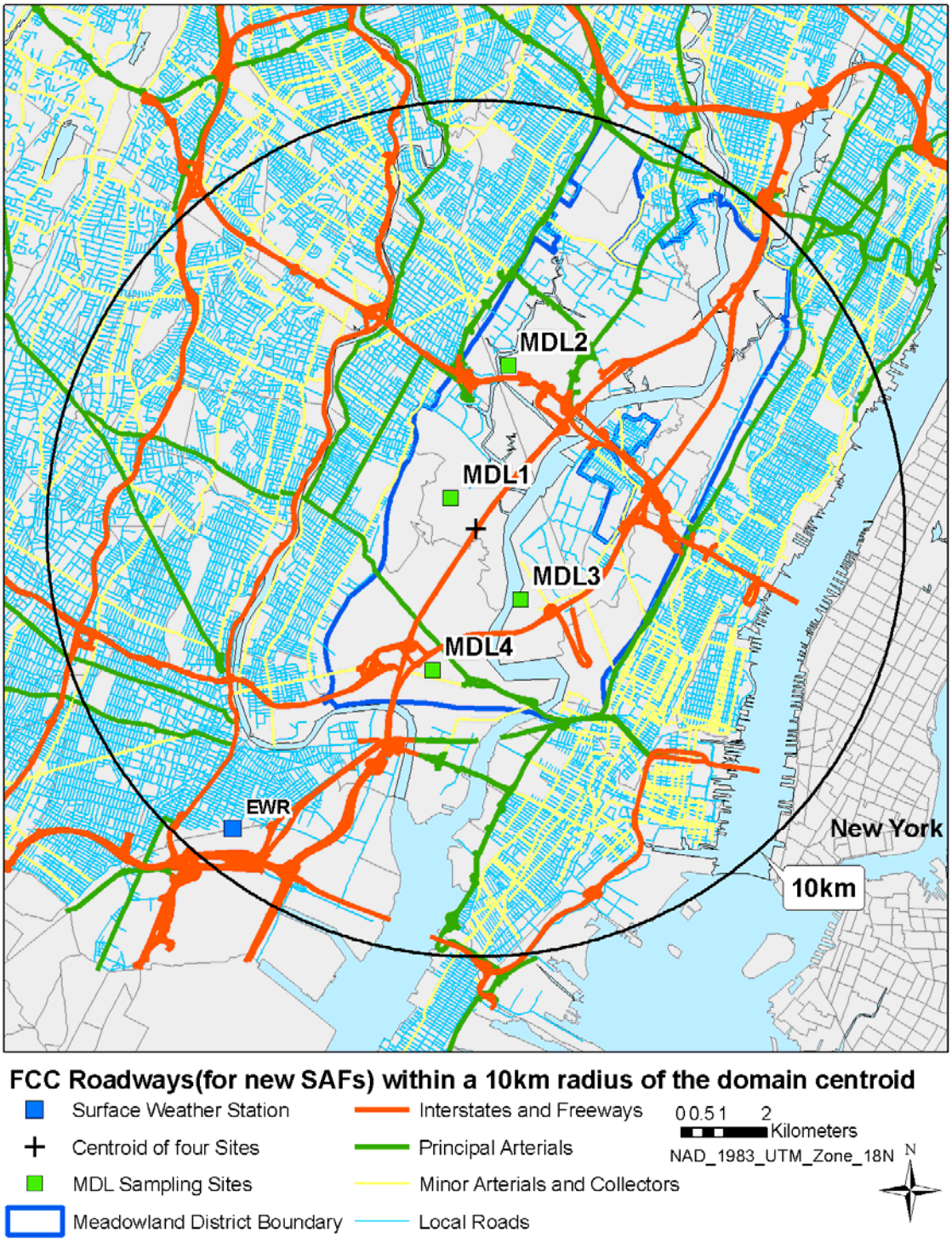


Figure 130. Geographic distributions of roadways within the 10km radius of the Meadowlands District used for developing the new spatial allocation factors (SAFs) based on the NJ-DOT 2007 FCC database (NJDOT, 2007).

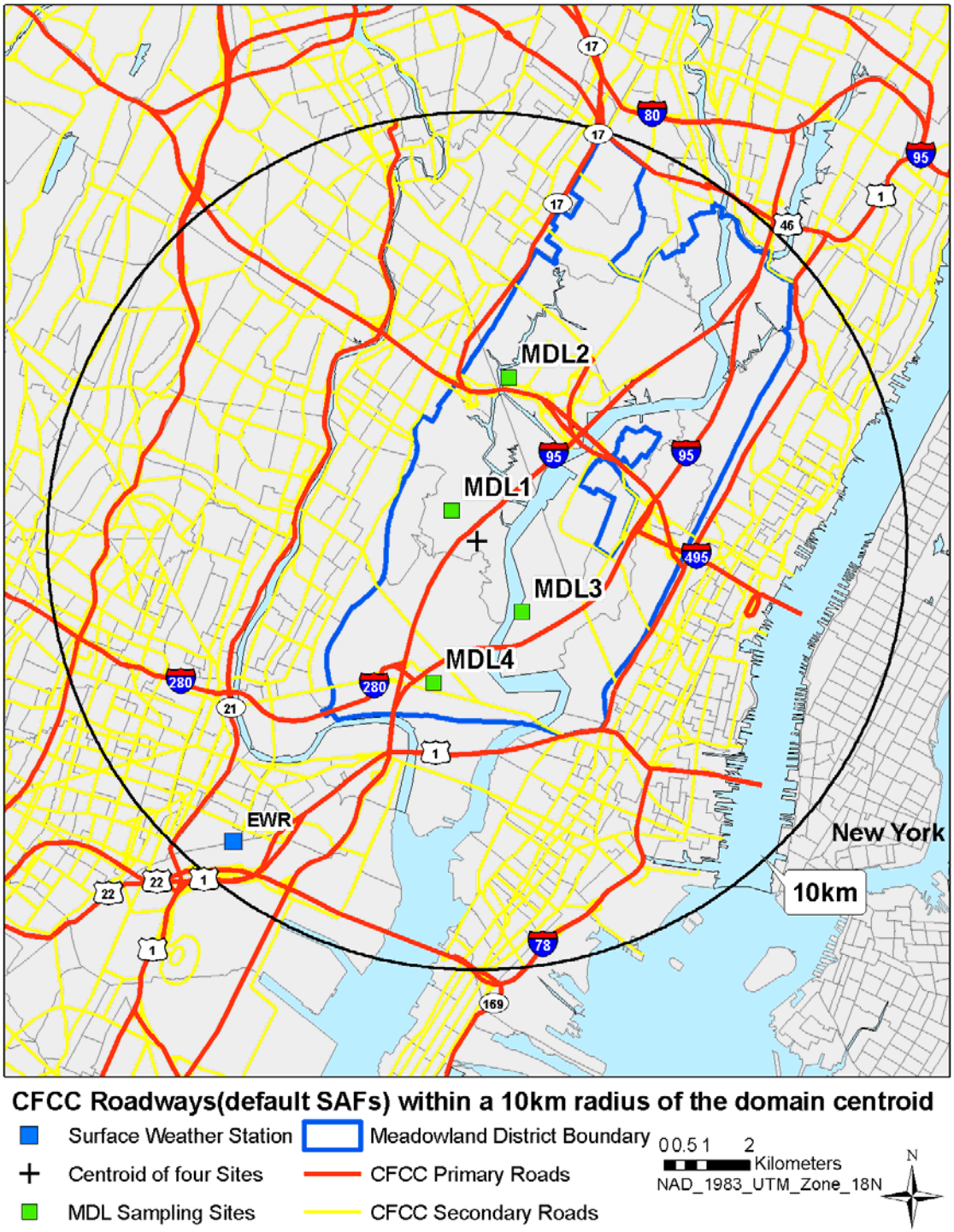


Figure 131. Geographic distributions of roadways within the 10km radius of the Meadowlands District used for developing the default spatial allocation factors (SAFs) based on the TIGER 2000 CFCC database (USCB, 2004).

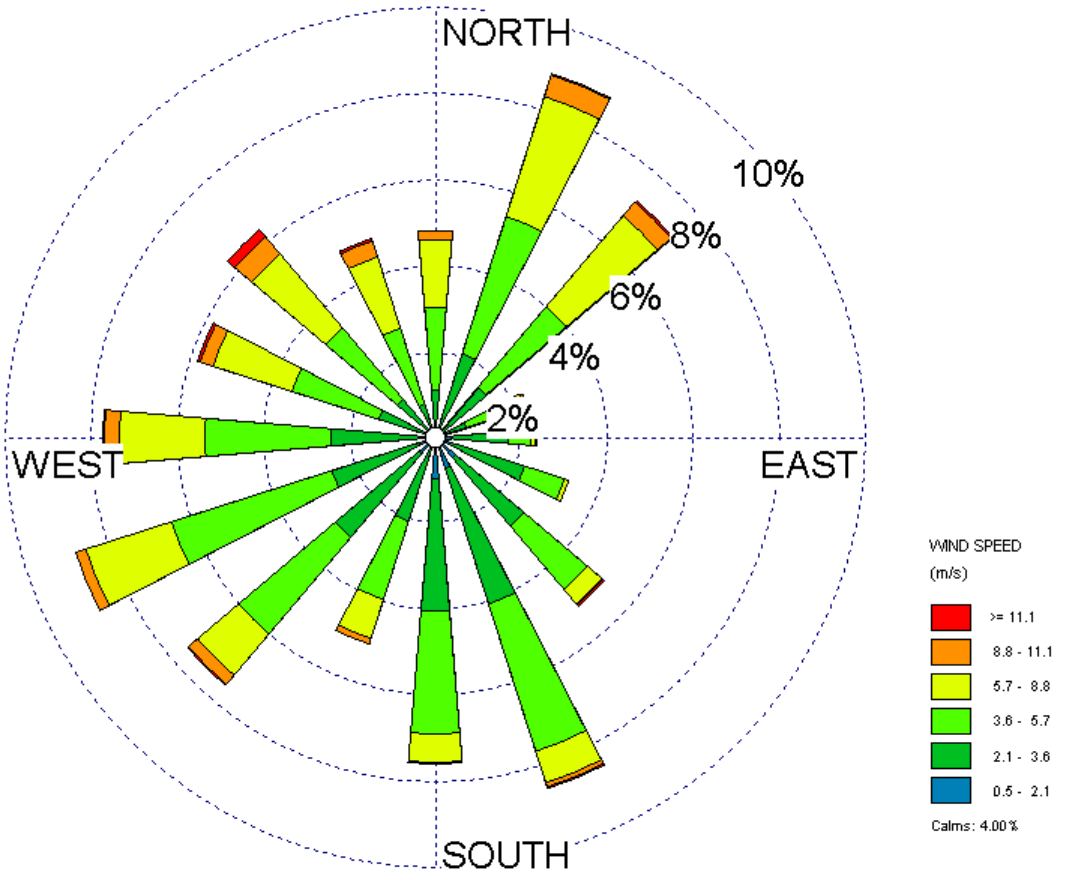


Figure 132. Wind rose plot for the modeling period from March 17th, 2005 to March 13th, 2007 based on the meteorological data from Newark Airport (WBAN: 14734). The direction of winds shown is the direction from which the wind is blowing.

2.3 Results and Discussion

2.3.1 Results of local-scale dispersion modeling

The results obtained after the implementation of local-scale air quality modeling are presented in three parts:

- emission modeling,
- model performance evaluation results of the dispersion modeling, and
- source contribution analyses.

2.3.1.1 Emission modeling

The extracted NEI-2002 emissions were processed through the EMS-HAP program for fine-scale spatial and temporal allocations of emissions. The EMS-HAP emission modeling results for NEI-2002 are presented in Appendix D for the 6 selected air toxics (Benzene, PERC, TCE, As, Pb, and Hg). The landfill emission modeling in the Meadowlands District was conducted to provide the adjustment factors for the landfill emissions in the NEI-1999 data. However, based on our preliminary modeling analyses, this landfill emission adjustment had very minor impact on the modeled concentrations of the selected air toxics in the Meadowlands District[6]. Therefore, the landfill emission adjustment was not performed on the NEI-2002 data.

2.3.1.1.1 Mobile on-road emission refinement

The geographical distributions of the annual Benzene mobile on-road emissions processed by both the default SAFs and the new SAFs were presented in Figure 133, Figure 134, Figure 135, and Figure 136, respectively for the following roadway categories: (a) interstates and expressways, (b) principal arterials, (c) minor arterials, and (d) local roads. In general, the geographical distributions of Benzene mobile on-road emissions estimated by the new SAFs showed better alignment with the actual roadway locations than those estimated by the default SAFs. The default SAFs incorrectly allocated mobile on-road emissions into some census tracts, which do not contain any road segments in that category. This trend was typical for the other chemicals, and indicated the improvement that can be obtained from scale allocation of emission estimates.

The differences of mobile on-road emissions processed by the new SAFs and the default SAFs were presented in Figure 137, Figure 138, Figure 139, and Figure 140, respectively for Benzene, Toluene, Ethylbenzene, and Xylenes for the census tracts within a 25km radius of the Meadowlands District. In general, the default SAFs tended to overestimate the mobile on-road emissions in the census tracts located within the Meadowlands District, which are also close to the interstates and the expressways. Possible reasons of the overestimation include: (a) out-dated roadway mileages in the default SAFs, (b) improper grouping of roadway categories, and (c) assuming uniform traffic volumes. Thus, the new developed SAFs for mobile on-road emissions improved the emissions estimates.

2.3.1.2 Results of model performance evaluation of the dispersion modeling

Three sets of sensitivity simulations were completed to identify the best modeling options with respect to available modeling inputs of the dispersion modeling. The 1st set of sensitivity simulations indicated that the combination of the NEI-2002 emissions and the Newark Airport meteorology provided better model performances for both the ISCST3 and AERMOD predictions[7]. The 2nd set was then conducted by using this modeling option to reveal the impact of the further

[6] The detailed results of the landfill emission modeling are presented in Appendix D.
[7] The detailed results of the 1st set of sensitivity runs are presented in Appendix E.

refinement of mobile on-road emissions on the model predictions for the benzene, toluene, ethylbenzene, and xylenes chemicals. The 3rd set was conducted to characterize the impact of the two different meteorology datasets on the model predictions for the time period of June 10, 2006 to March 13, 2007, which was not covered in the 1st set of sensitivity runs.

The model performance evaluation results were organized by three parts: (a) the mobile source related air toxics (i.e. the BTEX chemicals), which incorporated the results from the 2nd set of sensitivity runs, (b) the selected air toxics that are not mobile source related (i.e. the three chlorinated chemicals (PERC, TCE, PDB) and the three metal species (As, Pb and Hg)), and (c) the results of sensitivity simulations with respect to the meteorology inputs (i.e. the 3rd set of sensitivity runs). Comparisons of the time-series profiles of model predictions with field measurements of the ten air toxics were presented in Appendix F.

2.3.1.2.1 Results of model performance evaluations for the BTEX chemicals

The main focus of the BTEX evaluations were to examine the extent to which using the new spatial allocation factors for mobile on-road emissions could improve the predicted ambient concentrations in comparison with the measured values. Table 41 presented the results for the mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error (MFE)) calculated by comparing model predictions with measurement data from all 4 field sampling sites for the time period of March 17th, 2005 to March 13th, 2007. Graphical comparisons of MNB, MNE, MFB, and MFE were presented in Figure 141-Figure 144. The comparisons found:

- consistent trend for improved model performance with the refined link-based mobile on-road emissions across the BTEX chemicals.
- best model performance with the AERMOD predictions using the link-based mobile on-road emission inputs across the BTEX chemicals
- significant improvement using the link-based mobile on-road emissions in the ISCST3 simulations for benzene, which reduced the mean normalized bias (MNB) from 70.9% to 44.3% and the mean normalized error (MNE) from 82.2% to 61.2%.
- extent of improvement for toluene and xylenes, using the link-based versus the tract-based mobile on-road emissions was similar to benzene for the MNB metric.
- use of link-based mobile on-road emissions resulted in larger negative bias for ethylbenzene. However, the mean normalized error (MNE) metric still showed the improved model performances with a smaller positive value. The larger negative bias might be due to the bias resulted from uncertainties associated with emissions from other sources. This was revealed after the improvement of the mobile on-road emissions. The bias from uncertainties of other sources might have been compromised by the bias of using the tract-based mobile on-road emissions in the default approach.
- the model predictions of all the 6 modeling options were in agreement to within a factor of 2 with the ambient measurements of BTEX at the Meadowlands District long term monitoring.

Comparisons of the six model performance metrics among each of the 4 field sampling sites were presented in Table 42-Table 45 and Figure 145-Figure 148. The results were summarized below:

- the most significant improvements that came from using the link-based mobile on-road emissions was observed at the site MDL2 across the BTEX chemicals.
- use of link-based mobile on-road emissions for Ethylbenzene resulted in the bias metrics (MNB and MFB) hovering toward larger negative values that should not be translated into worse model performances, since there were reductions in the error metrics (MNE and MFE).

- extent of improvement in model performance using the link-based mobile on-road emissions was dependent on the proximity of the receptor (i.e. the field sampling sites) to major roadways. That was the main reason of most significant improvement of the MDL2 site estimates, which was due to its relatively close proximity to a major roadway, approximately 270 meters to New Jersey State Route 3.

2.3.1.2.2 Results of model performance evaluations for the chlorinated chemicals (PERC, TCE, and PDB) and the metal species (As, Pb, and Hg)

Model performance evaluations for the 3 chlorinated chemicals (i.e. TCE, PERC, and DCB) and the 3 metal species (As, Pb, and Hg) were conducted by comparing the model predictions of using the NEI-2002 emissions and the Newark Airport meteorological data and then comparing the results with the field measurements. The analyses included the time period of March 17th, 2005 to March 13th, 2007. Since emissions for these six chemicals were not from mobile (on-road and non-road) sources, the emission inputs of NEI-2002 were processed through the EMS-HAP program with the default census tract-based approach for mobile sources. The results of model performance evaluations are presented in Table 46-Table 48 and Figure 149-Figure 154, and are summarized below:

- Among the three chlorinated chemicals, PERC, TCE, and PDB, the performance of the model was best for PERC and poorest for PDB.
- The model predictions for all three chlorinated chemicals were generally within agreement by a factor of 2 with the field measurements.
- Among the 4 field sampling site receptors, the model performance was generally comparable to the field measurements across the three chlorinated chemicals (PERC, TCE, and PDB).
- Among the three metals As, Pb, and Hg, the model performance was best for Pb. The model predictions were generally in agreement with the field measurements within a factor of 2.
- For As the model predictions significantly under-estimated the field results, and for Hg there was agreement with the field measurements.
- The model performance between the two receptors (i.e. the 2 field sampling sites for metals: MDL1 and MDL2) were comparable to each other.

2.3.1.2.3 Results of model performance evaluations of the sensitivity simulations with respect to the meteorological inputs (MERI data vs. Newark Airport data)

In the 1st set of sensitivity runs, which was conducted for the modeling period from March 17, 2005 to November 6, 2005, the model performance was better for the model predictions using the Newark Airport data in comparison to the results obtained using the MERI data. It was then indicated by MERI personnel that "*The wind sensor measurements for the MERI station from January 2005 and up to June 2006 should be used with caution since a worn bearing in the sensor may have helped to produce erroneous data. Wind measurements starting June 9, 2006 are reliable.*" Therefore, the sensitivity simulations of using the two different meteorological inputs (MERI data vs. Newark Airport data) were conducted again for the modeling period from June 10, 2006 to March 13, 2007. The NEI-2002 data were used as the emission inputs and the dispersion model simulations were conducted for the BTEX chemicals.

It should be noted that the differences between the MERI data and the Newark Airport data were associated with the meteorological variables of wind speed, wind direction, and temperature. The other meteorological variables required by the dispersion models such as cloud cover, ceiling height, and so on were based on the data from Newark Airport (i.e. they were the same on both data sets), since the MERI meteorological data did not provide information for these variables.

The results of the second set of model performance evaluations are presented in Table 49 and Figure 155-Figure 156, and are summarized as follows:

- the model predictions based on the Newark Airport data had better model performances (i.e. smaller bias and error) than the predictions based on the MERI meteorological data across the BTEX chemicals.
- model predictions based on the MERI data had positive bias (i.e. overestimation) consistently across the BTEX chemicals, while the predictions based on the Newark Airport data had positive bias (i.e. overestimation) for Benzene and Toluene and negative bias (i.e. underestimation) for Ethylbenzene and Xylenes.
- model predictions based on both the Newark Airport data and MERI data were within the acceptable factor of 2 agreement with the measurements. Thus, either can be considered in future model applications for the Meadowlands District.

2.3.1.3 Results of source contribution analysis for assessing the impacts of local source emissions on the predicted ambient concentrations of air toxics

For assessing the impact of local ambient sources of air toxics on ambient levels in the Meadowlands District, we apportioned the contributions from ambient sources categorized by five emission groups (i.e. background, point, area, mobile on-road, and mobile non-road) using 48 hour averages of the AERMOD predictions of the BTEX chemicals. These AERMOD predictions were based on the best options of modeling inputs (i.e. the Newark Airport meteorological data and the NEI-2002 data with improved link-based mobile on-road emissions). The selection of BTEX chemicals for the source contribution analyses was mainly due to the fact that their ambient concentrations can be affected by all of the emission source categories (i.e. background, point, area, mobile on-road, and mobile non-road). In contrast, the ambient concentrations of the three chlorinated chemicals (PERC, TCE, and PDB) and the three metal species (As, Pb, and Hg) can only be affected by the point and area source emissions. Figure 157 presents an example of outputs obtained by averaging the source contribution analysis results conducted on the 5 selected sampled dates (9/7/2005, 1/11/2006, 2/16/2006, 3/12/2006, and 10/20/2006). The results were *typical* for other cases of sampled dates, and are summarized below:

- For benzene, the contributions from background were about 33% of the predicted values across the 4 receptor locations. Since benzene is a relatively inert chemical however, the contribution from long-range transport characterized by the background concentration is essential. The major contributors to ambient benzene levels from local emissions were mobile non-road sources (about 33%). This was followed by mobile on-road sources (about 17%) and non-point (area) sources (about15%) on average across the 4 receptors.
- For toluene, there was no contribution from background since it is a more reactive chemical. The major contributors to ambient toluene levels from local emissions were non-point (area) sources (about 43%), followed by mobile non-road sources (about 38%) and mobile on-road sources (about15%) on average across the 4 receptors.
- For ethylbenzene, there was no contribution from background. The major contributors from local emissions were mobile non-road sources (about 38%), followed by non-point (area) sources (about 32%) and mobile on-road sources (about25%) on average across the 4 receptors.
- For xylenes, there was relatively small contribution from background (about 6% on average). The major contributors from local emissions were non-point (area) sources (about 48%), followed by mobile non-road sources (about 25%) and mobile on-road sources (about19%) on average across the 4 receptors.

- The contributions from point sources were relatively small and negligible for the BTEX chemicals across the 4 receptor locations.

Table 41. Comparison of the model performance metrics (mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error (MFE)) of the 6 modeling scenarios in the 2nd set of sensitivity runs for the BTEX chemicals using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at all of the 4 receptor locations.

Chemical	Modeling Scenario[8]	Model Performance Metric					
		MB	ME	MNB	MNE	MFB	MFE
Benzene	I-TR	0.283	0.503	70.9%	82.2%	0.345	0.489
	I-LKTR	0.171	0.435	54.9%	69.3%	0.261	0.443
	I-LKRD	0.100	0.398	44.3%	61.2%	0.202	0.415
	A-TR	0.211	0.462	61.6%	74.9%	0.298	0.467
	A-LKTR	0.096	0.402	45.3%	62.5%	0.206	0.423
	A-LKRD	0.028	0.374	35.1%	55.2%	0.144	0.401
Toluene	I-TR	0.093	1.143	42.8%	67.0%	0.140	0.458
	I-LKTR	-0.214	1.055	25.0%	56.6%	0.018	0.436
	I-LKRD	-0.405	1.032	13.7%	51.3%	-0.068	0.433
	A-TR	-0.141	1.101	32.8%	63.0%	0.060	0.462
	A-LKTR	-0.456	1.066	14.2%	54.1%	-0.076	0.461
	A-LKRD	-0.639	1.078	3.2%	50.4%	-0.168	0.474
Ethylbenzene	I-TR	-0.157	0.296	14.1%	68.6%	-0.185	0.587
	I-LKTR	-0.205	0.304	-0.7%	64.1%	-0.308	0.625
	I-LKRD	-0.235	0.311	-10.9%	61.4%	-0.396	0.656
	A-TR	-0.201	0.293	1.9%	62.4%	-0.273	0.592
	A-LKTR	-0.251	0.308	-13.1%	59.6%	-0.412	0.645
	A-LKRD	-0.279	0.321	-22.8%	58.6%	-0.507	0.688
Xylenes	I-TR	0.217	1.070	48.8%	72.1%	0.194	0.502
	I-LKTR	0.037	1.000	36.0%	63.8%	0.110	0.481
	I-LKRD	-0.073	0.954	27.5%	58.3%	0.054	0.465
	A-TR	-0.018	0.991	35.7%	64.1%	0.107	0.487
	A-LKTR	-0.203	0.939	22.6%	56.5%	0.012	0.472
	A-LKRD	-0.309	0.914	14.3%	52.2%	-0.050	0.463

[8] The 6 modeling scenarios (i.e. the 2nd set of sensitivity runs) are described in details in Table 5.

Table 42. Comparison of the model performance metrics (mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error (MFE)) of the 6 modeling scenarios in the 2nd set of sensitivity runs for Benzene using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the 4 receptor locations.

Receptor Location	Modeling Scenario	Model Performance Metric					
		MB	ME	MNB	MNE	MFB	MFE
MDL1	I-TR	0.056	0.380	37.6%	55.8%	0.150	0.381
	I-LKTR	0.023	0.367	33.1%	52.7%	0.122	0.371
	I-LKRD	-0.010	0.360	28.7%	50.4%	0.090	0.366
	A-TR	-0.017	0.366	28.8%	50.6%	0.092	0.372
	A-LKTR	-0.053	0.357	24.0%	47.7%	0.059	0.364
	A-LKRD	-0.085	0.356	19.8%	46.0%	0.025	0.363
MDL2	I-TR	0.534	0.621	111.4%	115.5%	0.551	0.602
	I-LKTR	0.343	0.476	82.1%	89.4%	0.418	0.507
	I-LKRD	0.202	0.399	60.3%	72.7%	0.301	0.451
	A-TR	0.465	0.560	100.0%	104.8%	0.512	0.571
	A-LKTR	0.273	0.432	70.8%	80.1%	0.371	0.483
	A-LKRD	0.137	0.371	49.8%	65.0%	0.248	0.434
MDL3	I-TR	0.319	0.596	86.8%	98.9%	0.409	0.564
	I-LKTR	0.207	0.534	70.6%	85.7%	0.327	0.522
	I-LKRD	0.087	0.476	52.8%	72.1%	0.226	0.478
	A-TR	0.247	0.548	77.2%	90.6%	0.368	0.541
	A-LKTR	0.127	0.486	60.0%	77.0%	0.274	0.495
	A-LKRD	0.005	0.435	41.9%	63.9%	0.164	0.454
MDL4	I-TR	0.230	0.420	48.9%	59.7%	0.279	0.412
	I-LKTR	0.116	0.369	34.7%	50.1%	0.183	0.374
	I-LKRD	0.125	0.363	36.0%	50.1%	0.196	0.370
	A-TR	0.157	0.379	41.8%	54.6%	0.228	0.388
	A-LKTR	0.043	0.338	27.4%	45.7%	0.125	0.354
	A-LKRD	0.059	0.338	29.5%	46.4%	0.144	0.354

Table 43. Comparison of the model performance metrics (mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error (MFE)) of the 6 modeling scenarios in the 2nd set of sensitivity runs for Toluene using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the 4 receptor locations.

Receptor Location	Modeling Scenario	Model Performance Metric					
		MB	ME	MNB	MNE	MFB	MFE
MDL1	I-TR	-0.293	0.992	19.8%	53.9%	-0.010	0.440
	I-LKTR	-0.383	0.987	15.0%	52.1%	-0.049	0.443
	I-LKRD	-0.471	1.003	9.5%	50.6%	-0.094	0.452
	A-TR	-0.524	1.043	9.9%	52.6%	-0.101	0.477
	A-LKTR	-0.622	1.060	4.6%	51.4%	-0.148	0.486
	A-LKRD	-0.707	1.084	-0.7%	50.1%	-0.197	0.499
MDL2	I-TR	0.763	1.221	77.4%	88.4%	0.367	0.507
	I-LKTR	0.242	0.917	45.9%	63.8%	0.184	0.416
	I-LKRD	-0.139	0.833	21.9%	50.8%	0.012	0.390
	A-TR	0.544	1.046	66.7%	79.3%	0.305	0.467
	A-LKTR	0.021	0.857	34.7%	58.4%	0.107	0.411
	A-LKRD	-0.347	0.846	11.4%	49.0%	-0.074	0.420
MDL3	I-TR	0.169	1.203	44.5%	67.5%	0.170	0.461
	I-LKTR	-0.140	1.147	27.0%	58.2%	0.045	0.450
	I-LKRD	-0.460	1.134	8.3%	50.2%	-0.108	0.454
	A-TR	-0.071	1.145	36.1%	65.1%	0.093	0.465
	A-LKTR	-0.402	1.131	17.0%	56.7%	-0.052	0.474
	A-LKRD	-0.729	1.171	-2.5%	50.9%	-0.224	0.510
MDL4	I-TR	-0.268	1.160	29.4%	58.2%	0.033	0.422
	I-LKTR	-0.578	1.177	11.8%	52.4%	-0.109	0.438
	I-LKRD	-0.556	1.169	14.9%	53.4%	-0.086	0.437
	A-TR	-0.512	1.174	18.4%	54.9%	-0.055	0.439
	A-LKTR	-0.824	1.224	0.5%	50.3%	-0.212	0.472
	A-LKRD	-0.783	1.221	4.2%	51.5%	-0.180	0.469

Table 44. Comparison of the model performance metrics (mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error (MFE)) of the 6 modeling scenarios in the 2nd set of sensitivity runs for Ethylbenzene using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the 4 receptor locations.

Receptor Location	Modeling Scenario	Model Performance Metric					
		MB	ME	MNB	MNE	MFB	MFE
MDL1	I-TR	-0.163	0.233	-1.5%	61.3%	-0.295	0.588
	I-LKTR	-0.177	0.238	-6.4%	60.0%	-0.334	0.604
	I-LKRD	-0.191	0.245	-11.6%	59.3%	-0.384	0.628
	A-TR	-0.207	0.254	-13.2%	59.7%	-0.408	0.633
	A-LKTR	-0.222	0.262	-18.3%	59.2%	-0.458	0.657
	A-LKRD	-0.235	0.270	-23.2%	59.3%	-0.511	0.689
MDL2	I-TR	0.002	0.230	43.5%	74.6%	0.095	0.511
	I-LKTR	-0.080	0.227	17.2%	63.1%	-0.096	0.532
	I-LKRD	-0.139	0.237	-2.0%	59.2%	-0.271	0.593
	A-TR	-0.043	0.206	28.9%	63.3%	0.017	0.481
	A-LKTR	-0.124	0.215	3.1%	53.8%	-0.193	0.510
	A-LKRD	-0.181	0.238	-15.3%	53.6%	-0.381	0.598
MDL3	I-TR	-0.155	0.334	35.6%	83.1%	-0.078	0.597
	I-LKTR	-0.204	0.337	18.1%	75.6%	-0.207	0.624
	I-LKRD	-0.253	0.350	0.4%	70.8%	-0.360	0.682
	A-TR	-0.200	0.313	22.4%	73.9%	-0.158	0.576
	A-LKTR	-0.253	0.327	4.2%	68.7%	-0.309	0.626
	A-LKRD	-0.302	0.350	-13.7%	66.5%	-0.481	0.712
MDL4	I-TR	-0.317	0.394	-20.8%	55.8%	-0.463	0.656
	I-LKTR	-0.366	0.422	-31.9%	58.0%	-0.600	0.745
	I-LKRD	-0.363	0.419	-30.4%	56.8%	-0.574	0.725
	A-TR	-0.362	0.403	-30.4%	53.0%	-0.545	0.680
	A-LKTR	-0.410	0.437	-41.3%	57.0%	-0.694	0.789
	A-LKRD	-0.404	0.431	-39.3%	55.1%	-0.660	0.759

Table 45. Comparison of the model performance metrics (mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error (MFE)) of the 6 modeling scenarios in the 2nd set of sensitivity runs for Xylenes using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the 4 receptor locations.

Receptor Location	Modeling Scenario	Model Performance Metric					
		MB	ME	MNB	MNE	MFB	MFE
MDL1	I-TR	0.074	0.847	41.4%	66.4%	0.145	0.472
	I-LKTR	0.021	0.826	37.3%	63.6%	0.120	0.464
	I-LKRD	-0.030	0.818	32.9%	61.3%	0.089	0.462
	A-TR	-0.153	0.857	28.0%	60.7%	0.047	0.485
	A-LKTR	-0.211	0.843	23.5%	58.0%	0.015	0.479
	A-LKRD	-0.260	0.839	19.2%	55.9%	-0.018	0.477
MDL2	I-TR	0.794	1.055	82.1%	91.5%	0.417	0.534
	I-LKTR	0.489	0.858	58.8%	73.2%	0.284	0.466
	I-LKRD	0.268	0.760	41.8%	62.6%	0.167	0.434
	A-TR	0.571	0.874	67.1%	78.1%	0.342	0.479
	A-LKTR	0.266	0.713	43.7%	61.3%	0.196	0.418
	A-LKRD	0.052	0.672	27.3%	54.0%	0.069	0.409
MDL3	I-TR	0.378	1.171	58.6%	80.0%	0.260	0.542
	I-LKTR	0.196	1.103	45.2%	71.2%	0.174	0.521
	I-LKRD	0.010	1.040	31.1%	62.3%	0.075	0.501
	A-TR	0.124	1.014	44.5%	69.7%	0.173	0.507
	A-LKTR	-0.070	0.954	30.3%	61.0%	0.072	0.489
	A-LKRD	-0.260	0.918	15.8%	53.9%	-0.041	0.483
MDL4	I-TR	-0.378	1.224	13.0%	50.4%	-0.045	0.463
	I-LKTR	-0.559	1.230	2.7%	47.4%	-0.139	0.476
	I-LKRD	-0.547	1.215	3.9%	46.7%	-0.120	0.466
	A-TR	-0.618	1.231	3.2%	47.8%	-0.132	0.478
	A-LKTR	-0.800	1.258	-7.2%	45.9%	-0.236	0.503
	A-LKRD	-0.777	1.236	-5.5%	44.8%	-0.212	0.487

Table 46. Comparison of the model performance metrics (mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error (MFE)) of the two dispersion model predictions (ISCST3 vs. AERMOD) for the 3 chlorinated chemicals (Tetrachloroethene (PERC), Trichloroethene (TCE), and p-Dichlorobenzene (PDB)) and 3 metals (As, Pb, and Hg) using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at all of the receptor locations.

Chemical	MODEL	Model Performance Metric					
		MB	ME	MNB	MNE	MFB	MFE
PERC	ISCST3	-0.247	0.449	17.8%	78.0%	-0.21	0.68
	AERMOD	-0.317	0.429	0.1%	67.7%	-0.32	0.68
TCE	ISCST3	-0.181	0.199	-15.3%	79.9%	-0.61	0.84
	AERMOD	-0.184	0.200	-19.6%	76.8%	-0.62	0.84
PDB	ISCST3	-0.147	0.153	-34.5%	76.7%	-0.81	0.96
	AERMOD	-0.154	0.158	-42.9%	76.7%	-0.90	1.03
Arsenic (fine PM)	ISCST3	-0.746	0.746	-88.7%	88.7%	-1.64	1.64
	AERMOD	-0.764	0.764	-91.5%	91.7%	-1.71	1.71
Lead (fine PM)	ISCST3	-2.327	2.467	-37.0%	74.0%	-0.79	0.93
	AERMOD	-2.518	2.612	-44.7%	73.2%	-0.87	0.99
Mercury (fine PM)	ISCST3	-0.246	0.246	-97.0%	97.0%	-1.90	1.90
	AERMOD	-0.248	0.248	-98.0%	98.0%	-1.93	1.93

Table 47. Comparison of the model performance metrics (mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error (MFE)) of the two dispersion model predictions (ISCST3 vs. AERMOD) for the 3 chlorinated chemicals (Tetrachloroethene (PERC), Trichloroethene (TCE), and p-Dichlorobenzene (PDB)) using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the receptor locations.

Chemical	Receptor Location	MODEL	Model Performance Metric					
			MB	ME	MNB	MNE	MFB	MFE
PERC	MDL1	ISCST3	-0.352	0.546	8.0%	73.5%	-0.268	0.722
		AERMOD	-0.426	0.523	-8.0%	64.4%	-0.388	0.709
	MDL2	ISCST3	-0.135	0.312	17.8%	72.3%	-0.156	0.617
		AERMOD	-0.198	0.305	-0.2%	63.4%	-0.284	0.624
	MDL3	ISCST3	-0.224	0.497	43.3%	101.7%	-0.136	0.738
		AERMOD	-0.305	0.459	19.8%	84.0%	-0.249	0.715
	MDL4	ISCST3	-0.279	0.447	4.1%	66.5%	-0.262	0.654
		AERMOD	-0.342	0.435	-9.9%	60.2%	-0.369	0.662
TCE	MDL1	ISCST3	-0.183	0.192	-32.5%	65.4%	-0.681	0.806
		AERMOD	-0.185	0.192	-33.4%	64.9%	-0.688	0.808
	MDL2	ISCST3	-0.165	0.196	7.5%	97.4%	-0.523	0.831
		AERMOD	-0.177	0.199	-6.5%	88.5%	-0.585	0.849
	MDL3	ISCST3	-0.182	0.201	-14.9%	82.5%	-0.599	0.891
		AERMOD	-0.182	0.200	-16.8%	80.3%	-0.598	0.880
	MDL4	ISCST3	-0.193	0.208	-20.8%	74.9%	-0.622	0.835
		AERMOD	-0.193	0.208	-21.2%	74.0%	-0.619	0.829
PDB	MDL1	ISCST3	-0.162	0.169	-32.4%	82.1%	-0.838	1.004
		AERMOD	-0.169	0.174	-38.9%	82.5%	-0.917	1.064
	MDL2	ISCST3	-0.114	0.118	-23.9%	76.8%	-0.711	0.839
		AERMOD	-0.121	0.124	-34.7%	74.5%	-0.800	0.900
	MDL3	ISCST3	-0.177	0.182	-48.1%	70.4%	-0.898	1.023
		AERMOD	-0.185	0.189	-54.5%	72.6%	-0.992	1.100
	MDL4	ISCST3	-0.134	0.141	-34.2%	76.7%	-0.810	0.962
		AERMOD	-0.142	0.147	-44.5%	76.8%	-0.912	1.046

Table 48. Comparison of the model performance metrics (mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error (MFE)) of the two dispersion model predictions (ISCST3 vs. AERMOD) for 3 metals (As, Pb, and Hg) using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the receptor locations.

Chemical	Receptor Location	MODEL	Model Performance Metric					
			MB	ME	MNB	MNE	MFB	MFE
As	MDL1	ISCST3	-0.836	0.836	-90.0%	90.0%	-1.677	1.677
		AERMOD	-0.853	0.853	-92.0%	92.4%	-1.738	1.743
	MDL2	ISCST3	-0.669	0.669	-87.6%	87.6%	-1.603	1.603
		AERMOD	-0.687	0.687	-91.0%	91.0%	-1.691	1.691
Pb	MDL1	ISCST3	-2.652	2.742	-46.7%	70.1%	-0.861	0.951
		AERMOD	-2.871	2.913	-52.9%	72.2%	-0.962	1.020
	MDL2	ISCST3	-2.048	2.231	-28.8%	77.4%	-0.731	0.910
		AERMOD	-2.216	2.353	-37.6%	74.1%	-0.798	0.956
Hg	MDL1	ISCST3	-0.248	0.248	-97.1%	97.1%	-1.898	1.898
		AERMOD	-0.250	0.250	-97.9%	97.9%	-1.921	1.921
	MDL2	ISCST3	-0.244	0.244	-97.0%	97.0%	-1.894	1.894
		AERMOD	-0.246	0.246	-98.1%	98.1%	-1.930	1.930

Table 49. Comparison of the model performance metrics (mean bias (MB), mean error (ME), mean normalized bias (MNB), mean normalized error (MNE), mean fractional bias (MFB), and mean fractional error (MFE)) of the ISCST3 model predictions with the two different meteorology inputs (Newark Airport vs. MERI) for BTEX using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at all of the receptor locations.

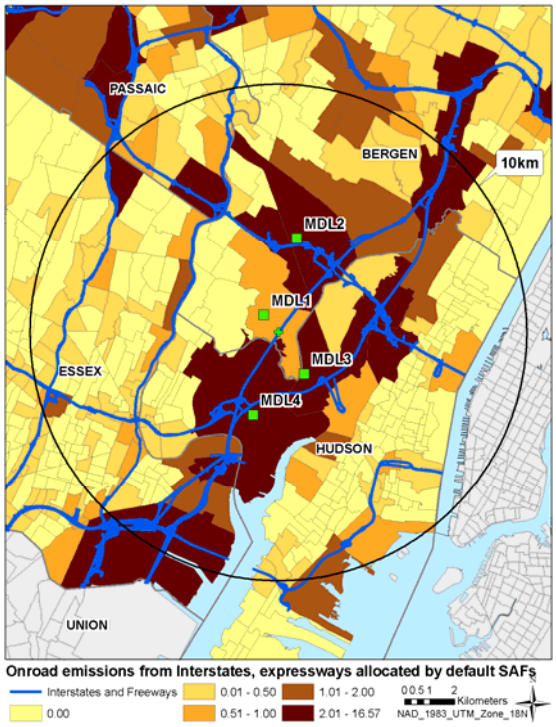
Chemical	Meteorology data	Model Performance Metric					
		MB	ME	MNB	MNE	MFB	MFE
Benzene	Newark Airport	0.224	0.340	50.2%	59.3%	0.287	0.394
	MERI	0.536	0.558	98.0%	99.8%	0.538	0.559
Toluene	Newark Airport	-0.194	0.957	21.2%	52.4%	0.018	0.428
	MERI	0.962	1.221	86.2%	89.9%	0.486	0.532
Ethylbenzene	Newark Airport	-0.196	0.286	-0.1%	69.2%	-0.351	0.671
	MERI	-0.002	0.279	71.7%	104.2%	0.154	0.605
Xylenes	Newark Airport	-0.348	0.967	-2.8%	41.7%	-0.156	0.431
	MERI	0.570	0.979	44.6%	53.9%	0.287	0.401

Table 50. Percentage contributions from ambient sources categorized by five emission groups (i.e. point, non-point (area), mobile non-road, mobile on-road, and background) to the predicted 48-hr averages of the ISCST3 predictions for the BTEX chemicals at each of the 4 receptor locations[9].

Receptor location	Observed Conc (ug/m^3)	Predicted conc. (ug/m^3)	Percentage contributions of				
			Point Src.	nonpoint Src.	nonroad Src.	onroad Src.	background
Benzene							
MDL1	1.654	1.307	2%	15%	32%	17%	34%
MDL2	1.508	1.404	1%	13%	37%	17%	32%
MDL3	1.278	1.427	2%	16%	30%	18%	34%
MDL4	1.690	1.493	2%	16%	35%	14%	32%
Toluene							
MDL1	4.640	3.231	7%	42%	35%	16%	0%
MDL2	5.037	3.419	5%	38%	41%	17%	0%
MDL3	4.254	3.331	3%	47%	35%	16%	0%
MDL4	4.786	3.514	2%	44%	40%	13%	0%
Ethylbenzene							
MDL1	0.900	0.470	4%	32%	37%	27%	0%
MDL2	0.913	0.512	3%	26%	42%	29%	0%
MDL3	0.695	0.523	5%	35%	34%	26%	0%
MDL4	1.281	0.566	5%	36%	39%	19%	0%
Xylenes							
MDL1	3.319	2.795	2%	48%	24%	20%	6%
MDL2	3.508	2.904	2%	43%	28%	21%	6%
MDL3	2.795	3.045	3%	51%	22%	18%	6%
MDL4	5.440	3.233	4%	51%	26%	15%	5%

[9] The results presented are obtained by averaging the outputs of the source contribution analyses conducted on the 5 selected sampled dates (9/7/2005, 1/11/2006, 2/16/2006, 3/12/2006, and 10/20/2006). These results were typical for other cases of sampled dates.

(a)



(b)

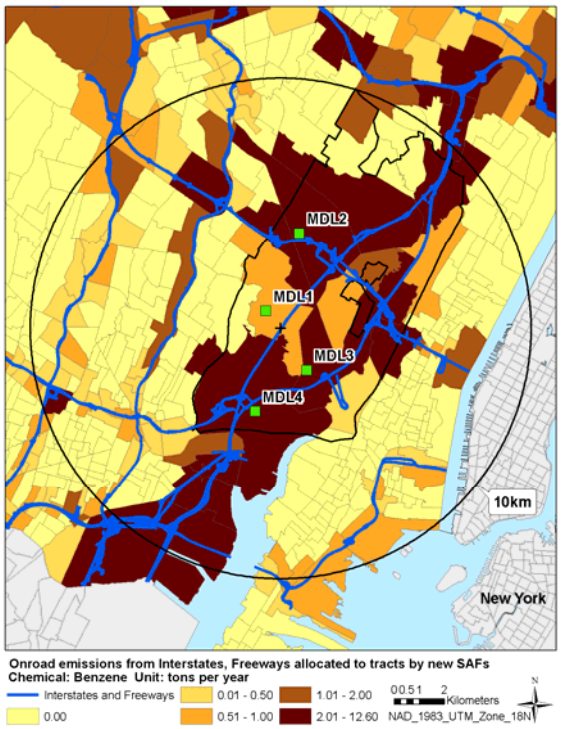
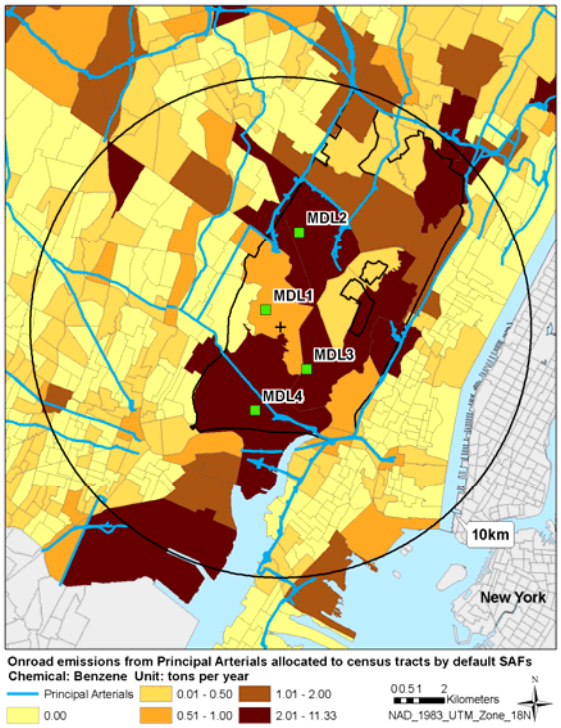


Figure 133. 2002 annual Benzene emissions (short tons/year) from mobile on-road sources of interstate highways and expressways allocated to the census tracts within a 10km radius of the Meadowlands District using (a) the default spatial allocation factors (SAFs) and (b) the new SAFs.

(a)



(b)

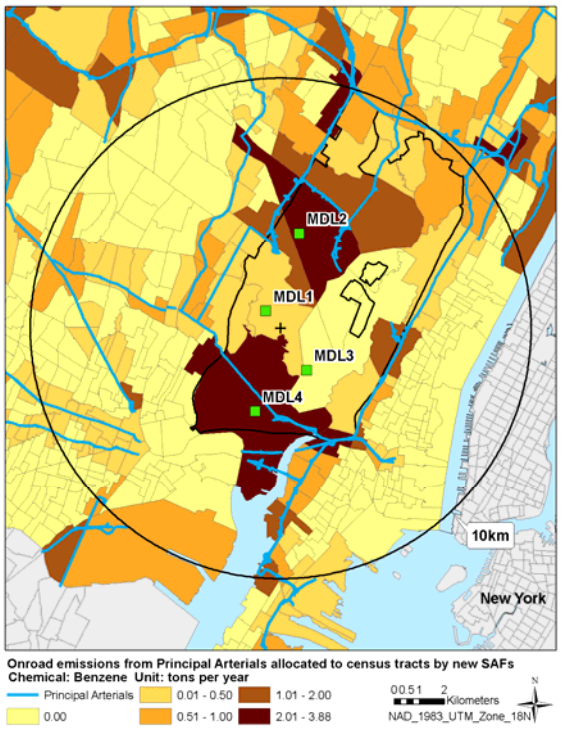
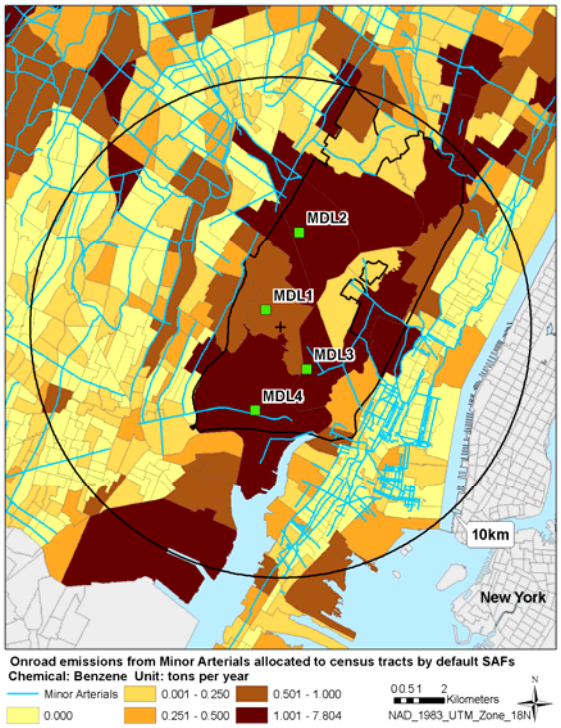


Figure 134. 2002 annual Benzene emissions (short tons/year) from mobile on-road sources of principal arterials allocated to the census tracts within a 10km radius of the Meadowlands District using (a) the default spatial allocation factors (SAFs) and (b) the new SAFs.

(a)



(b)

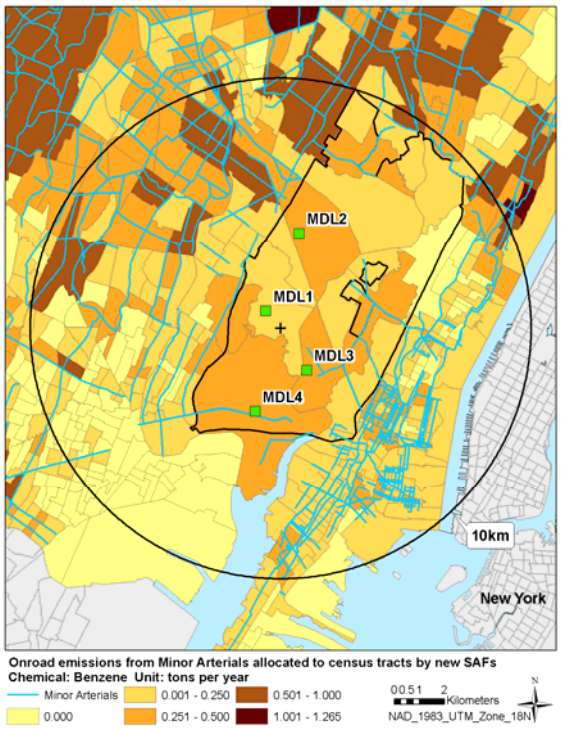
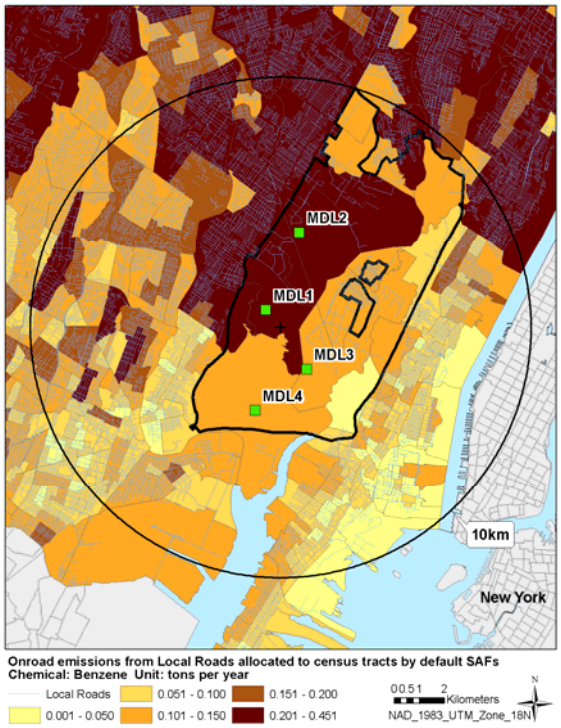


Figure 135. 2002 annual Benzene emissions (short tons/year) from mobile on-road sources of minor arterials allocated to the census tracts within a 10km radius of the Meadowlands District using (a) the default spatial allocation factors (SAFs) and (b) the new SAFs.

(a)



(b)

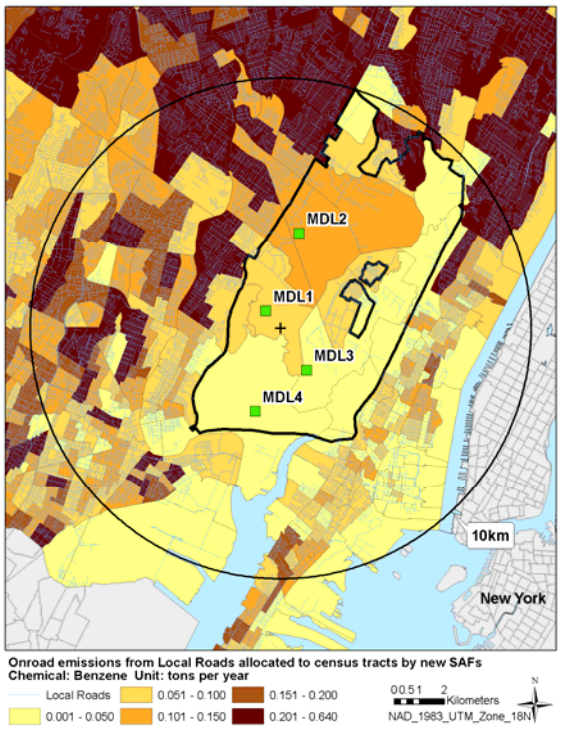


Figure 136. 2002 annual Benzene emissions (short tons/year) from mobile on-road sources of local roads allocated to the census tracts within a 10km radius of the Meadowlands District using (a) the default spatial allocation factors (SAFs) and (b) the new SAFs.

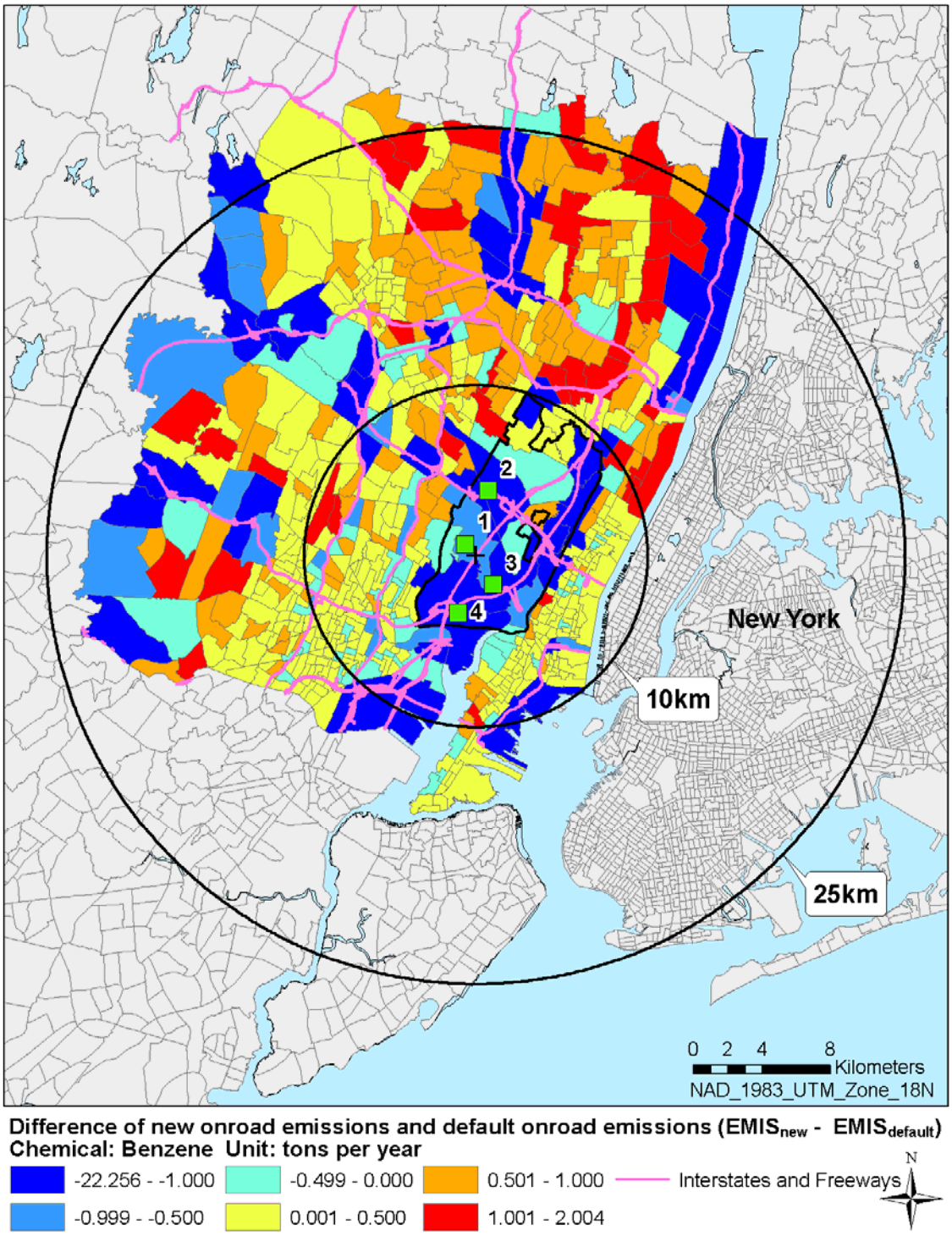


Figure 137. Differences between the 2002 annual Benzene mobile on-road emissions (short tons/year) allocated by the new SAFs and the default SAFs for the census tracts within a 10km radius of the Meadowlands District.

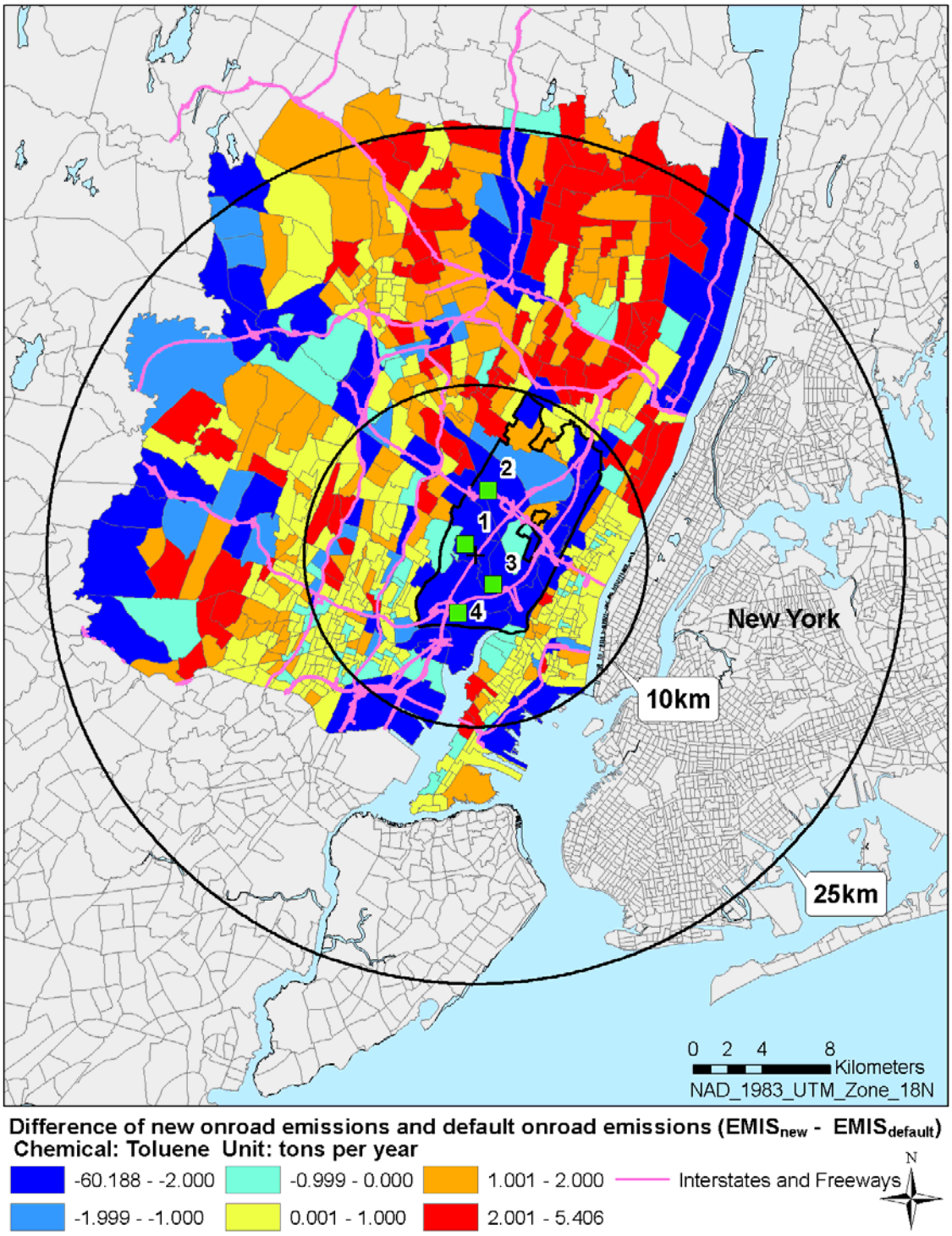


Figure 138. Differences between the 2002 annual Toluene mobile on-road emissions (short tons/year) allocated by the new SAFs and the default SAFs for the census tracts within a 10km radius of the Meadowlands District.

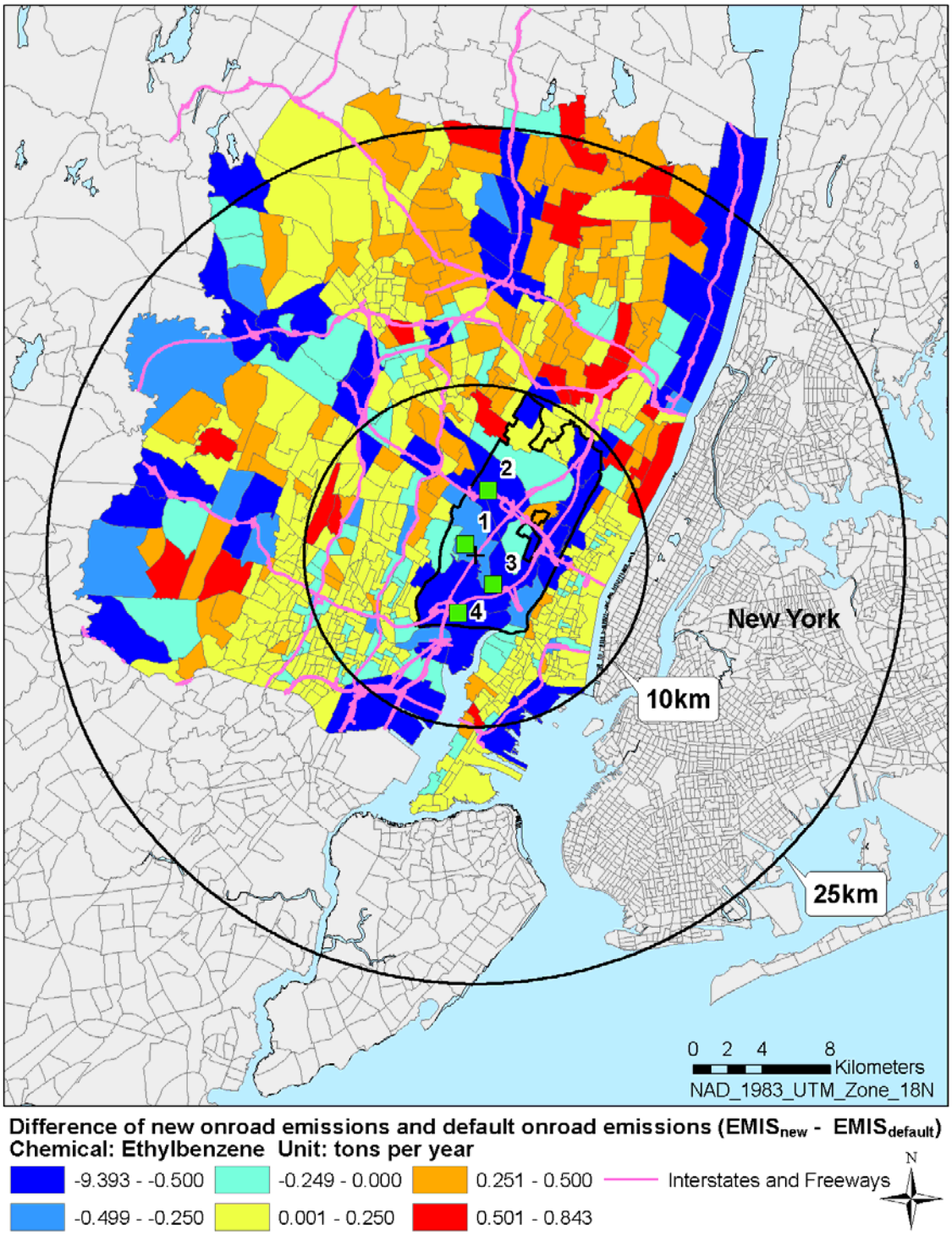


Figure 139. Differences between the 2002 annual Ethylbenzene mobile on-road emissions (short tons/year) allocated by the new SAFs and the default SAFs for the census tracts within a 10km radius of the Meadowlands District.

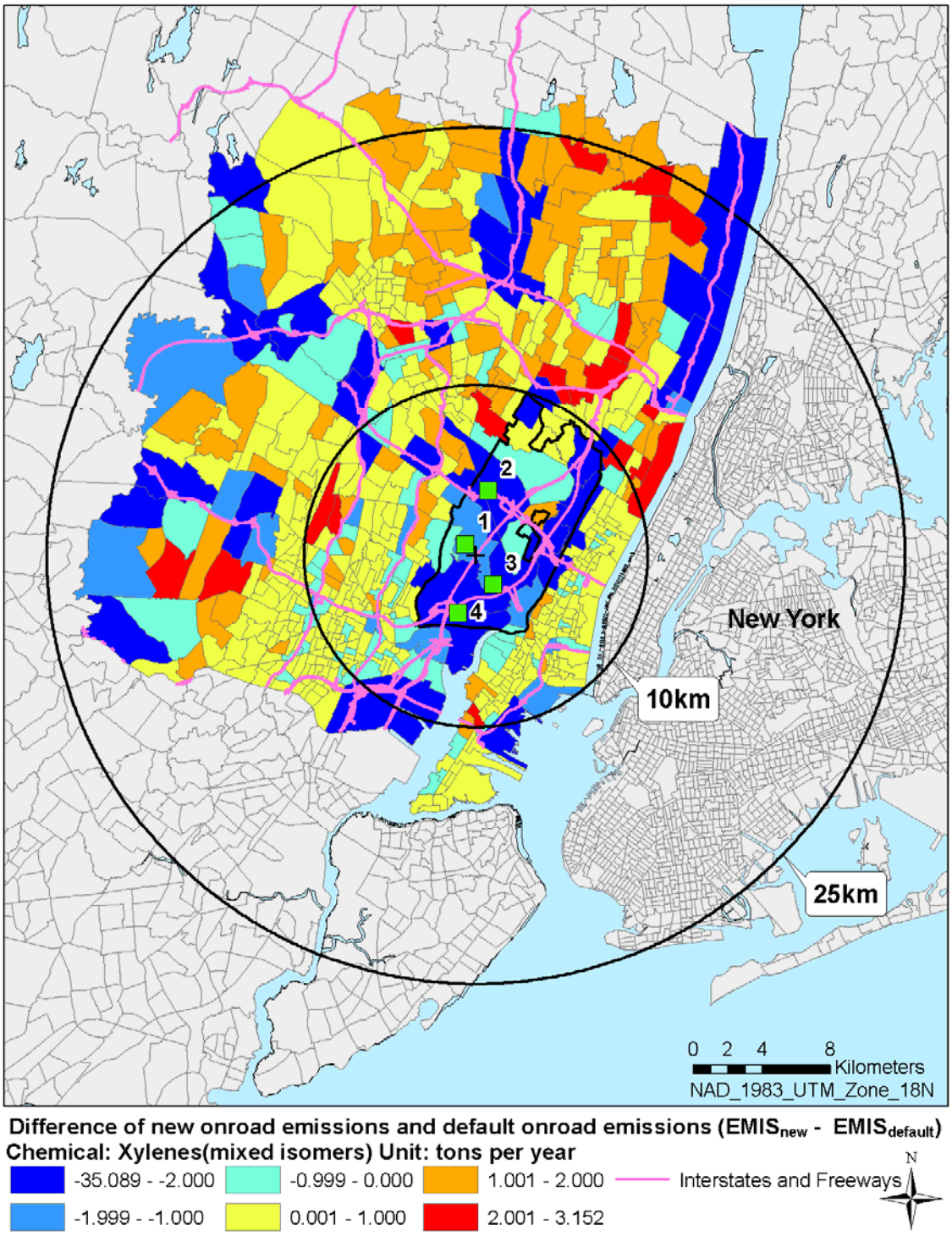


Figure 140. Differences between the 2002 annual Xylenes mobile on-road emissions (short tons/year) allocated by the new SAFs and the default SAFs for the census tracts within a 10km radius of the Meadowlands District.

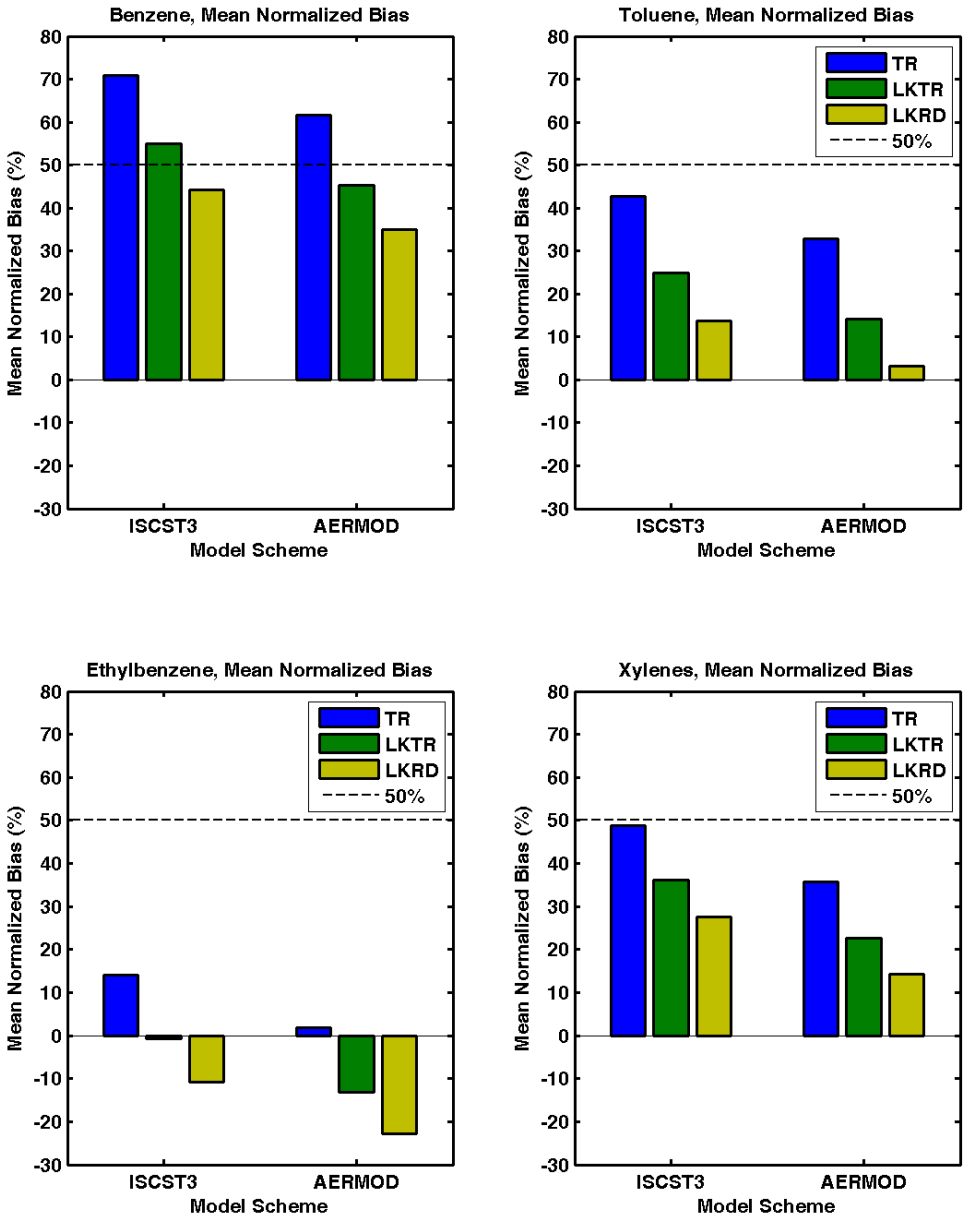


Figure 141. Comparisons of mean normalized bias (MNB) of the model predictions obtained from the 6 modeling scenarios (listed in Table 40) of the 2nd set of sensitivity runs for the BTEX chemicals. The MNB metrics were calculated using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at all of the receptor locations. Note: three options (TR, LKTR, LKRD) of spatial allocation factors were available for processing mobile on-road emissions, where TR is the default census tract-based approach, LKTR is the improved link-based approach for adjusting the source strengths of mobile on-road emissions but still allocating to census tracts, and LKRD is the improved link-based approach for adjusting both source strengths and locations of mobile on-road emissions.

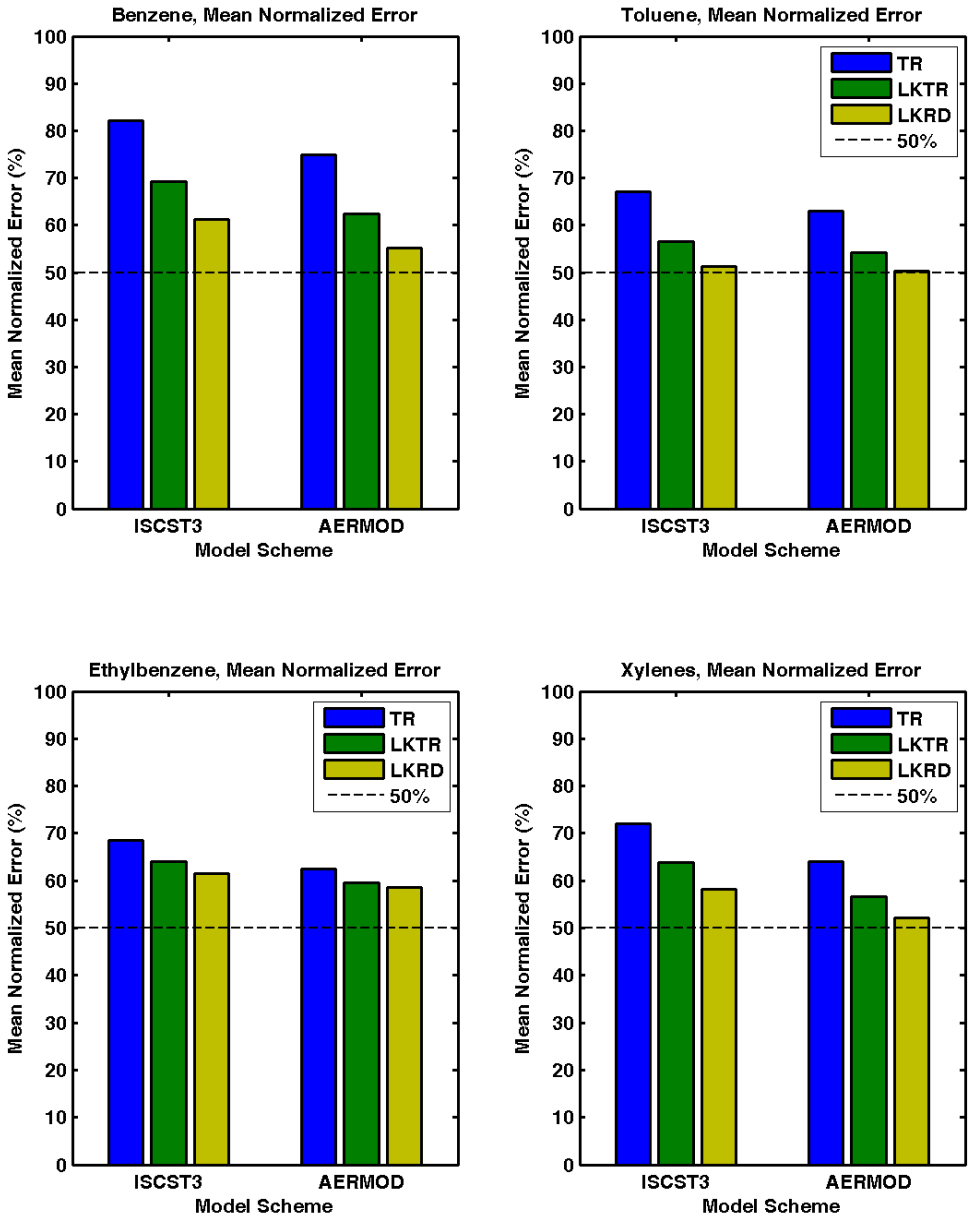


Figure 142. Comparisons of mean normalized error (MNE) of the model predictions obtained from the 6 modeling scenarios (listed in Table 40) of the 2nd set of sensitivity runs for the BTEX chemicals. The MNE metrics were calculated using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at all of the receptor locations. Note: three options (TR, LKTR, LKRD) of spatial allocation factors were available for processing mobile on-road emissions, where TR is the default census tract-based approach, LKTR is the improved link-based approach for adjusting the source strengths of mobile on-road emissions but still allocating to census tracts, and LKRD is the improved link-based approach for adjusting both source strengths and locations of mobile on-road emissions.

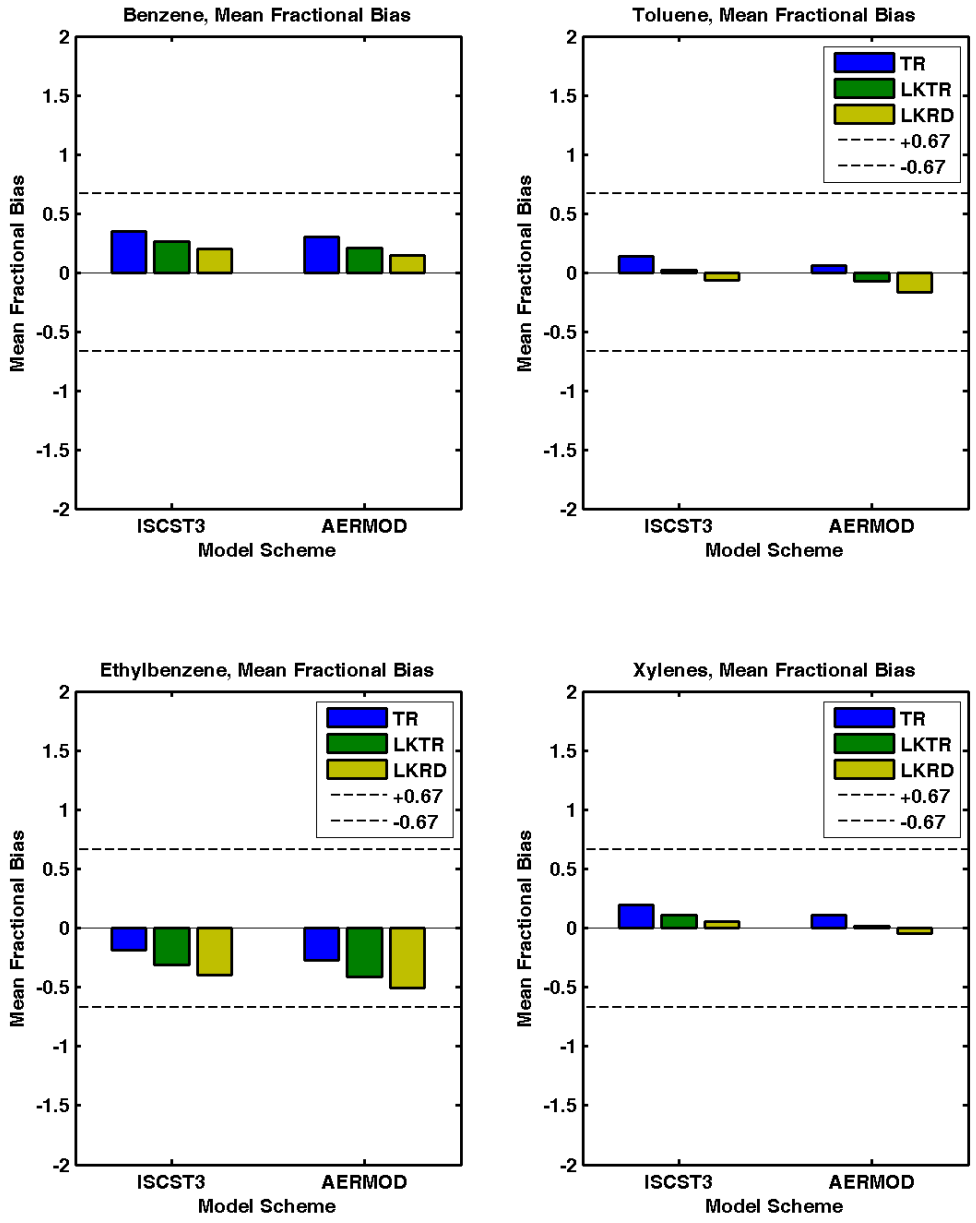


Figure 143. Comparisons of mean fractional bias (MFB) of the model predictions obtained from the 6 modeling scenarios (listed in Table 40) of the 2nd set of sensitivity runs for the BTEX chemicals. The MFB metrics were calculated using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at all of the receptor locations. Note: three options (TR, LKTR, LKRD) of spatial allocation factors were available for processing mobile on-road emissions, where TR is the default census tract-based approach, LKTR is the improved link-based approach for adjusting the source strengths of mobile on-road emissions but still allocating to census tracts, and LKRD is the improved link-based approach for adjusting both source strengths and locations of mobile on-road emissions.

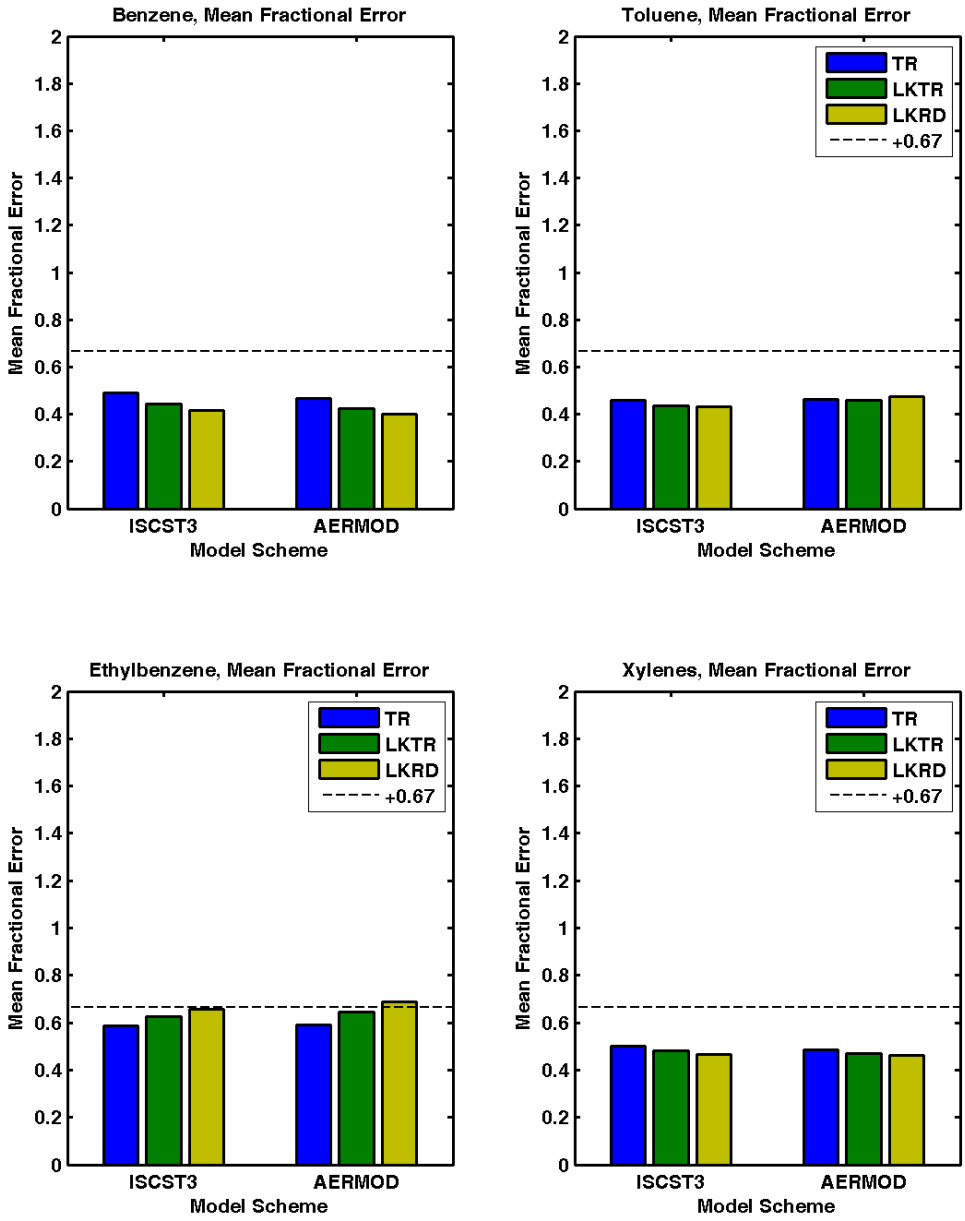


Figure 144. Comparisons of mean fractional error (MFE) of the model predictions obtained from the 6 modeling scenarios (listed in Table 40) of the 2nd set of sensitivity runs for the BTEX chemicals. The MFE metrics were calculated using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at all of the receptor locations. Note: three options (TR, LKTR, LKRD) of spatial allocation factors were available for processing mobile on-road emissions, where TR is the default census tract-based approach, LKTR is the improved link-based approach for adjusting the source strengths of mobile on-road emissions but still allocating to census tracts, and LKRD is the improved link-based approach for adjusting both source strengths and locations of mobile on-road emissions.

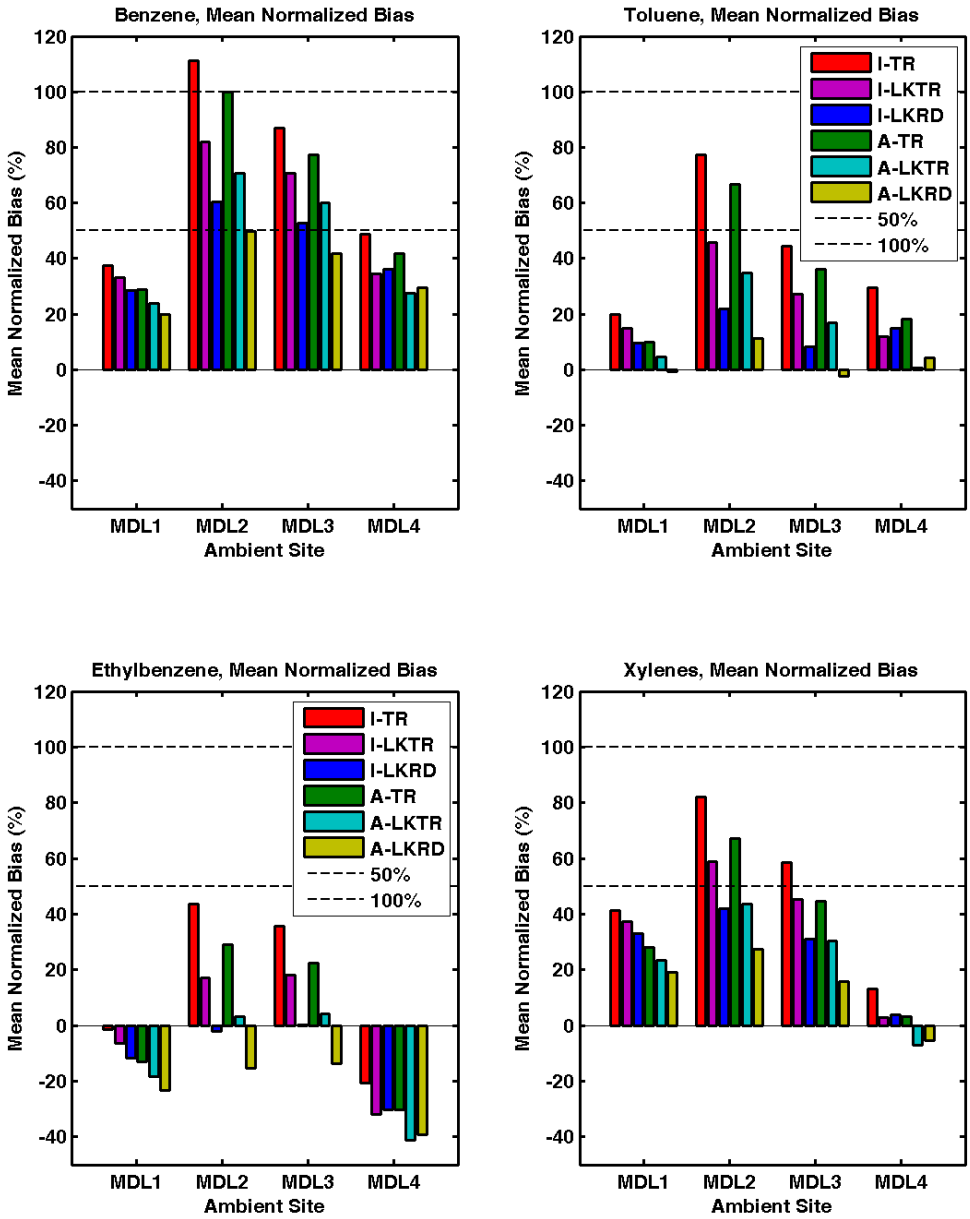


Figure 145. Comparisons of mean normalized bias (MNB) of the model predictions obtained from the 6 modeling scenarios (listed in Table 40) of the 2nd set of sensitivity runs for the BTEX chemicals. The MNB metrics were calculated using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the receptor locations. Note: three options (TR, LKTR, LKRD) of spatial allocation factors were available for processing mobile on-road emissions, where TR is the default census tract-based approach, LKTR is the improved link-based approach for adjusting the source strengths of mobile on-road emissions but still allocating to census tracts, and LKRD is the improved link-based approach for adjusting both source strengths and locations of mobile on-road emissions.

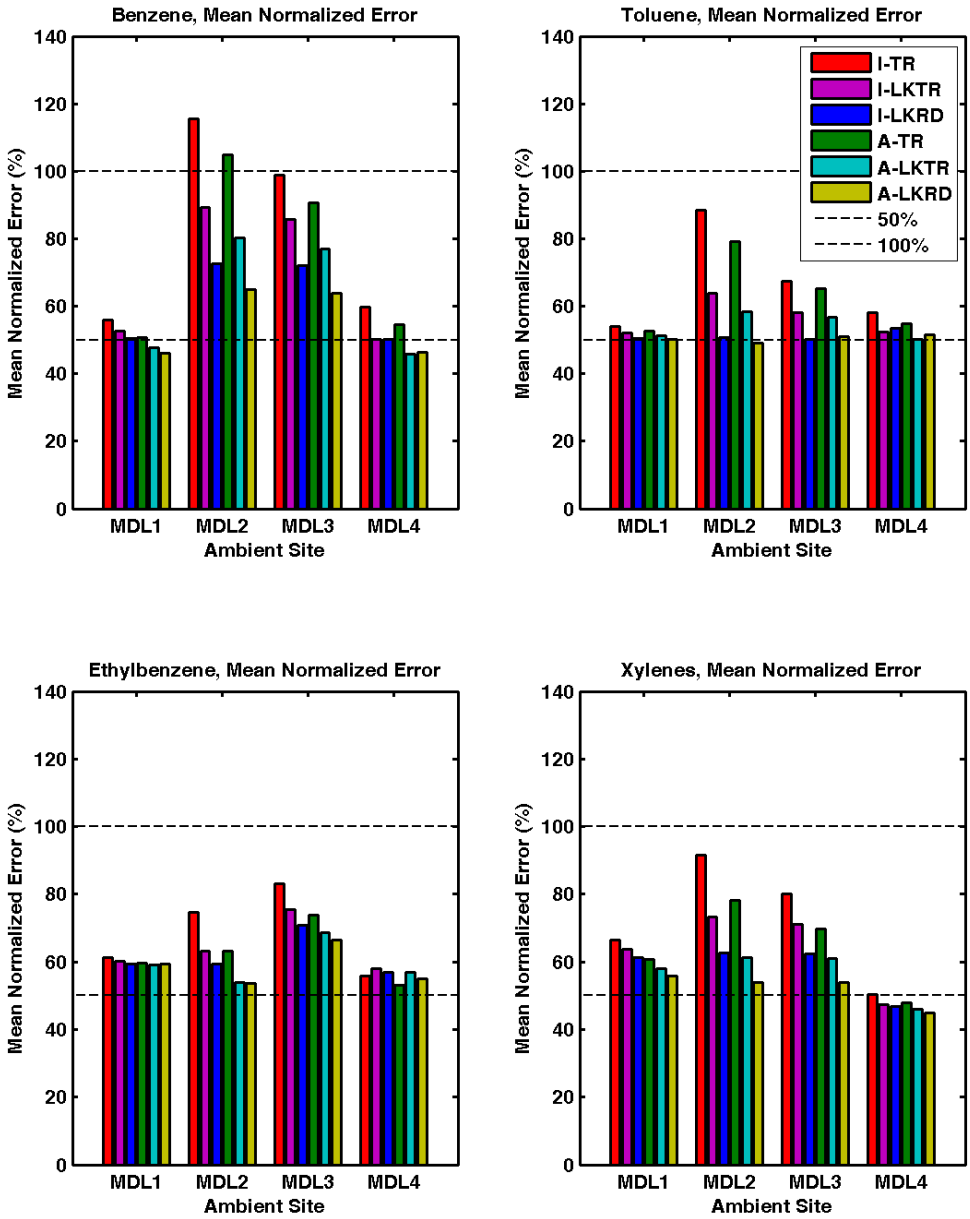


Figure 146. Comparisons of mean normalized error (MNE) of the model predictions obtained from the 6 modeling scenarios (listed in Table 40) of the 2nd set of sensitivity runs for the BTEX chemicals. The MNE metrics were calculated using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the receptor locations. Note: three options (TR, LKTR, LKRD) of spatial allocation factors were available for processing mobile on-road emissions, where TR is the default census tract-based approach, LKTR is the improved link-based approach for adjusting the source strengths of mobile on-road emissions but still allocating to census tracts, and LKRD is the improved link-based approach for adjusting both source strengths and locations of mobile on-road emissions.

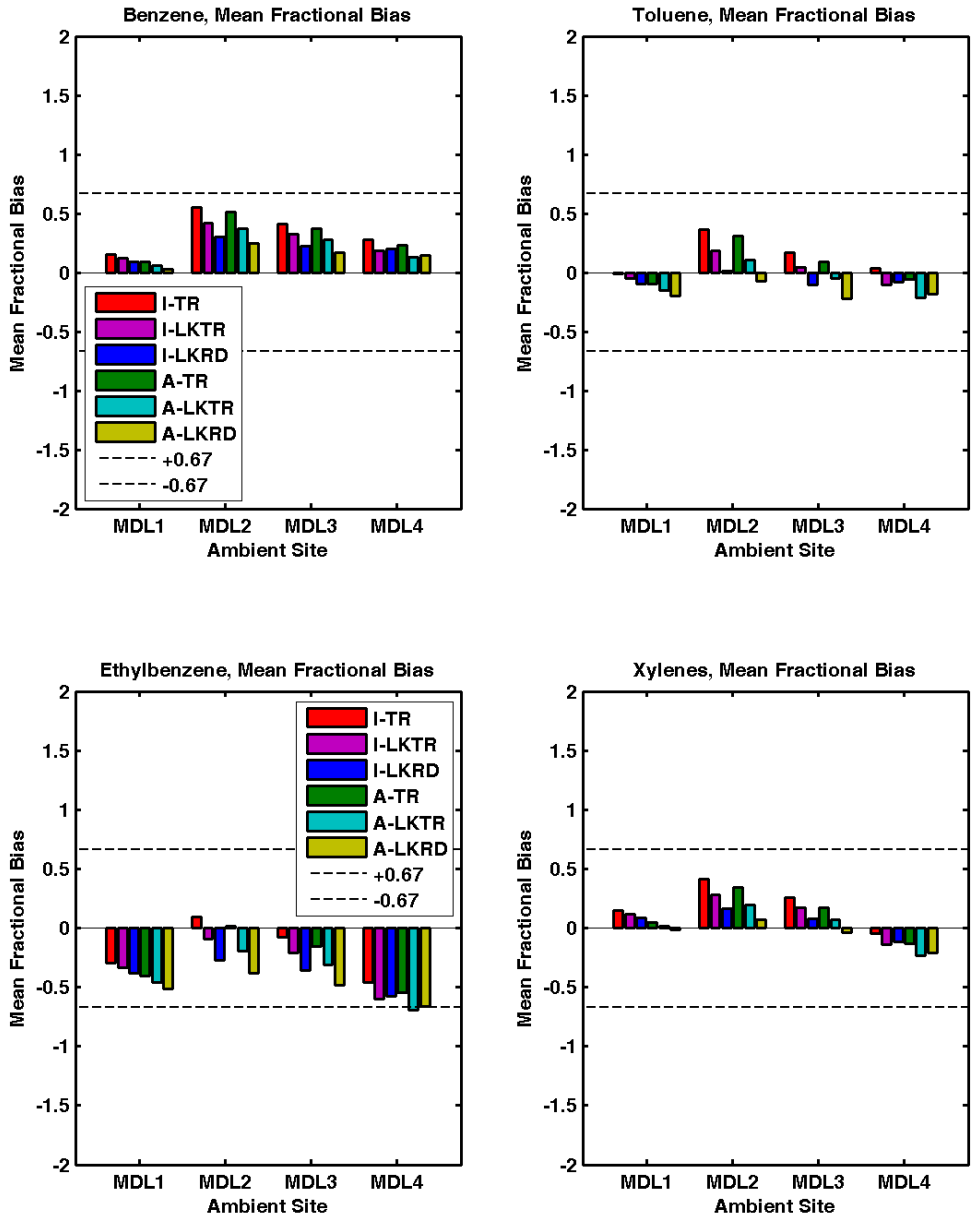


Figure 147. Comparisons of mean fractional bias (MFB) of the model predictions obtained from the 6 modeling scenarios (listed in Table 40) of the 2nd set of sensitivity runs for the BTEX chemicals. The MFB metrics were calculated using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the receptor locations. Note: three options (TR, LKTR, LKRD) of spatial allocation factors were available for processing mobile on-road emissions, where TR is the default census tract-based approach, LKTR is the improved link-based approach for adjusting the source strengths of mobile on-road emissions but still allocating to census tracts, and LKRD is the improved link-based approach for adjusting both source strengths and locations of mobile on-road emissions.

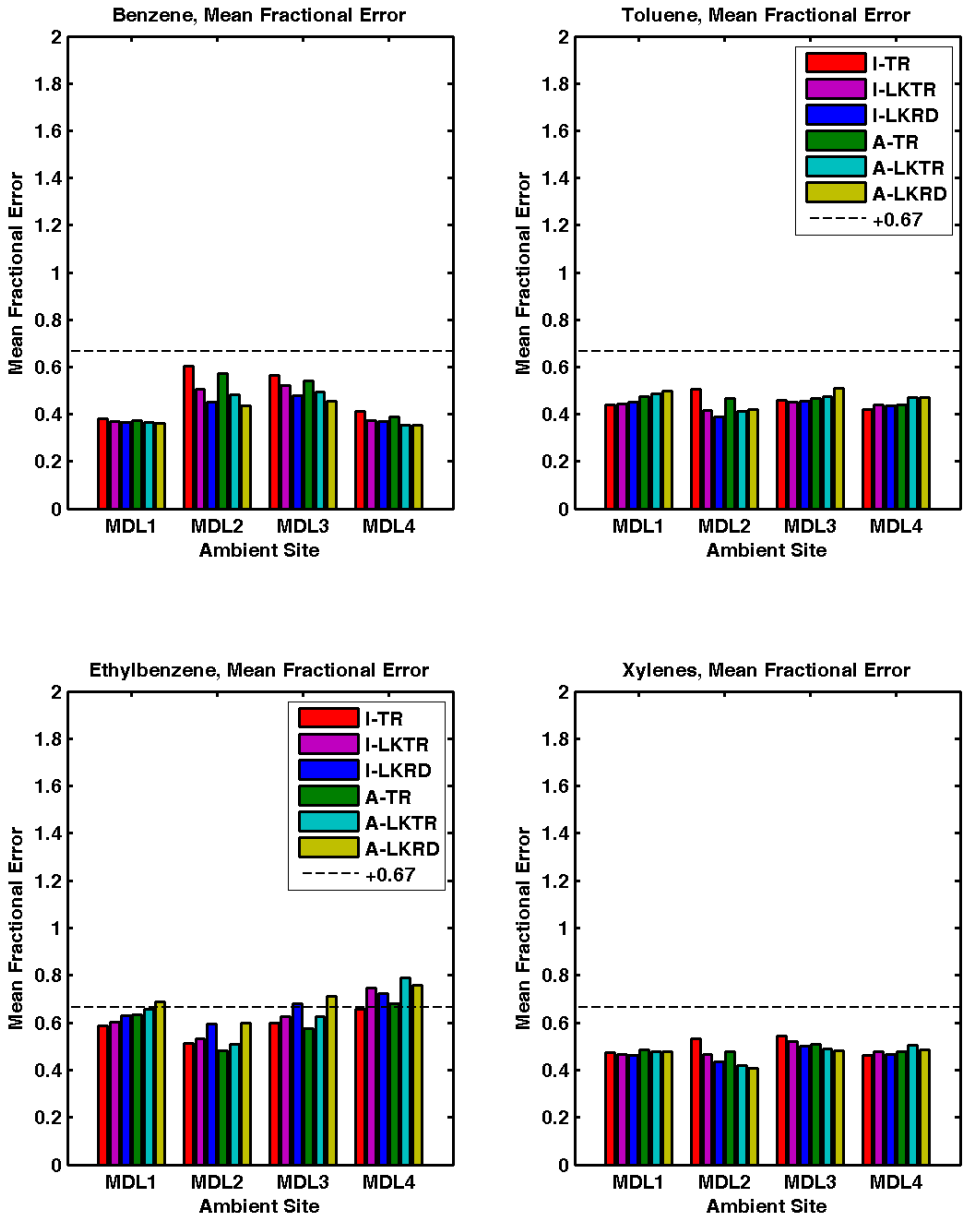


Figure 148. Comparisons of mean fractional error (MFE) of the model predictions obtained from the 6 modeling scenarios (listed in Table 40) of the 2nd set of sensitivity runs for the BTEX chemicals. The MFE metrics were calculated using model predictions matched with field measurements for the time period of March 17, 2005 to March 13, 2007 at each of the receptor locations. Note: three options (TR, LKTR, LKRD) of spatial allocation factors were available for processing mobile on-road emissions, where TR is the default census tract-based approach, LKTR is the improved link-based approach for adjusting the source strengths of mobile on-road emissions but still allocating to census tracts, and LKRD is the improved link-based approach for adjusting both source strengths and locations of mobile on-road emissions.

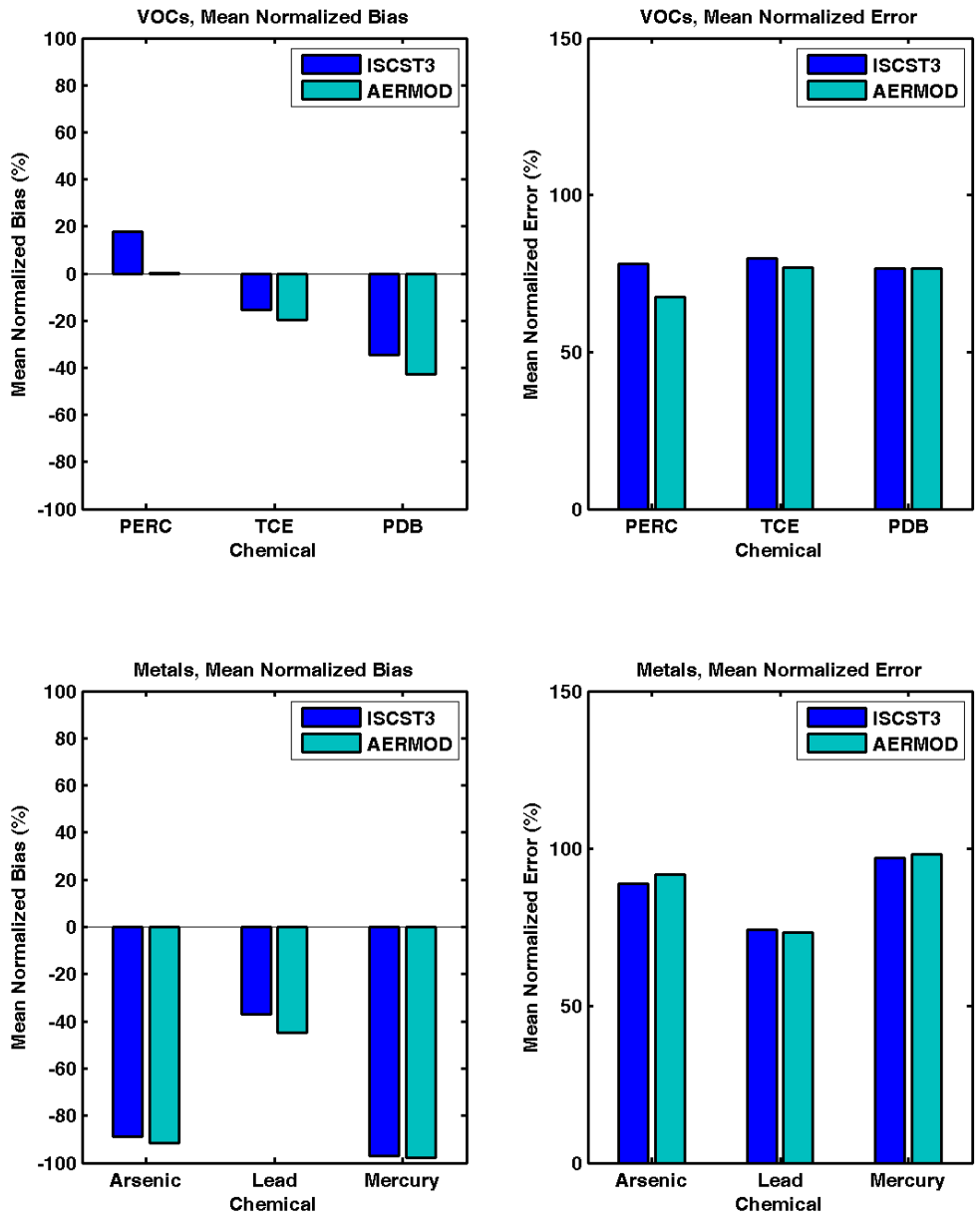


Figure 149. Comparisons of mean normalized bias (MNB) and mean normalized error (MNE) of the ISCST3 and AERMOD model predictions for the three chlorinated chemicals (PERC, TCE, and PDB) and the three metals (As, Pb, and Hg) with the inputs of NEI-2002 emissions and Newark Airport meteorology. The MNB and MNE metrics were calculated using all of the model predictions matched with field measurements for the period of March 17th, 2005 to March 13th, 2007 at all of the receptor locations.

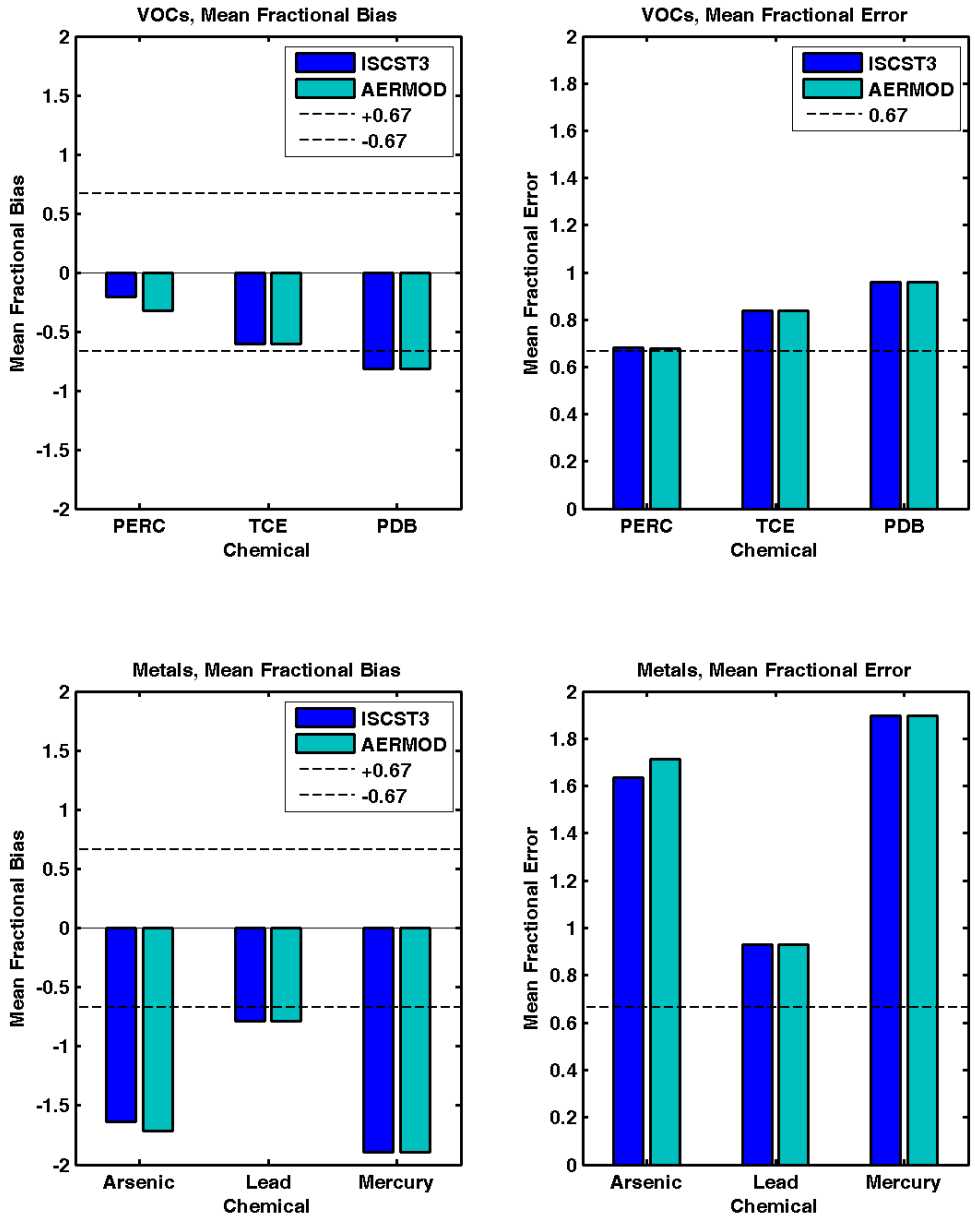


Figure 150. Comparisons of mean fractional bias (MFB) and mean fractional error (MFE) of the ISCST3 and AERMOD model predictions for the three chlorinated chemicals (PERC, TCE, and PDB) and the three metals (As, Pb, and Hg) with the inputs of NEI-2002 emissions and Newark Airport meteorology. The MFB and MFE metrics were calculated using all of the model predictions matched with field measurements for the period of March 17th, 2005 to March 13th, 2007 at all of the receptor locations.

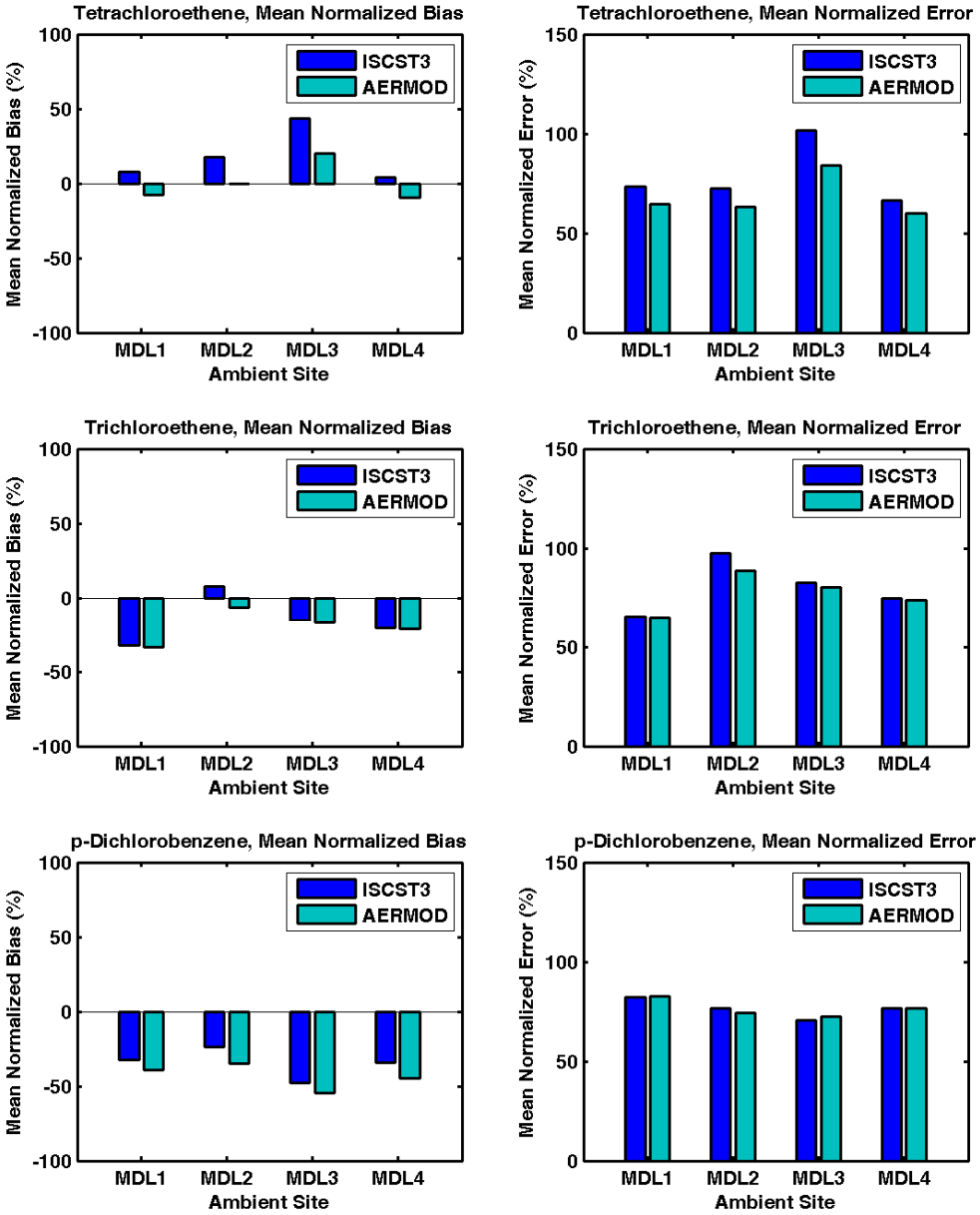


Figure 151. Comparisons of mean normalized bias (MNB) and mean normalized error (MNE) of the ISCST3 and AERMOD model predictions for the three chlorinated chemicals (PERC, TCE, and PDB) with the inputs of NEI-2002 emissions and Newark Airport meteorology. The MNB and MNE metrics were calculated using the model predictions matched with field measurements at each of the field sampling sites for the period of March 17th, 2005 to March 13th, 2007.

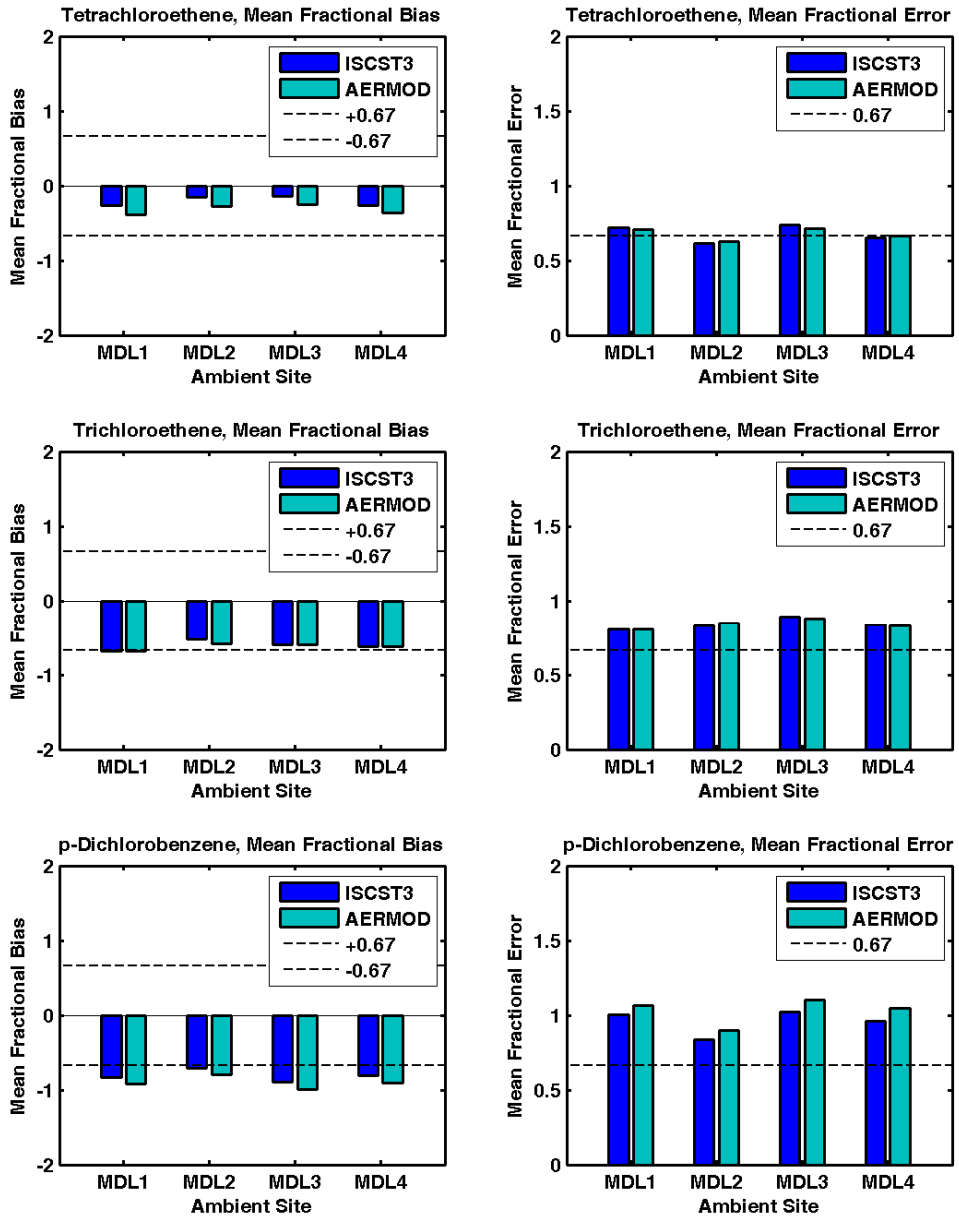


Figure 152. Comparisons of mean fractional bias (MFB) and mean fractional error (MFE) of the ISCST3 and AERMOD model predictions for the three chlorinated chemicals (PERC, TCE, and PDB) with the inputs of NEI-2002 emissions and Newark Airport meteorology. The MFB and MFE metrics were calculated using the model predictions matched with field measurements at each of the field sampling sites for the period of March 17th, 2005 to March 13th, 2007.

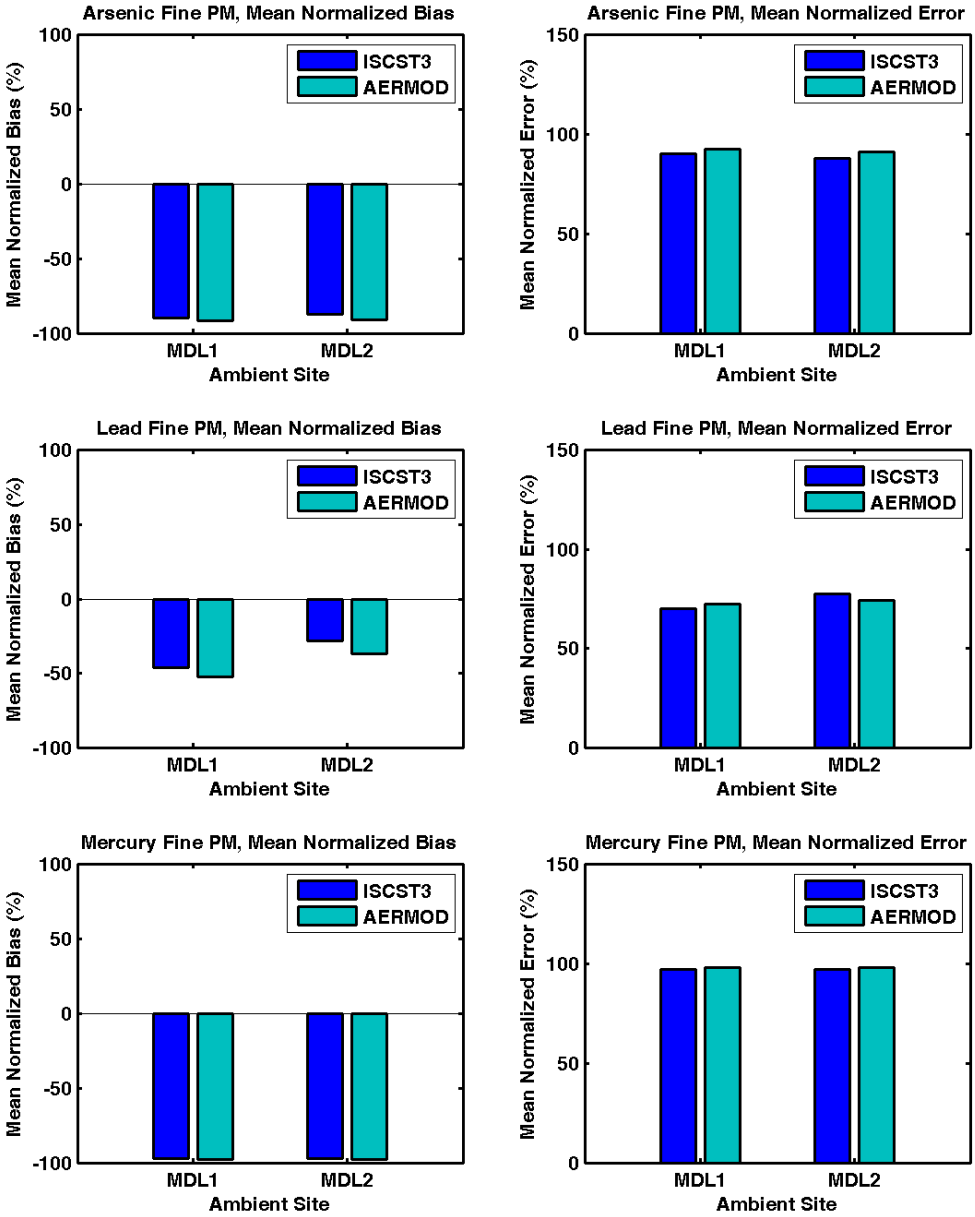


Figure 153. Comparisons of mean normalized bias (MNB) and mean normalized error (MNE) of the ISCST3 and AERMOD model predictions for the three metals (As, Pb, and Hg) with the inputs of NEI-2002 emissions and Newark Airport meteorology. The MNB and MNE metrics were calculated using the model predictions matched with field measurements at each of the field sampling sites for the period of March 17th, 2005 to March 13th, 2007.

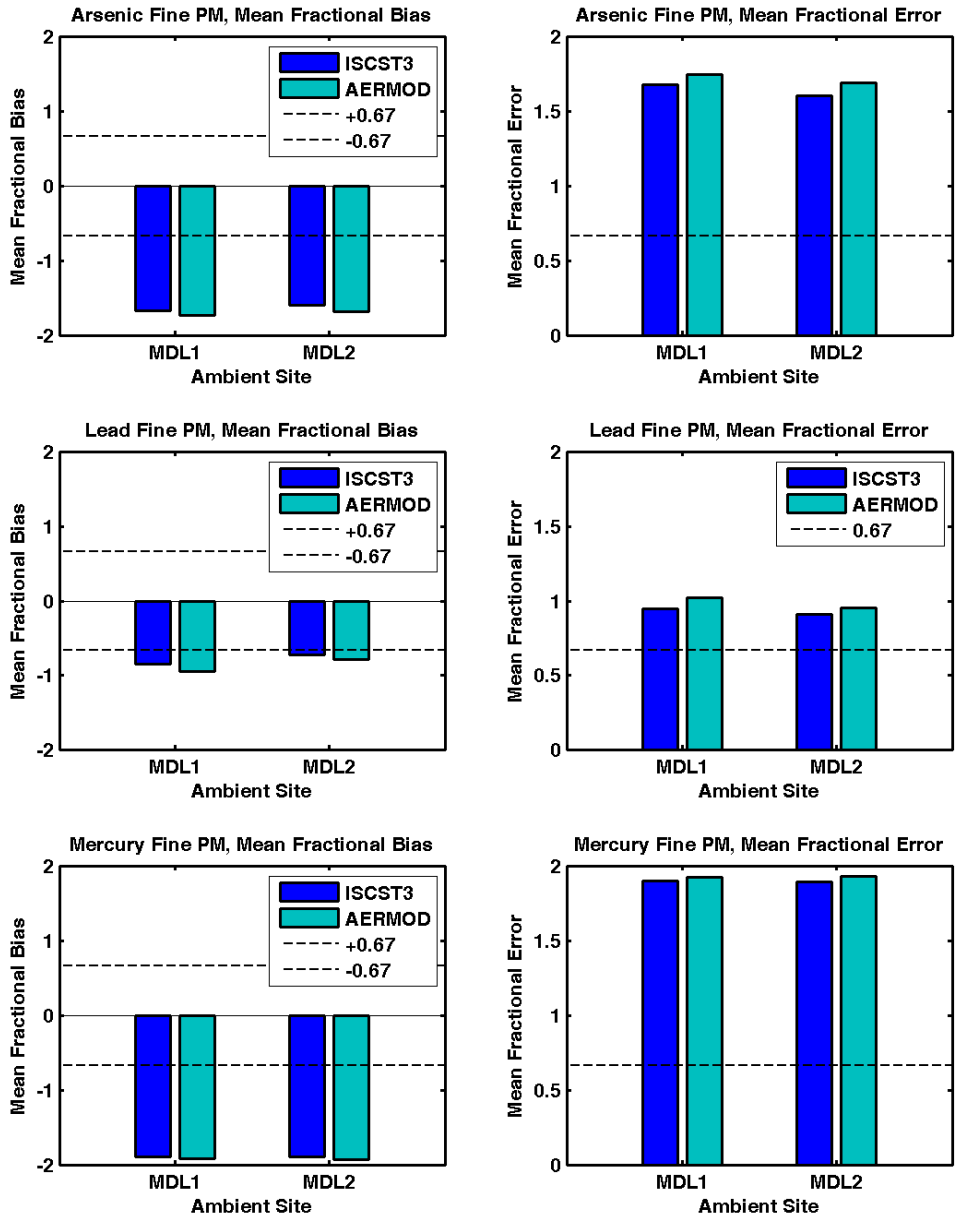


Figure 154. Comparisons of mean fractional bias (MFB) and mean fractional error (MFE) of the ISCST3 and AERMOD model predictions for the three metals (As, Pb, and Hg) with the inputs of NEI-2002 emissions and Newark Airport meteorology. The MNB and MNE metrics were calculated using the model predictions matched with field measurements at each of the field sampling sites for the period of March 17th, 2005 to March 13th, 2007.

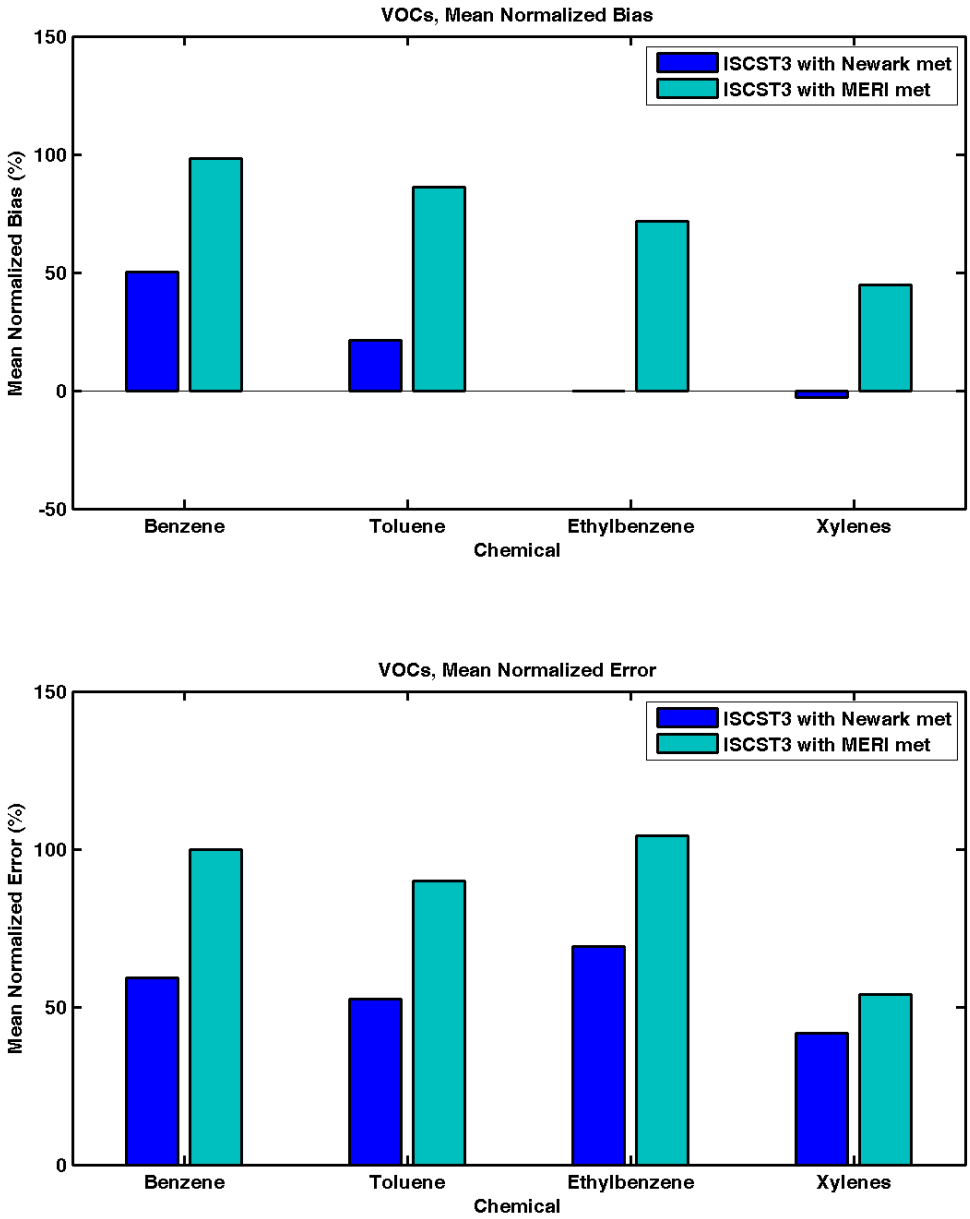


Figure 155. Comparisons of mean normalized bias (MNB) and mean normalized error (MNE) of the ISCST3 model predictions for BTEX with the two different meteorology inputs (Newark Airport data vs. MERI data). The MNB and MNE metrics were calculated using the model predictions matched with field measurements at all of the field sampling sites for the period of June 10, 2006 to March 13, 2007.

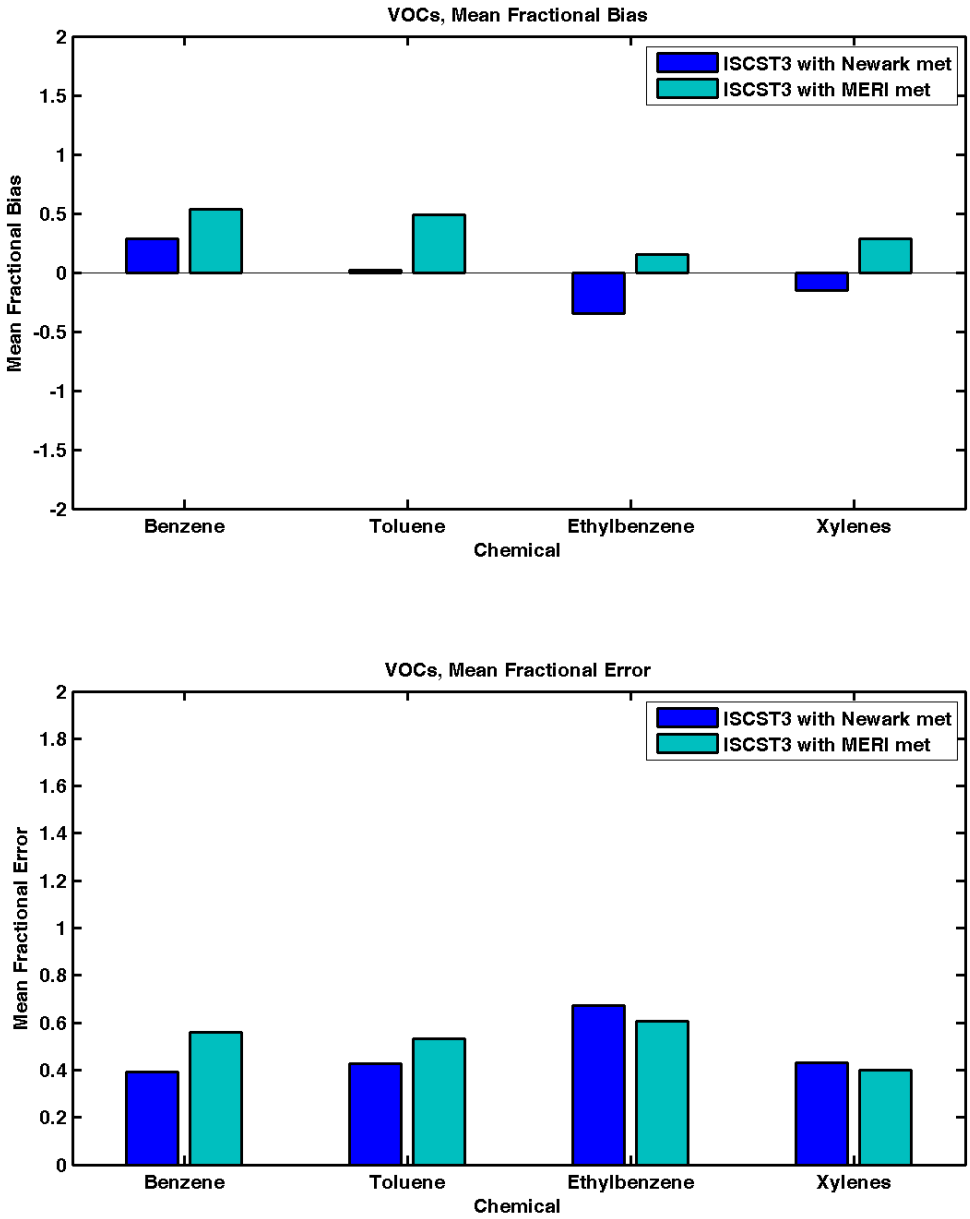


Figure 156. Comparisons of mean fractional bias (MFB) and mean fractional error (MFE) of the ISCST3 model predictions for BTEX with the two different meteorology inputs (Newark Airport data vs. MERI data). The MFB and MFE metrics were calculated using the model predictions matched with field measurements at all of the field sampling sites for the period of June 10, 2006 to March 13, 2007.

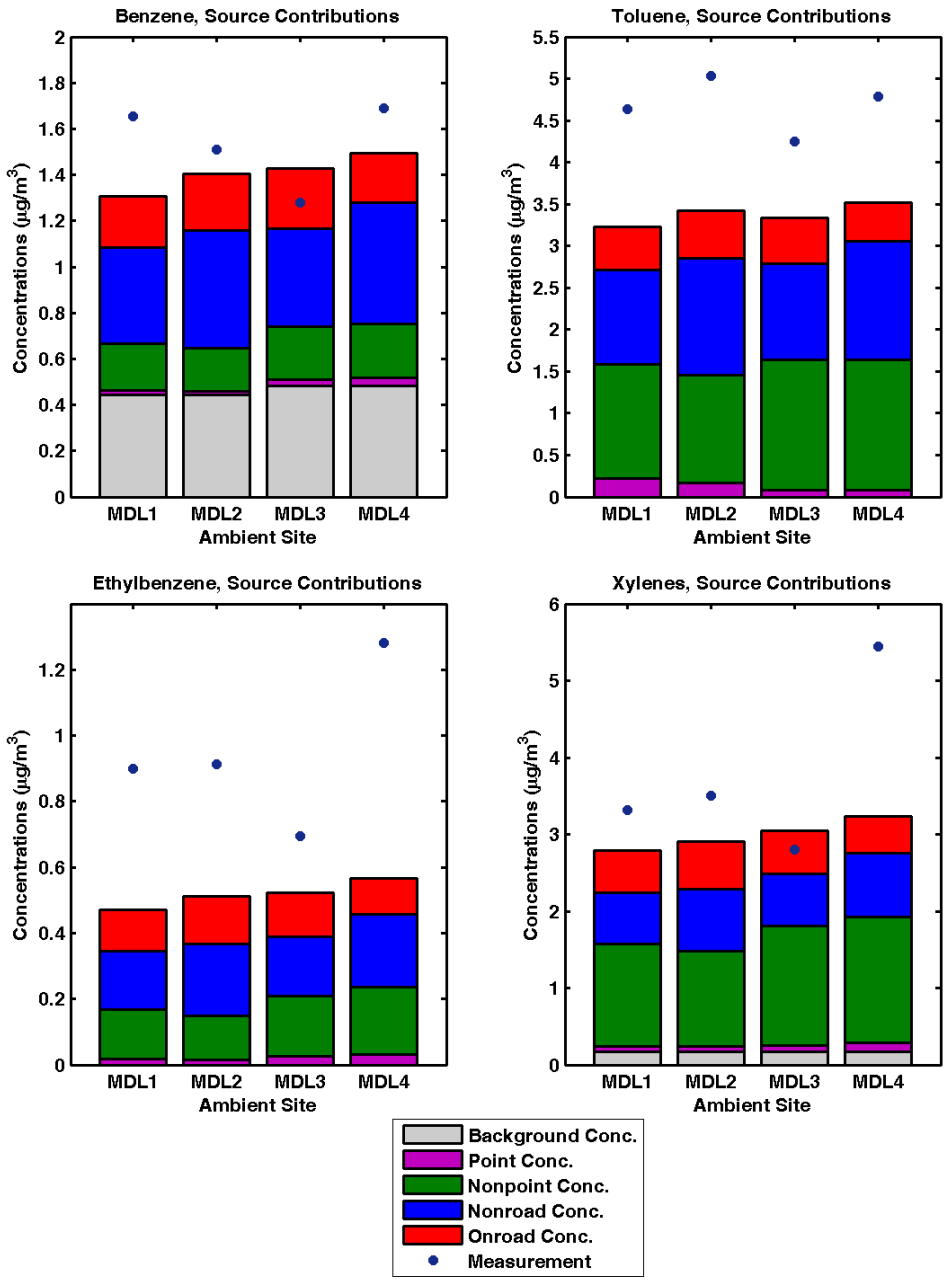


Figure 157. Contributions of ambient sources categorized by five emission groups (i.e. point, non-point (area), mobile non-road, mobile on-road, and background) to the predicted 48-hr averages of the ISCST3 predictions for the BTEX chemicals at each of the 4 receptor locations in the Meadowlands District. Note: The results presented are obtained by averaging the outputs of the source contribution analyses conducted on the 5 selected sampled dates (9/7/2005, 1/11/2006, 2/16/2006, 3/12/2006, and 10/20/2006), which are typical for other sampled dates.

2.4 Summary Conclusions for Modeling Study

Modeling analyses were completed for the time period of March 17th, 2005 to March 13th, 2007 which matched with the time span of the entire field measurement collections focusing on characterizing air quality with respect to the ten selected air toxics (benzene, toluene, ethylbenzene, xylenes, PERC, TCE, PDB, As, Pb, and Hg) for the Meadowlands District. Specifically, the following modeling tasks were conducted.

- Geo-databases of local and regional emissions and aerometric information utilizing existing inventories and standard modeling approaches were developed to facilitate the investigation and quantification of baseline ambient air quality in the vicinity of the Meadowlands District.
- Spatial allocation of mobile on-road emissions methodology was improved by using for the Meadowlands data based on a roadway link-based approach, and implemented in the emission modeling for better characterization of source locations and strengths for mobile on-road emissions. The results provided a better attribution of mobile sources (on-road) which is essential for providing a baseline for future development. The results can be augmented in the future after the impact of development on roadway traffic are characterized or estimated for various sections.
- Iterations of local-scale air quality modeling were performed in order to test the sensitivity of predicted ambient concentrations of the ten selected air toxics with respect to uncertainties in available modeling options. Specifically, different sets of modeling scenarios were performed by combining the following options:
    - Dispersion model: ISCST3 versus AERMOD
    - Emissions inputs: NEI-1999 versus NEI-2002, where the mobile on-road emissions were processed with both options of the census tract-based (the default) approach and the roadway link-based approach.
    - Meteorology inputs: Newark Airport data versus MERI data.
- Extensive model performance evaluations were conducted by comparing the dispersion modeling results with the sensitivity runs with the entire field measurements of the ten selected air toxics for identifying the best modeling options. These evaluations were conducted through six quantitative model performance metrics (i.e., mean bias, mean error, mean normalized bias, mean normalized error, fractional bias, and fractional error).
- Source contribution analyses were completed for the BTEX chemical for assessing the impacts of local ambient sources on the ambient levels in the Meadowlands District.

Performance evaluation findings were summarized as follows.

- Model predictions were generally in agreement with the field measurements of 7 air toxics (Benzene, Toluene, Ethylbenzene, Xylenes, PERC, TCE, PDB, and Pb) within the factor of 2 acceptance criterion recommended by U.S. EPA.
- For As, the model predictions were significantly under-estimated. The emission inventory appears to “miss” major As g sources that need to be identified.
- For Hg, the majority of field measurements were below the detection limits. The corresponding model predictions were also below the detection limits. Therefore, the model predictions were qualitatively in agreement with the field measurements.
- The refinement of mobile on-road emissions through the link-based spatial allocation significantly improved the model performances for the BTEX chemicals. The improvement over the default spatial allocation approach (i.e. census tract-based) generally resulted in

15% to 25% decreases of the mean normalized errors in the comparison with field measurements.

- The model predictions based on the Newark Airport meteorological data had better model performances than those based on the MERI meteorological data but either are acceptable for future modeling analyses.
- The two standard atmospheric dispersion models (ISCST3 and AERMOD) have similar model performances. However, AERMOD showed marginally better model performance than ISCST3 due to its improved incorporation of local meteorology.
- Source contribution analysis results indicated that the local mobile on-road, mobile non-road, and non-point (area) sources were significant contributors to the ambient levels of the BTEX chemicals in the Meadowland District. Further, the contributions from mobile non-road sources were relatively larger than the other two source categories (mobile on-road and non-point) for Benzene and Ethylbenzene. The contributions from non-point (area) sources were relatively larger than mobile non-road and on-road sources for Toluene and Xylenes.

Based upon the comparability between the ambient measurements and the detailed emissions and dispersion modeling results, a firm baseline of the air quality modeling system has been developed for the Meadowlands. This modeling system can be used to assess future states of air quality reflecting impact of specific (and alternative) planned development for the Meadowlands District. Specifically, the emission growth from the current base year (i.e. NEI-2002) to future years can be projected by considering the Meadowlands District specific economic and population growth, fuel consumption, vehicle miles traveled etc. impacted by the development plan. In addition, the rules and policies on emission reductions (i.e. control strategies) from regulatory agencies will need to be taken into account for the projection of future year emissions. Embedded within the air quality modeling system, the "Growth and Control" module of the EMS-HAP program can be used to compute future year (or projected) emissions as a result of projected economic growth and/or emission reduction strategy scenarios.

For the application to the Meadowlands District, the source specific growth factors and control strategies for emission reduction will need to be developed by incorporating the impacts from the development plan of the Meadowlands District. For instance, in the Chapter 10 (Systems Plans) of the Master Plan, Strategy 3 of System 1 mentions "*Encourage emission reductions of pollutants from mobile and stationary sources to improve the metropolitan area's air quality.*" Specific plans include: "*Permit types of land development in patterns that will influence the choices of travel modes available through zoning, planning for areas in need of redevelopment, and design guidelines. Implement smart growth transportation initiatives to enhance the viability of future projects. For example, locating jobs and services in closer proximity reduces reliance upon the automobile.*" Further, Strategy 3 of System 3 mentions: "*Promote vehicular free flow throughout the District. An efficient and effective roadway network can be realized through improving critical links in the system, enhancing access to transit facilities, and introducing innovative methods to reduce traffic and improve traffic flow. The "Mobility 2030" transportation plan will take into account currently proposed roadway improvement projects while considering additional roadway projects that could improve the system.*" The implementation of these plans will impact the roadway network, traffic flows, as well as population density within and around the Meadowlands District in the future. These impacts will result in substantial changes in mobile source emissions in the Meadowlands District. The modeling tools developed in the current study for refining mobile emission estimates can be used to assess the impacts and benefits of implementing these development plans in the District for improving air quality.

Once potential changes in source emissions are projected, the air quality modeling analysis can be re-conducted to assess the impacts of development plans on future air quality of the

Meadowlands District. Further, because of the coherence in the modeling and measurement changes in pollution levels at future or currently operated sites could also trigger the need to re-do the modeling activities to find out why the changes are occurring.

3 General Recommendations for Future Study

1. The Modeling and Measurement results provide a wealth of baseline information, and the modeling tools applied by EOHSI can be used in a prognostic manner as part of future implementation plans to examine the impact of major new sources or land developments in the Meadowlands during the design phases of development, i.e. housing, commercial facilities, sports and entertainment projects. This could help guide the development of more efficient energy technologies, and transportation plans.

2. Exposure monitoring can be incorporated in development projects that include major construction activities or changes in traffic patterns to evaluate changes in personnel exposure during the implementation of the projects and confirm the assumptions underlying the emission projections.

3. To better understand spatial variability in this area, the new sampling strategy called "Saturation" recently implemented by EOHSI could provide a better picture of the spatial variation of VOCs and aldehyde,s thereby improving the knowledge base on spatial variability across various sections of the Meadowlands. It involves placement of passive 24 to 48 hour samplers within a grid associated with strategic locations for examining potentially significant human or ecological exposures. This was employed successfully in a recent study completed in Camden, NJ.

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Appendix A Quality Assurance

A.1 Long Term/Fixed Site Ambient Air Sampling

A.1.1 Overview

The sampling scheme for the collection of PM and VOC samples were provided to MERI personnel responsible for collection of samples, including the collection of duplicate samples and blank samples at a frequency of 10% of the samples. In addition, duplicate samples for VOCs were to have been collected for analysis at EOHSI at a 5% sampling rate. A sampling protocol designating when to collect these QA/QC samplers at each site and for each sample type was developed at EOHSI and provided to MERI personnel (Table A-1). Unfortunately, only few duplicate and blank samples were collected during the study, most of these during the first several months into the study. The following present the results of the analysis of the QA/QC samples.

A.1.2 $PM_{2.5}$ Pump Issues

$PM_{2.5}$ samples were to have been collected from two sites every 6th day for 48 hours. The log information showing the dates that valid samples were collected and the reasons for invalidating a sample are given in Table A-2. A number of missing sample dates or lost samples were encountered during the study. For some samples the flow rate was occasionally not recorded, which resulted in an invalidation of the sample since that is required to determine sample volume. The most frequent problems were the flow rate was outside the acceptable criteria, flow rates <8.5l/min (28 teflon filter samples and 25 quartz filter samples) or the flow rate changing more than 15% (5 teflon filter samples and 6 quartz filter samples). A flow rate <8.5l/min would result in a sufficient change in the size cutoff so that the fraction collected could not be classified as $PM_{2.5}$, while a flow rate change >15% would result in the volume of air collected having an uncertainty exceeding the pre-established data objective goals.

A.1.3 $PM_{2.5}$ Mass

The average blank values for the mass samples was -0.00005±0.004mg (a negative blank is indicates a slight loss of material due to handling of the filter) (Table A-3) with the overall precision (%RSD) of the analyses based on paired samples 21% (Table A-4 and Figure A-1).

A.1.4 $PM_{2.5}$ Metals

The metals were analyzed by ICP-MS. The standard procedures for the instrumental analyses included running laboratory blanks and external NIST QC checks as follows, for every six to eight samples, a 10-ppb solution made from NIST traceable SM- 1811-001 and SM-1811-002 (high-purity element solutions containing 23 elements) was run as a quality control sample (Table A-5). If the quality control sample was not within ± 20% of the certified value for target elements, the instrument was recalibrated and the batch was reanalyzed. Accuracy was determined by comparisons with certified results from standard solution (NIST 1643) and urban PM standard (NIST 1648) to reflect digestion and matrix-extraction recoveries, respectively. Recoveries for most "extractable" elements were between 91% and 103% (Table A-5). Six sampling pairs were collected for the precision measurement. For the target the metals the calculated precisions were: Mg 58%, Mn 38%, Cu 41%, Ni 108%, As 35%, Pb 66% and V 47%, with only three sample pairs being above detection for Cd and Se and none for Hg, so their precision could not be calculated. For the non-target compound the vast majority of the metals were below detection in most of the sample pairs. Blank levels in the handling blanks were below detection for all metals except Mg, Ti, Ni, Cu and Cr and less than 20% of the amount measured on >75% of the samples for Mg,, Ti, and Cu and slightly less for Ni, thus no blank correction was applied for the metals. For chromium,

the blank was highly variable and for some blank filters exceeded the median concentration measured on the samples. The highly variable blank levels combined with the limited number of blanks collected precluded adequately characterizing the chromium blank contribution to samples, so chromium air concentrations are not reported. The detection limit was improved for samples collected after the first few samples when the sample preparation method was altered to reduce the value of water/acid used to digest the sample. The detection limits for conditions used for the vast majority (>90%) of the samples, assuming a nominal flow rate of 10 l/min and a sampling duration of 48hours are presented in (Table A-6).

A.1.5 Elemental and Organic Carbon

The average blank values for the organic carbon (OC) was 1.3 µg per filter which corresponds to an equivalent blank air concentration of 47ng/m^3 assuming a collection flow rate of 10 l/min and 48 hour sampling duration, while elemental carbon (EC) was not detected on any of the blank filters (Table A-7). The overall precisions (%RSD) of the analyses based on paired samples were 32%, 27% and 31% for OC, EC and TC, respectively. The equivalent air concentration detection limit OC and TC, based on the variability around the blanks is 50ng/m^3, while for EC the detection limit was better than 50ng/m^3, based on the instrumentation detections limit.

A.1.6 Volatile Organic Compounds.

These samples were collected and analyzed by personnel at MERI, so this report presents a review of the table provided by MERI. A review of the overall submitted QC data indicate that the compounds eluting prior to chloroform were problematic as the peak assignment was not unique and the reported concentration in the spiked samples were either zero or much higher than the amount added. In discussing this with Dr. Shin, he indicated that the peaks in this region of the chromatogram were poorly resolved and broad and he did not have a high degree of confidence in their reported concentration. It was also noted that the same peak was selected for two compounds, 1,1-dichloroethene and trans 1,2-dichloroethene so the correct identification of that peak and the corresponding concentration can not be determined. It is therefore recommended that no reported concentrations be provided for the following compounds: chlormethane, vinyl chloride, bromomethane, trichlorofluormethane, methylene chloride, 1,1-dichloroethene, *t*-1,2-dichloroethene, 1,1-dichloroethane, 2,2-dichloropropane and bromochloromethane.

Blank values were measured in the solvent and badge extract after they were carried to and from the field. Measurable blank levels were present for many of the aromatic hydrocarbons, as is often found for these badges, and for several of the chlorinated hydrocarbons. The blank levels concentrations bromodichloromethane and chlorobenzene exceeded what would be expected in the badges and were higher than many of the sample concentration. It therefore is suspected that these two compounds were contaminated and should not be reported. Overall, the Standard Calibration curves are good with a correlation coefficient better than 0.95 for most compounds of interest and run with sufficient frequency throughout the study. Some uncertainty exists with standard at the very low concentrations range (liquid standards of 20 and 50ppb) which is typical of these analyses so the very low level concentrations have a greater percent uncertainty. Surrogates and internal standards were within the 15 and 9% RSD, respectively. The method detection limits (MDL) were calculated using the 3M published diffusion rates and a nominal sampling time of 48 hours (Table A-8). The MDL were based on seven repetitive injections at the lowest level standard, which for some compounds had variable recoveries as low as 40% so may have greater uncertainty than would have occurred if a slightly higher concentration had be used. Paired samples (21 collected in 2005 and 2 collected in 2006) were used to calculate the %RSD for the 15 compounds that were detected in sufficient number of samples. The MDL was substituted for the concentration when a concentration was below the detection limit. Styrene %RSD is biased low due to the large number of both the sample and duplicates being below detection. The compounds that had all of there

samples above the detection limit included benzene, toluene, tetrachloroethene, and xylenes. The high %RSD for many of these compounds is a result of the very low concentration present in the majority of the samples which typically has greater uncertainty in their measurement.

There also appears to be a possible error with the m/p xylene measurement made during 2005. The values should be checked to make sure the calibration curve is based on the sum of the concentration of these two compounds in the standard and not just the equivalent value of all of the other compounds since the two compounds co-elute. The values for 2006 and 2007 seem to be correct.

A.2 Intensive Air Sampling

A.2.1 Overview

Samples were collected by EOHSI along hiking trails for VOC analyses using an active pump samplers and adsorbent trap and subsequently analyzed at EOHSI by thermal desorption coupled with GC/MS. Blank values were measured using traps that were carried to and from the field and place in the sampler but had no air was pulled through the trap. Paired samples were collected during each sampling session, with two pairs collected during the first and third sampling periods and all samples (13 pairs) collected in duplicate during the second sampling period.

Measurable blank levels were consistently present for only benzene and toluene, with an occasional detectable value for 1,2,4 trimethylbenzene, trichlorofluoromethane, bromochloromethane and methylene chloride. The aromatic compounds present in the blank are derived from the degradation of the absorbent Tenax, with is a synthetic aromatic polymer, while it is likely that the trichlorofluoromethane and methylene chloride present in the blank are contaminates from the air during the transport or storage of the traps or introduced during the handling in the laboratory. The mean blank values for benzene and toluene from each sampling period were subtracted from the sample measurements to correct for the background and used to calculate the method minimum detection limit.

External standards were routinely run during the analyses and with an acceptance criterion of within ±30% of the expected value for that series of analyses to be considered valid for a compound. Table A-9 shows that the mean calculated concentration for the 2005 external standards as an example of these calibration checks. The calibration curves had R^2 values exceeding 0.9 and in most case 0.95 for compounds that were present in the samples. The method detection limits (MDL) were calculated using a sample volume of 4l and the standard deviation from seven repetitive injections at a low level standard or from the field blanks (Table A-10). The paired samples were used to calculate the %RSD (Table A-11). The precision was only calculated for the13 compounds detected in sufficient number of samples for determining a statistically meaningful value.

Quality Control Analyses for Metals

Table A-1. 2005 - 2006 Meadowlands background air monitoring schedule

No.	Dates		Teflon				Q Backup after Teflon			Quartz				VOCs					
	Started	Ended	T1	T2	T dup	T blank	Q T1	Q T2	Q T dup	Q1	Q2	Q dup	Q blank	V1	V2	V3	V4	V dup	V blank
1	3/17/2005	3/19/2005	1	1	1	1				1	1		1	1	1	1	1	1	1
2	3/23/2005	3/25/2005	1	1	1	1				1	1			1	1	1	1		1
3	3/29/2005	3/31/2005												1	1	1	1	1	
4	4/4/2005	4/6/2005	1	1						1	1	1		1	1	1	1		1
5	4/10/2005	4/12/2005	1	1						1	1		1	1	1	1	1	1	
6	4/16/2005	4/18/2005	1	1	1					1	1			1	1	1	1		1
7	4/22/2005	4/24/2005	1	1		1				1	1			1	1	1	1	1	
8	4/28/2005	4/30/2005	1	1						1	1	1		1	1	1	1		1
9	5/4/2005	5/6/2005	1	1						1	1			1	1	1	1	1	1
10	5/10/2005	5/12/2005	1	1						1	1		1	1	1	1	1	1	
11	5/16/2005	5/18/2005	1	1	1					1	1			1	1	1	1		1
12	5/22/2005	5/24/2005	1	1		1				1	1			1	1	1	1	1	
13	5/28/2005	5/30/2005	1	1						1	1	1		1	1	1	1		1
14	6/3/2005	6/5/2005	1	1						1	1			1	1	1	1		
15	6/9/2005	6/11/2005	1	1						1	1		1	1	1	1	1	1	
16	6/15/2005	6/17/2005	1	1	1					1	1			1	1	1	1		1
17	6/21/2005	6/23/2005	1	1		1	1	1		1	1			1	1	1	1	1	
18	6/27/2005	6/29/2005	1	1			1	1		1	1	1		1	1	1	1		1
19	7/3/2005	7/5/2005	1	1			1	1		1	1			1	1	1	1		
20	7/9/2005	7/11/2005	1	1			1	1		1	1		1	1	1	1	1	1	
21	7/15/2005	7/17/2005	1	1	1		1	1	1	1	1			1	1	1	1		1
22	7/21/2005	7/23/2005	1	1		1	1	1		1	1			1	1	1	1	1	
23	7/27/2005	7/29/2005	1	1			1	1		1	1	1		1	1	1	1		1
24	8/2/2005	8/4/2005	1	1			1	1		1	1			1	1	1	1	1	
25	8/8/2005	8/10/2005	1	1			1	1		1	1		1	1	1	1	1		1
26	8/14/2005	8/16/2005	1	1	1		1	1	1	1	1			1	1	1	1	1	
27	8/20/2005	8/22/2005	1	1		1	1	1		1	1			1	1	1	1		1
28	8/26/2005	8/28/2005	1	1			1	1		1	1	1		1	1	1	1		
29	9/1/2005	9/3/2005	1	1			1	1		1	1			1	1	1	1	1	
30	9/7/2005	9/9/2005	1	1			1	1		1	1		1	1	1	1	1		1
31	9/13/2005	9/15/2005	1	1	1		1	1	1	1	1			1	1	1	1	1	
32	9/19/2005	9/21/2005	1	1		1	1	1		1	1			1	1	1	1		1
33	9/25/2005	9/27/2005	1	1			1	1		1	1	1		1	1	1	1		
34	10/1/2005	10/3/2005	1	1			1	1		1	1			1	1	1	1	1	
35	10/7/2005	10/9/2005	1	1			1	1		1	1		1	1	1	1	1		1
36	10/13/2005	10/15/2005	1	1	1		1	1	1	1	1			1	1	1	1	1	
37	10/19/2005	10/21/2005	1	1		1	1	1		1	1			1	1	1	1		1
38	10/25/2005	10/27/2005	1	1			1	1		1	1	1		1	1	1	1	1	
39	10/31/2005	11/2/2005	1	1			1	1		1	1			1	1	1	1		1
40	11/6/2005	11/8/2005	1	1			1	1		1	1		1	1	1	1	1	1	
41	11/12/2005	11/14/2005	1	1	1		1	1	1	1	1			1	1	1	1		1
42	11/18/2005	11/20/2005	1	1		1	1	1		1	1			1	1	1	1		

Table A-1. (continued)

No.	Dates		Teflon				Q Backup after Teflon			Quartz				VOCs					
	Started	Ended	T1	T2	T dup	T blank	Q T1	Q T2	Q T dup	Q1	Q2	Q dup	Q blank	V1	V2	V3	V4	V dup	V blank
43	11/24/2005	11/26/2005	1	1			1	1		1	1	1		1	1	1	1	1	
44	11/30/2005	12/2/2005	1	1			1	1		1	1			1	1	1	1		1
45	12/6/2005	12/8/2005	1	1			1	1		1	1		1	1	1	1	1	1	
46	12/12/2005	12/14/2005	1	1	1		1	1	1	1	1			1	1	1	1		1
47	12/18/2005	12/20/2005	1	1		1	1	1		1	1			1	1	1	1		
48	12/24/2005	12/26/2005	1	1			1	1		1	1	1		1	1	1	1	1	
49	12/30/2005	1/1/2006	1	1			1	1		1	1			1	1	1	1		1
50	1/5/2006	1/7/2006	1	1			1	1		1	1		1	1	1	1	1	1	
51	1/11/2006	1/13/2006	1	1	1		1	1	1	1	1			1	1	1	1		1
52	1/17/2006	1/19/2006	1	1		1	1	1		1	1			1	1	1	1	1	
53	1/23/2006	1/25/2006	1	1			1	1		1	1	1		1	1	1	1		1
54	1/29/2006	1/31/2006	1	1			1	1		1	1			1	1	1	1	1	
55	2/4/2006	2/6/2006	1	1			1	1		1	1		1	1	1	1	1		1
56	2/10/2006	2/12/2006	1	1	1		1	1	1	1	1			1	1	1	1		
57	2/16/2006	2/18/2006	1	1		1	1	1		1	1			1	1	1	1	1	
58	2/22/2006	2/24/2006	1	1			1	1		1	1	1		1	1	1	1		1
59	2/28/2006	3/2/2006	1	1			1	1		1	1			1	1	1	1	1	
60	3/6/2006	3/8/2006	1	1			1	1		1	1		1	1	1	1	1		1
61	3/12/2006	3/14/2006	1	1	1		1	1	1	1	1			1	1	1	1		
62	3/18/2006	3/20/2006	1	1		1	1	1		1	1			1	1	1	1	1	
63	3/24/2006	3/26/2006	1	1			1	1		1	1	1		1	1	1	1		1
64	3/30/2006	4/1/2006	1	1			1	1		1	1			1	1	1	1	1	
65	4/5/2006	4/7/2006	1	1			1	1		1	1		1	1	1	1	1		1
66	4/11/2006	4/13/2006	1	1	1		1	1	1	1	1			1	1	1	1		
67	4/17/2006	4/19/2006	1	1		1	1	1		1	1			1	1	1	1	1	
68	4/23/2006	4/25/2006	1	1			1	1		1	1	1		1	1	1	1		1
69	4/29/2006	5/1/2006	1	1			1	1		1	1			1	1	1	1	1	
70	5/5/2006	5/7/2006	1	1			1	1		1	1		1	1	1	1	1		1
71	5/11/2006	5/13/2006	1	1	1		1	1	1	1	1			1	1	1	1		
72	5/17/2006	5/19/2006	1	1		1	1	1		1	1			1	1	1	1	1	
73	5/23/2006	5/25/2006	1	1			1	1		1	1	1		1	1	1	1		1
74	5/29/2006	5/31/2006	1	1			1	1		1	1			1	1	1	1	1	
75	6/4/2006	6/6/2006	1	1			1	1		1	1		1	1	1	1	1		1
76	6/10/2006	6/12/2006	1	1	1		1	1	1	1	1			1	1	1	1		
77	6/16/2006	6/18/2006	1	1		1	1	1		1	1			1	1	1	1	1	
78	6/22/2006	6/24/2006	1	1			1	1		1	1	1		1	1	1	1		1
79	6/28/2006	6/30/2006	1	1			1	1		1	1			1	1	1	1	1	
80	7/4/2006	7/6/2006	1	1			1	1		1	1		1	1	1	1	1		1
81	7/10/2006	7/12/2006	1	1	1		1	1	1	1	1			1	1	1	1		
82	7/16/2006	7/18/2006	1	1		1	1	1		1	1			1	1	1	1	1	
83	7/22/2006	7/24/2006	1	1			1	1		1	1	1		1	1	1	1		1
84	7/28/2006	7/30/2006	1	1			1	1		1	1			1	1	1	1	1	
85	8/3/2006	8/5/2006	1	1			1	1		1	1		1	1	1	1	1		1

Table A-1. (continued)

No.	Dates		Teflon				Q Backup after Teflon			Quartz				VOCs					
	Started	Ended	T1	T2	T dup	T blank	Q T1	Q T2	Q T dup	Q1	Q2	Q dup	Q blank	V1	V2	V3	V4	V dup	V blank
86	8/9/2006	8/11/2006	1	1	1		1	1	1	1	1			1	1	1	1		
87	8/15/2006	8/17/2006	1	1		1	1	1		1	1			1	1	1	1	1	
88	8/21/2006	8/23/2006	1	1			1	1		1	1	1		1	1	1	1		1
89	8/27/2006	8/29/2006	1	1			1	1		1	1			1	1	1	1	1	
90	9/2/2006	9/4/2006	1	1			1	1		1	1		1	1	1	1	1		1
91	9/8/2006	9/10/2006	1	1	1		1	1	1	1	1			1	1	1	1		
92	9/14/2006	9/16/2006	1	1		1	1	1		1	1	1		1	1	1	1	1	
93	9/20/2006	9/22/2006	1	1			1	1		1	1			1	1	1	1		1
94	9/26/2006	9/28/2006	1	1			1	1		1	1			1	1	1	1	1	
95	10/2/2006	10/4/2006	1	1			1	1		1	1	1	1	1	1	1	1		1
96	10/8/2006	10/10/2006	1	1	1		1	1	1	1	1			1	1	1	1		
97	10/14/2006	10/16/2006	1	1		1	1	1		1	1			1	1	1	1	1	
98	10/20/2006	10/22/2006	1	1			1	1		1	1	1		1	1	1	1		1
99	10/26/2006	10/28/2006	1	1			1	1		1	1			1	1	1	1	1	
100	11/1/2006	11/3/2006	1	1			1	1		1	1		1	1	1	1	1		1
101	11/7/2006	11/9/2006	1	1	1		1	1	1	1	1			1	1	1	1		
102	11/13/2006	11/15/2006	1	1		1	1	1		1	1			1	1	1	1	1	
103	11/19/2006	11/21/2006	1	1			1	1		1	1	1		1	1	1	1		1
104	11/25/2006	11/27/2006	1	1			1	1		1	1			1	1	1	1	1	
105	12/1/2006	12/3/2006	1	1			1	1		1	1		1	1	1	1	1		1
106	12/7/2006	12/9/2006	1	1	1		1	1	1	1	1			1	1	1	1		
107	12/13/2006	12/15/2006	1	1		1	1	1		1	1			1	1	1	1	1	
108	12/19/2006	12/21/2006	1	1			1	1		1	1	1		1	1	1	1		1
109	12/25/2006	12/27/2006	1	1			1	1		1	1			1	1	1	1	1	
110	12/31/2006	1/2/2007	1	1			1	1		1	1		1	1	1	1	1		1
111	1/6/2007	1/8/2007	1	1	1		1	1	1	1	1			1	1	1	1		
112	1/12/2007	1/14/2007	1	1		1	1	1		1	1			1	1	1	1	1	
113	1/18/2007	1/20/2007	1	1			1	1		1	1	1		1	1	1	1		1
114	1/24/2007	1/26/2007	1	1			1	1		1	1			1	1	1	1	1	
115	1/30/2007	2/1/2007	1	1			1	1		1	1		1	1	1	1	1		1
116	2/5/2007	2/7/2007	1	1	1		1	1	1	1	1			1	1	1	1		
117	2/11/2007	2/13/2007	1	1		1	1	1		1	1			1	1	1	1	1	
118	2/17/2007	2/19/2007	1	1			1	1		1	1	1		1	1	1	1		1
119	2/23/2007	2/25/2007	1	1			1	1		1	1			1	1	1	1	1	
120	3/1/2007	3/3/2007	1	1			1	1		1	1		1	1	1	1	1		1
121	3/7/2007	3/9/2007	1	1	1		1	1	1	1	1			1	1	1	1		
122	3/13/2007	3/15/2007	1	1		1	1	1		1	1			1	1	1	1	1	
Counts			**121**	**121**	**26**	**26**	**106**	**106**	**21**	**121**	**121**	**25**	**25**	**122**	**122**	**122**	**122**	**52**	**52**
Total Samples & percents			**Total**	**242**	**10.7%**	**10.7%**				**Total**	**242**	**10.3%**	**10.3%**			**Total**	**488**	**10.7%**	**10.7%**

Table A-2 Log information showing dates valid samples were collected and reasons for invalidating a sample

			Quartz Filter																
Date Started	Date Ended	Operator	Site	ID (Qtz)	Time Started	Initial Flow	Time Ended	Final Flow	Average Flow (l/min)	% Flow Change	Post Leak Test	Time & Date Started	Time & Date Ended	Sample Duration	Duration (min)	Volume (m3)	Sample Validity	NOTES
03/17/05	03/19/05	JS	1	001	12:34	9.52	11:57				OK	3/17/05 12:34 PM	3/19/05 11:57 AM	47:23	2843		n	Low flow on Dup and Q1 - not valid
03/17/05	03/19/05	JS	2	002	15:12	10.01	12:53				OK	3/17/05 3:12 PM	3/19/05 12:53 PM	45:41	2741		n	
03/17/05	03/19/05	JS	Blank	003														Low flow on Dup and Q1 - not valid
03/17/05	03/19/05	JS																
03/23/05	03/25/05	JS	1	004													n	Q1 pump malfuntion - not valid
03/23/05	03/25/05	JS	2	005	9:25	10.23	9:12	9.43	9.83	-8%	OK	3/23/05 9:25 AM	3/25/05 9:12 AM	47:47	2747	27.00	y	
03/23/05	03/25/05	JS	Blank	006														
03/23/05	03/25/05	JS																
04/04/05	04/06/05	MN	1	008	12:39	9.73	11:35	9.02	9.37	-7%	OK	4/4/05 12:39 PM	4/6/05 11:35 AM	46:56	2816	26.40	y	Flow meter not working. Samples held until 4/4.
04/04/05	04/06/05	MN	2	009	12:05	10.07	11:17	9.46	9.77	-6%	OK	4/4/05 12:05 PM	4/6/05 11:17 AM	47:12	2832	27.66	y	
04/04/05	04/06/05	MN	1 (duplicate)	010	12:39	10.05	11:37	9.20	9.62	-8%	OK	4/4/05 12:39 PM	4/6/05 11:37 AM	46:58	2818	27.12	y	
04/10/05	04/12/05	JS	1	014	10:10	10.12	11:59	9.66	9.89	-5%	OK	4/10/05 10:10 AM	4/12/05 11:59 AM	49:49	2989	29.56	y	
04/10/05	04/12/05	JS	2	015	11:32	9.99	11:05	9.51	9.75	-5%	OK	4/10/05 11:32 AM	4/12/05 11:05 AM	47:33	2853	27.81	y	
04/10/05	04/12/05	JS	Blank	016														
04/16/05	04/18/05	MN	1	011	16:10	10.94	14:17	9.82	10.38	-10%	OK	4/16/05 4:10 PM	4/18/05 2:17 PM	46:07	2767	28.72	y	
04/16/05	04/18/05	MN	2	012	15:45	10.27	14:00	9.39	9.83	-9%	OK	4/16/05 3:45 PM	4/18/05 2:00 PM	46:15	2775	27.28	y	
04/16/05	04/18/05	MN																
04/22/05	04/24/05	JS	1	018	11:24	10.49	10:41	9.83	10.16	-6%	OK	4/22/05 11:24 AM	4/24/05 10:41 AM	47:17	2837	28.82	y	
04/22/05	04/24/05	JS	2	017	11:07	10.12	10:26	9.54	9.83	-6%	OK	4/22/05 11:07 AM	4/24/05 10:26 AM	47:19	2839	27.91	y	
04/22/05	04/24/05	JS																
04/28/05	04/30/05	JS	1	019	12:47	10.48	10:35	9.54	10.01	-9%	OK	4/28/05 12:47 PM	4/30/05 10:35 AM	45:48	2758	27.61	y	
04/28/05	04/30/05	JS	2	020	12:31	10.07	10:49	9.39	9.73	-7%	OK	4/28/05 12:31 PM	4/30/05 10:49 AM	46:18	2778	27.02	y	
04/28/05	04/30/05	JS	2 (duplicate)	021	12:31	10.05	11:10	9.28	9.67	-8%	OK	4/28/05 12:31 PM	4/30/05 11:10 AM	46:39	2799	27.06		
05/04/05	05/06/05	JS	1	022	11:56	10.53	10:38	9.71	10.12	-8%	OK	5/4/05 11:56 AM	5/6/05 10:38 AM	46:42	2802	28.36	y	
05/04/05	05/06/05	JS	2	023	11:35	9.99	10:26	9.21	9.60	-8%	OK	5/4/05 11:35 AM	5/6/05 10:26 AM	46:51	2811	26.99	y	
05/10/05	05/12/05	JS	1	024	12:15	10.67	11:18	9.63	10.15	-10%	OK	5/10/05 12:15 PM	5/12/05 11:18 AM	47:03	2823	28.65	y	
05/10/05	05/12/05	JS	2	025	11:47	10.06	10:56	9.87	9.97	-2%	OK	5/10/05 11:47 AM	5/12/05 10:56 AM	47:09	2829	28.19	y	
05/10/05	05/12/05	JS	Blank	026														
05/16/05	05/18/05	JS	1	027	13:34	10.78	14:11	9.84	10.31	-9%	OK	5/16/05 1:34 PM	5/18/05 2:11 PM	48:37	2917	30.07	y	
05/16/05	05/18/05	JS	2	028	13:09	10.27	13:51	9.29	9.78	-10%	OK	5/16/05 1:09 PM	5/18/05 1:51 PM	48:42	2922	28.58	y	
05/16/05	05/18/05	JS																
05/22/05	05/24/05	JS	1	029	9:45	10.80	9:30	10.31	10.56	-5%	OK	5/22/05 9:45 AM	5/24/05 9:30 AM	47:45	2865	30.24	y	
05/22/05	05/24/05	JS	2	030	10:28	10.38	10:47	9.35	9.87	-10%	OK	5/22/05 10:28 AM	5/24/05 10:47 AM	48:19	2899	28.60	y	
05/22/05	05/24/05	JS																
05/28/05	05/30/05	JS	1	031	11:54	10.08	11:50	8.97	9.53	-11%	OK	5/28/05 11:54 AM	5/30/05 11:50 AM	47:56	2876	27.39	y	
05/28/05	05/30/05	JS	2	032	12:45	10.13	12:27	9.03	9.58	-11%	OK	5/28/05 12:45 PM	5/30/05 12:27 PM	47:42	2862	27.42	y	
06/03/05	06/05/05	JS	1	033	13:13	10.26	13:10	9.86	10.06	-4%	OK	6/3/05 1:13 PM	6/5/05 1:10 PM	47:57	2877	28.94	y	
06/03/05	06/05/05	JS	2	034	12:38	9.90	13:39	9.96	9.93	1%	OK	6/3/05 12:38 PM	6/5/05 1:39 PM	49:01	2941	29.21	y	
06/03/05	06/05/05	JS	1 (duplicate)	035	13:13	10.81	13:10	10.10	10.46	-7%	OK	6/3/05 1:13 PM	6/5/05 1:10 PM	47:57	2877	30.08	y	
06/09/05	06/11/05	JS	1	038	10:57	10.24	11:28	9.55	9.90	-7%	OK	6/9/05 10:57 AM	6/11/05 11:28 AM	48:31	2911	28.80	y	
06/09/05	06/11/05	JS	2	036	10:26	10.15	11:10	8.96	9.56	-12%	OK	6/9/05 10:26 AM	6/11/05 11:10 AM	48:44	2924	27.94	y	
06/09/05	06/11/05	JS	BLANK	037														
06/15/05	06/17/05	JS	1	039	12:04	10.62	11:23	9.67	10.15	-9%	OK	6/15/05 12:04 PM	6/17/05 11:23 AM	47:19	2839	28.80	y	
06/15/05	06/17/05	JS	2	040	11:39	10.23	10:55	9.18	9.71	-10%	OK	6/15/05 11:39 AM	6/17/05 10:55 AM	47:16	2836	27.52	y	
06/15/05	06/17/05	JS																
06/21/05	06/23/05	JS	1	043	12:27	10.85	11:54				NA	6/21/05 12:27 PM	6/23/05 11:54 AM	47:27	2847		n	Power problem at site 1. Not valid
06/21/05	06/23/05	JS	2	044	12:09	10.09	11:36	8.92	9.51	-12%	OK	6/21/05 12:09 PM	6/23/05 11:36 AM	47:27	2847	27.06	y	
06/21/05	06/23/05	JS																
06/27/05	06/29/05	JS	1	045	12:36	10.15	15:10	9.29	9.72	-8%	OK	6/27/05 12:36 PM	6/29/05 3:10 PM	50:34	3034	29.49	y	

Table A 2 (continued)

			Quartz Filter															
Date Started	Date Ended	Operator	Site	ID (Qtz)	Time Started	Initial Flow	Time Ended	Final Flow	Average Flow (l/min)	% Flow Change	Post Leak Test	Time & Date Started	Time & Date Ended	Sample Duration	Duration (min)	Volume (m3)	Sample Validity	NOTES
06/27/05	06/29/05	JS	2	046	12:16	10.14	14:55	9.25	9.70	-9%	OK	6/27/05 12:16 PM	6/29/05 2:55 PM	50:39	3039	29.46	y	
06/27/05	06/29/05	JS	BLANK	049														T049 and Q050 were loaded and unloaded blanks
07/03/05	07/05/05	JS	1	056	13:28	10.55	11:52	9.26	9.91	-12%	OK	7/3/05 1:28 PM	7/5/05 11:52 AM	46:24	2784	27.58	y	
07/03/05	07/05/05	JS	2	064	13:14	10.51	11:25	9.70	10.11	-8%	OK	7/3/05 1:14 PM	7/5/05 11:25 AM	46:11	2771	28.00	y	
07/03/05	07/05/05	JS	BLANK	054														
07/03/05	07/05/05	JS	BLANK	055														T051 and Q055 were loaded and unloaded blanks
07/09/05	07/11/05	JS	1	065	12:41	7.06	12:32	6.75	6.91	-4%	OK	7/9/05 12:41 PM	7/11/05 12:32 PM	47:51	2871	19.82	n	Low flow at Q1
07/09/05	07/11/05	JS	2	066	13:06	10.24	12:14	9.05	9.65	-12%	OK	7/9/05 1:06 PM	7/11/05 12:14 PM	47:08	2828	27.28	y	
07/15/05	07/17/05	JS	1	070	10:52	7.91	11:12	6.97	7.44	-12%	OK	7/15/05 10:52 AM	7/17/05 11:12 AM	48:20	2900	21.58	n	
07/15/05	07/17/05	JS	2	069	11:20	10.12	12:39	8.93	9.53	-12%	OK	7/15/05 11:20 AM	7/17/05 12:39 PM	49:19	2959	28.18	y	
07/21/05	07/23/05	MN	1	075	11:10	8.86	13:50	8.89	8.88	0%	OK	7/21/05 11:10 AM	7/23/05 1:50 PM	50:40	3040	26.98	y	
07/21/05	07/23/05	MN	2	076	10:54	9.86	14:10	9.69	9.78	-2%	OK	7/21/05 10:54 AM	7/23/05 2:10 PM	51:16	3076	30.07	y	
07/27/05	07/29/05	EK	1	079	13:17	9.08	12:53	8.48	8.78	-7%	OK	7/27/05 1:17 PM	7/29/05 12:53 PM	47:36	2856	25.08	y	
07/27/05	07/29/05	EK	2	081	11:51	9.65	11:40	8.60	9.13	-11%	OK	7/27/05 11:51 AM	7/29/05 11:40 AM	47:49	2869	26.18	y	
08/02/05	08/04/05	EK	1	094	11:02	9.95	11:37	9.64	9.80	-3%	OK	8/2/05 11:02 AM	8/4/05 11:37 AM	48:35	2915	28.55	y	
08/02/05	08/04/05	EK	2	092	10:20	9.74	10:47	8.81	9.28	-10%	OK	8/2/05 10:20 AM	8/4/05 10:47 AM	48:27	2907	26.96	y	
08/08/05	08/10/05	EK	1	085	12:06	9.91	11:46	9.64	9.78	-3%	OK	8/8/05 12:06 PM	8/10/05 11:46 AM	47:40	2860	27.96	y	
08/08/05	08/10/05	EK	2	084	11:47	9.72	11:24	9.40	9.56	-3%	OK	8/8/05 11:47 AM	8/10/05 11:24 AM	47:37	2857	27.31	y	
08/14/05	08/16/05	JS	1	087	14:57	10.04	14:00				OK	8/14/05 2:57 PM	8/16/05 2:00 PM	47:03	2823		n	Power was cut to both sites. Not valid
08/14/05	08/16/05	JS	2	088	14:46	10.76	13:45				OK	8/14/05 2:46 PM	8/16/05 1:45 PM	46:59	2819		n	not valid
08/14/05	08/16/05	JS																
08/20/05	08/22/05	EK	1	115	12:47	10.23	13:13	7.83	9.03	-23%	OK	8/20/05 12:47 PM	8/22/05 1:13 PM	48:26	2886	26.06	n	
08/20/05	08/22/05	EK	2	113	12:23	10.42	12:50	9.63	10.03	-8%	OK	8/20/05 12:23 PM	8/22/05 12:50 PM	48:27	2887	28.94	y	
08/20/05	08/22/05	EK																
08/26/05	08/28/05	JS	1	096	14:05	10.50	13:01	9.65	10.08	-8%	OK	8/26/05 2:05 PM	8/28/05 1:01 PM	46:56	2816	28.37	y	
08/26/05	08/28/05	JS	2	097	13:49	10.49	12:43	9.67	10.08	-8%	OK	8/26/05 1:49 PM	8/28/05 12:43 PM	46:54	2814	28.37	y	
09/01/05	09/03/05	JS	1	100	9:58	10.22	11:54	9.76	9.99	-5%	OK	9/1/05 9:58 AM	9/3/05 11:54 AM	49:56	2996	29.93	y	
09/01/05	09/03/05	JS	2	101	9:43	10.31	11:35	9.60	9.96	-7%	OK	9/1/05 9:43 AM	9/3/05 11:35 AM	49:52	2992	29.79	y	
09/07/05	09/09/05	JS	1	106	12:10	10.51	12:07	9.98	10.25	-5%	OK	9/7/05 12:10 PM	9/9/05 12:07 PM	47:57	2877	29.47	y	
09/07/05	09/09/05	JS	2	105	11:53	10.30	11:52	9.69	10.00	-6%	OK	9/7/05 11:53 AM	9/9/05 11:52 AM	47:59	2879	28.78	y	
09/13/05	09/15/05	JS	1	110	10:10	10.45	10:10	9.57	10.01	-8%	OK	9/13/05 10:10 AM	9/15/05 10:10 AM	48:00	2880	28.83	y	
09/13/05	09/15/05	JS	2	111	10:58	10.34	11:43	9.74	10.04	-6%	OK	9/13/05 10:58 AM	9/15/05 11:43 AM	48:45	2825	28.36	y	
09/19/05	09/21/05	JS																NO QUARTZ FILTERS
09/19/05	09/21/05	JS																
09/25/05	09/27/05	EK	1	116	15:10	10.54	14:10	9.69	10.12	-8%	OK	9/25/05 3:10 PM	9/27/05 2:10 PM	47:00	2820	28.52	y	
09/25/05	09/27/05	EK	2	118	14:52	10.50	14:50	9.62	10.06	-8%	OK	9/25/05 2:52 PM	9/27/05 2:50 PM	47:58	2878	28.95	y	
10/01/05	10/03/05	EK	1	135	15:55	10.38	14:10	9.70	10.04	-7%	OK	10/1/05 3:55 PM	10/3/05 2:10 PM	46:15	2775	27.86	y	
10/01/05	10/03/05	EK	2	137	15:42	10.42	14:56	9.44	9.93	-9%	OK	10/1/05 3:42 PM	10/3/05 2:56 PM	47:14	2834	28.14	y	
10/07/05	10/09/05	JS	1	122	14:55	10.17	14:08	10.27	10.22	1%	OK	10/7/05 2:55 PM	10/9/05 2:08 PM	47:13	2833	28.95	y	
10/07/05	10/09/05	JS	2	123	14:42	10.28	13:54	9.49	9.89	-8%	OK	10/7/05 2:42 PM	10/9/05 1:54 PM	47:12	2832	27.99	y	
10/07/05	10/09/05	JS	BLANK	124														
10/13/05	10/15/05	JS	1	127	13:18	10.42	15:24	10.33	10.38	-1%	OK	10/13/05 1:18 PM	10/15/05 3:24 PM	50:06	3006	31.19	y	
10/13/05	10/15/05	JS	2	128	13:03	10.14	14:58	9.81	9.98	-3%	OK	10/13/05 1:03 PM	10/15/05 2:58 PM	49:55	4995	49.83	y	
10/19/05	10/21/05	JS	1	131	13:35	10.32	14:05	5.74	8.03	-44%	OK	10/19/05 1:35 PM	10/21/05 2:05 PM	48:30	2910	23.37	n	Low flow at Q1
10/19/05	10/21/05	JS	2	132	13:50	10.24	13:47	9.50	9.87	-7%	OK	10/19/05 1:50 PM	10/21/05 1:47 PM	47:57	2877	28.40	y	
10/19/05	10/21/05	JS	BLANK	133														
10/25/05	10/27/05	JS	1	138	12:57	6.47	11:15	10.14	8.31	57%	OK	10/25/05 12:57 PM	10/27/05 11:15 AM	46:18	2778	23.07	n	Low flow at Q1 again
10/25/05	10/27/05	JS	2	139	10:34	6.11	10:15	9.66	7.89	58%	OK	10/25/05 10:34 AM	10/27/05 10:15 AM	47:41	2861	22.56	n	
10/31/05	11/02/05	JS	1	161	13:45		14:00					10/31/05 1:45 PM	11/2/05 2:00 PM	48:15	2895		n	Flow meter was not working. No flow measures recorded. Not valid

Table A 2 (continued)

			Quartz Filter															
Date Started	Date Ended	Operator	Site	ID (Qtz)	Time Started	Initial Flow	Time Ended	Final Flow	Average Flow (l/min)	% Flow Change	Post Leak Test	Time & Date Started	Time & Date Ended	Sample Duration	Duration (min)	Volume (m3)	Sample Validity	NOTES
10/31/05	11/02/05	JS	2	162	13:15		14:30					10/31/05 1:15 PM	11/2/05 2:30 PM	49:15	2955		n	Flow meter was not working. No flow measures recorded. Not valid
11/06/05	11/08/05	EK	1	169	14:22	10.39	14:35	9.47	9.93	-9%	OK	11/6/05 2:22 PM	11/8/05 2:35 PM	48:13	2893	28.73	y	Hole in T filter 99
11/06/06	11/08/06	EK	2	165	14:08	10.21	14:21	9.47	9.84	-7%	OK	11/6/06 2:08 PM	11/8/06 2:21 PM	48:13	2893	28.47	y	
11/12/05	11/14/05	EK	1	171	15:53		14:25					11/12/05 3:53 PM	11/14/05 2:25 PM	46:32	2792		n	Flow meter was not working. No flow measures recorded. Not valid
11/12/05	11/14/05	EK	2	175	15:39		14:03					11/12/05 3:39 PM	11/14/05 2:03 PM	46:24	2784		n	Flow meter was not working. No flow measures recorded. Not valid
11/18/05	11/20/05	JS	1	151	14:41	9.57	13:20	9.94	9.76	4%	OK	11/18/05 2:41 PM	11/20/05 1:20 PM	46:39	2799	27.30	y	
11/18/05	11/20/05	JS	2	152	14:26	10.22	13:09	9.48	9.85	-7%	NG	11/18/05 2:26 PM	11/20/05 1:09 PM	46:43	2803	27.61	y	
11/24/05	11/26/05	JS	1	142	13:50	9.78	14:30	9.04	9.41	-8%	OK	11/24/05 1:50 PM	11/26/05 2:30 PM	48:40	2920	27.48	y	
11/24/05	11/26/05	JS	2	159	13:20	10.44	14:10	9.65	10.05	-8%	OK	11/24/05 1:20 PM	11/26/05 2:10 PM	48:50	2930	29.43	y	
11/30/05	12/02/05	JS	1	147	13:35	10.61	12:25	10.09	10.35	-5%	OK	11/30/05 1:35 PM	12/2/05 12:25 PM	46:50	2810	29.08	y	
11/30/05	12/02/05	JS	2	148	12:05	10.48	13:15	9.85	10.17	-6%	OK	11/30/05 12:05 PM	12/2/05 1:15 PM	49:10	2950	29.99	y	
12/06/05	12/08/05	JS	1	157	11:40	9.55	14:26	10.09	9.82	6%	OK	12/6/05 11:40 AM	12/8/05 2:26 PM	50:46	3046	29.91	y	
12/06/05	12/08/05	JS	2	156	11:20	10.29	14:10	9.75	10.02	-5%	OK	12/6/05 11:20 AM	12/8/05 2:10 PM	50:50	3050	30.56	y	
12/12/05	12/14/05	JS	1	143	10:29	9.21	10:45	9.02	9.12	-2%	OK	12/12/05 10:29 AM	12/14/05 10:45 AM	48:16	2896	26.40	y	
12/12/05	12/14/05	JS	2	144	9:35	10.20	10:34	9.64	9.92	-5%	OK	12/12/05 9:35 AM	12/14/05 10:34 AM	48:59	2939	29.15	y	
12/18/05	12/20/05	JS	1	160	14:40	9.93	13:32	10.38	10.16	5%	OK	12/18/05 2:40 PM	12/20/05 1:32 PM	46:52	2812	28.56	y	
12/18/05	12/20/05	JS	2	187	14:25	10.17	13:15	9.64	9.91	-5%	OK	12/18/05 2:25 PM	12/20/05 1:15 PM	46:50	2810	27.83	y	
12/24/05	12/26/05	JS	1	185	11:10	10.44	12:45	10.46	10.45	0%	OK	12/24/05 11:10 AM	12/26/05 12:45 PM	49:35	2975	31.09	y	
12/24/05	12/26/05	JS	2	186	11:54	10.13	13:40	9.52	9.83	-6%	OK	12/24/05 11:54 AM	12/26/05 1:40 PM	49:46	2986	29.34	y	
12/30/05	01/01/06	EK	1	179	9:22	9.83	12:04	10.48	10.16	7%	OK	12/30/05 9:22 AM	1/1/06 12:04 PM	50:42	3042	30.89	y	
12/30/05	01/01/06	EK	2	180	9:05	10.14	13:00	9.27	9.71	-9%	OK	12/30/05 9:05 AM	1/1/06 1:00 PM	51:55	3115	30.23	y	
01/05/06	01/07/06	JS	1	177	12:26	10.20	14:55	10.51	10.36	3%	OK	1/5/06 12:26 PM	1/7/06 2:55 PM	50:29	3029	31.37	y	
01/05/06	01/07/06	JS	2	178	12:05	10.07	14:45	9.31	9.69	-8%	OK	1/5/06 12:05 PM	1/7/06 2:45 PM	50:40	3040	29.46	y	
01/11/06	01/13/06	JS	1	202	13:01	10.52	13:44	10.06	10.29	-4%	OK	1/11/06 1:01 PM	1/13/06 1:44 PM	48:43	2923	30.08	y	
01/11/06	01/13/06	JS	2	203	12:38	10.63	13:26	10.00	10.32	-6%	OK	1/11/06 12:38 PM	1/13/06 1:26 PM	48:48	2928	30.20	y	
01/11/06	01/13/06	JS	2 (duplicate)	204	12:38	10.27	13:26	9.80	10.04	-5%	OK	1/11/06 12:38 PM	1/13/06 1:26 PM	48:48	2928	29.38	y	
01/17/06	01/19/06	JS	1	193	12:15	10.08	11:12	10.10	10.09	0%	OK	1/17/06 12:15 PM	1/19/06 11:12 AM	46:57	2817	28.42	y	
01/17/06	01/19/06	JS	2	197	11:54	10.82	10:55	10.05	10.44	-7%	OK	1/17/06 11:54 AM	1/19/06 10:55 AM	47:01	2821	29.44	y	
01/23/06	01/25/06	JS	1	191	12:39	10.51	13:40	10.21	10.36	-3%	OK	1/23/06 12:39 PM	1/25/06 1:40 PM	49:01	2941	30.47	y	
01/23/06	01/25/06	JS	2	192	12:23	10.90	13:23	10.10	10.50	-7%	OK	1/23/06 12:23 PM	1/25/06 1:23 PM	49:00	2940	30.87	y	
01/23/06	01/25/06	JS																
01/29/06	01/31/06	EK	1	195	13:25	9.40	13:58	7.80	8.60	-17%	OK	1/29/06 1:25 PM	1/31/06 1:58 PM	48:33	2813	24.19	n	
01/29/06	01/31/06	EK	2	196	13:05	10.90	13:31	10.33	10.62	-5%	OK	1/29/06 1:05 PM	1/31/06 1:31 PM	48:26	2906	30.85	y	
02/04/06	02/06/06	EK	1	250	12:00	10.20	11:51	10.08	10.14	-1%	OK	2/4/06 12:00 PM	2/6/06 11:51 AM	47:51	2871	29.11	y	
02/04/06	02/06/06	EK	2	252	11:45	10.78	10:46	10.20	10.49	-5%	OK	2/4/06 11:45 AM	2/6/06 10:46 AM	47:01	2821	29.59	y	
02/10/06	02/12/06	JS	1	254	12:55	9.38	15:19	9.57	9.48	2%	OK	2/10/06 12:55 PM	2/12/06 3:19 PM	50:24	3024	28.65	y	
02/10/06	02/12/06	JS	2	256	12:31	10.61	14:57	9.58	10.10	-10%	OK	2/10/06 12:31 PM	2/12/06 2:57 PM	50:26	3026	30.55	y	
02/16/06	02/18/06	JS	1	257	12:02	10.35	12:21	9.88	10.12	-5%	OK	2/16/06 12:02 PM	2/18/06 12:21 PM	48:19	2899	29.32	y	not found
02/16/06	02/18/06	EK	2	262	12:17	10.58	12:10	9.7	10.14	-8%	OK	2/16/06 12:17 PM	2/18/06 12:10 PM	47:53	2873	29.13	y	
02/22/06	02/24/06	EK	1	249	9:57	8.99	10:45	8.81	8.90	-2%	OK	2/22/06 9:57 AM	2/24/06 10:45 AM	48:48	2928	26.06	y	
02/22/06	02/24/06	JS	2	266	9:40	10.41	10:28	10.05	10.23	-3%	OK	2/22/06 9:40 AM	2/24/06 10:28 AM	48:48	2928	29.95	y	
02/28/06	03/02/06	JS	1	253	10:28	9.2	11:15	9.17	9.19	0%	OK	2/28/06 10:28 AM	3/2/06 11:15 AM	48:47	2927	26.88	y	
02/28/06	03/02/06	JS	2	264	10:15	10.41	10:52	9.72	10.07	-7%	OK	2/28/06 10:15 AM	3/2/06 10:52 AM	48:37	2817	28.35	y	
03/06/06	03/08/06	JS	1	289	11:30	9.64	10:55	9.57	9.61	-1%	OK	3/6/06 11:30 AM	3/8/06 10:55 AM	47:25	2845	27.33	y	
03/06/06	03/08/06	JS	2	270	11:09	10.86	10:35	9.9	10.38	-9%	OK	3/6/06 11:09 AM	3/8/06 10:35 AM	47:26	2846	29.54	y	
03/06/06	03/08/06	JS																
03/12/06	03/14/06	EK	1	288	13:04	10.04	12:40	10.05	10.05	0%	OK	3/12/06 1:04 PM	3/14/06 12:40 PM	47:36	2856	28.69	y	
03/12/06	03/14/06	JS	2	272	12:49	10.79	13:23	10	10.40	-7%	OK	3/12/06 12:49 PM	3/14/06 1:23 PM	48:34	2914	30.29	y	
03/18/06	03/20/06	EK	1	281	12:25	10.14	13:04	10.1	10.12	0%	OK	3/18/06 12:25 PM	3/20/06 1:04 PM	48:39	2919	29.54	y	

Table A 2 (continued)

			Quartz Filter																
Date Started	Date Ended	Operator	Site	ID (Qtz)	Time Started	Initial Flow	Time Ended	Final Flow	Average Flow (l/min)	% Flow Change	Post Leak Test	Time & Date Started	Time & Date Ended	Sample Duration	Duration (min)	Volume (m3)	Sample Validity	NOTES
03/18/06	03/20/06	JS	2	285	12:10	10.19	10:30	10.09	10.14	-1%	OK	3/18/06 12:10 PM	3/20/06 10:30 AM	46:20	2780	28.19	y	
03/24/06	03/26/06	JS	1	273	12:08	10.19	11:28	9.88	10.04	-3%	OK	3/24/06 12:08 PM	3/26/06 11:28 AM	47:20	2840	28.50	y	
03/24/06	03/26/06	EK	2	301	11:51	10.59	11:09	9.49	10.04	-10%	OK	3/24/06 11:51 AM	3/26/06 11:09 AM	47:18	2838	28.49	y	
03/30/06	04/01/06	JS	1	305	11:56	10.2	11:45	9.52	9.86	-7%	OK	3/30/06 11:56 AM	4/1/06 11:45 AM	47:49	2769	27.30	y	
03/30/06	04/01/06	EK	2	298	11:43	10.41	11:25	9.36	9.89	-10%	OK	3/30/06 11:43 AM	4/1/06 11:25 AM	47:42	2862	28.29	y	
04/05/06	04/07/06	JS	1	299	10:31	10.16	11:18	9.4	9.78	-7%	OK	4/5/06 10:31 AM	4/7/06 11:18 AM	48:47	2867	28.04	y	
04/05/06	04/07/06	JS	2	293	10:16	10.47	11:04	9.7	10.09	-7%	OK	4/5/06 10:16 AM	4/7/06 11:04 AM	48:48	2928	29.53	y	
04/05/06	04/07/06	JS																
04/11/06	04/13/06	JS	1	311	10:56	10.03	9:23	9.6	9.82	-4%	OK	4/11/06 10:56 AM	4/13/06 9:23 AM	46:27	2787	27.35	y	
04/11/06	04/13/06	JS	2	312	10:41	10.4	9:08	9.6	10.00	-8%	OK	4/11/06 10:41 AM	4/13/06 9:08 AM	46:27	2787	27.87	y	
04/11/06	04/13/06	EK																
04/17/06	04/19/06	EK	1	275	13:58	10.26	14:07	9.3	9.78	-9%	OK	4/17/06 1:58 PM	4/19/06 2:07 PM	48:09	2889	28.25	y	
04/17/06	04/19/06	JS	2	308	13:46	10.35	13:53	9.17	9.76	-11%	OK	4/17/06 1:46 PM	4/19/06 1:53 PM	48:07	2887	28.18	y	
04/23/06	04/25/06	EK	1	325	11:30	9.7	10:35	9.28	9.49	-4%	OK	4/23/06 11:30 AM	4/25/06 10:35 AM	47:05	2825	26.81	y	Ripped Q1 filter on unloading
04/23/06	04/25/06	JS	2	326	10:45	10.75	9:18	10.48	10.62	-3%	OK	4/23/06 10:45 AM	4/25/06 9:18 AM	46:33	2793	29.65	y	
04/29/06	05/01/06	EK	1	328	14:40	10.4	12:47	9.4	9.90	-10%	OK	4/29/06 2:40 PM	5/1/06 12:47 PM	46:07	2767	27.39	y	
04/29/06	05/01/06	JS	2	322	14:25	11.5	12:33	10.83	11.17	-6%	OK	4/29/06 2:25 PM	5/1/06 12:33 PM	46:08	2768	30.90	y	
05/05/06	05/07/06	JS	1	317	13:02	10.2	12:00	9.5	9.85	-7%	OK	5/5/06 1:02 PM	5/7/06 12:00 PM	46:58	2818	27.76	y	Q1 filter ripped during sampling
05/05/06	05/07/06	JS	2	319	12:37	10.4	11:45	9.5	9.95	-9%	OK	5/5/06 12:37 PM	5/7/06 11:45 AM	47:08	2828	28.14	y	
05/05/06	05/07/06	JS																
05/11/06	05/13/06	JS	1	276	10:13	9.85	9:42	9.34	9.60	-5%	OK	5/11/06 10:13 AM	5/13/06 9:42 AM	47:29	2849	27.34	y	
05/11/06	05/13/06	EK	2	313	10:00	10.43	9:28	9.67	10.05	-7%	OK	5/11/06 10:00 AM	5/13/06 9:28 AM	47:28	2848	28.62	y	
05/17/06	05/19/06	JS	1	307	12:28	10.22	11:11	9.35	9.79	-9%	OK	5/17/06 12:28 PM	5/19/06 11:11 AM	46:43	2803	27.43	y	
05/17/06	05/19/06	JS	2	309	12:13	10.44	10:48	9.75	10.10	-7%	OK	5/17/06 12:13 PM	5/19/06 10:48 AM	46:35	2795	28.22	y	
05/23/06	05/25/06	EK	1	314	10:10	9.9	11:52	9.28	9.59	-6%	OK	5/23/06 10:10 AM	5/25/06 11:52 AM	49:42	2982	28.60	y	
05/23/06	05/25/06	JS	2	315	9:55	9.8	11:43	9.5	9.65	-3%	OK	5/23/06 9:55 AM	5/25/06 11:43 AM	49:48	2988	28.83	y	
05/29/06	05/31/06	JS	1	330	13:42	10.2	11:52	9.4	9.80	-8%	OK	5/29/06 1:42 PM	5/31/06 11:52 AM	46:10	2770	27.15	y	
05/29/06	05/31/06	JS	2	354	13:28	10.33	11:36	9.61	9.97	-7%	OK	5/29/06 1:28 PM	5/31/06 11:36 AM	46:08	2768	27.60	y	
06/04/06	06/06/06	JS	1	344	13:42	10.4	13:17				OK	6/4/06 1:42 PM	6/6/06 1:17 PM	47:35	2855		n	Station 1 was unplugged - no final flow- - not valid
06/04/06	06/06/06	JS	2	363	13:28	10.12	13:00	9.54	9.83	-6%	OK	6/4/06 1:28 PM	6/6/06 1:00 PM	47:32	2852	28.04	y	
06/10/06	06/12/06	EK	1	370	8:45	10.4	10:30	9.2	9.80	-12%	OK	6/10/06 8:45 AM	6/12/06 10:30 AM	49:45	2985	29.25	y	Teflon Pump not working
06/10/06	06/12/06	EK	2	376	8:30	9.9	10:16	9.47	9.69	-4%	OK	6/10/06 8:30 AM	6/12/06 10:16 AM	49:46	2986	28.92	y	
06/16/06	06/18/06	JS	1	377	9:30	10	10:30	9.05	9.53	-9%	OK	6/16/06 9:30 AM	6/18/06 10:30 AM	49:00	2940	28.00	y	
06/16/06	06/18/06	JS	2	374	11:11	10.93	10:43	9.97	10.45	-9%	OK	6/16/06 11:11 AM	6/18/06 10:43 AM	47:32	2852	29.80	y	
06/22/06	06/24/06	JS	1	357	9:45	9.88	8:52	8.9	9.39	-10%	OK	6/22/06 9:45 AM	6/24/06 8:52 AM	47:07	2827	26.55	y	
06/22/06	06/24/06	JS	2	341	9:58	10.7	9:05	9.77	10.24	-9%	OK	6/22/06 9:58 AM	6/24/06 9:05 AM	47:07	2827	28.93	y	
06/28/06	06/30/06	JS	1	342	11:50	9.86	9:51	8.97	9.42	-9%	OK	6/28/06 11:50 AM	6/30/06 9:51 AM	46:01	2761	25.99	y	No Teflon Filters
06/28/06	06/30/06	JS	2	369	1:12	10.79	11:25	9.48	10.14	-12%	OK	6/28/06 1:12 PM	6/30/06 11:25 AM	46:13	2773	28.10	y	
07/04/06	07/06/06	JS	1	332	12:25	9.14	12:25	9.01	9.08	-1%	OK	7/4/06 12:25 PM	7/6/06 12:25 PM	48:00	2880	26.14	y	
07/04/06	07/06/06	JS	2	364	12:10	10.43	12:05	10.16	10.30	-3%	OK	7/4/06 12:10 PM	7/6/06 12:05 PM	47:55	2875	29.60	y	
07/10/06	07/12/06	JS	1	334	11:45	11.4	11:15	4.82	8.11	-58%	OK	7/10/06 11:45 AM	7/12/06 11:15 AM	47:30	2850	23.11	n	
07/10/06	07/12/06	JS	2	336	11:25	12	11:00	10.65	11.33	-11%	OK	7/10/06 11:25 AM	7/12/06 11:00 AM	47:35	2855	32.33	y	
07/16/06	07/18/06	JS	1	353	10:22	10.9	10:45	7.6	9.25	-30%	OK	7/16/06 10:22 AM	7/18/06 10:45 AM	48:23	2903	26.85	n	
07/16/06	07/18/06	JS	2	348	10:05	10.3	10:30	9.1	9.70	-12%	OK	7/16/06 10:05 AM	7/18/06 10:30 AM	48:25	2905	28.18	y	
07/22/06	07/24/06	JS	1	372	13:45	9.7	13:30	8.9	9.30	-8%	OK	7/22/06 1:45 PM	7/24/06 1:30 PM	47:45	2865	26.64	y	
07/22/06	07/24/06	JS	2	351	13:30	10.4	12:40					7/22/06 1:30 PM	7/24/06 12:40 PM	47:10	2830		n	no final flow - not valid
07/28/06	07/30/06	JS	1	339	15:00	10.75	15:23	9.78	10.27	-9%	OK	7/28/06 3:00 PM	7/30/06 3:23 PM	48:23	2903	29.80	y	
07/28/06	07/30/06	JS	2	347	14:47	9	15:08	8.97	8.99	0%	OK	7/28/06 2:47 PM	7/30/06 3:08 PM	48:21	2901	26.07	y	
08/03/06	08/05/06	JS	1	329	10:52	9.71	10:27	9.31	9.51	-4%	OK	8/3/06 10:52 AM	8/5/06 10:27 AM	47:35	2855	27.15	y	

Table A 2 (continued)

			Quartz Filter															
Date Started	Date Ended	Operator	Site	ID (Qtz)	Time Started	Initial Flow	Time Ended	Final Flow	Average Flow (l/min)	% Flow Change	Post Leak Test	Time & Date Started	Time & Date Ended	Sample Duration	Duration (min)	Volume (m3)	Sample Validity	NOTES
08/03/06	08/05/06	EK	2	358	10:38	10.84	10:12	9.95	10.40	-8%	OK	8/3/06 10:38 AM	8/5/06 10:12 AM	47:34	2854	29.67	y	
08/09/06	08/11/06	JS	1	361	12:34	9.44	12:17	8.98	9.21	-5%	OK	8/9/06 12:34 PM	8/11/06 12:17 PM	47:43	2863	26.37	y	
08/09/06	08/11/06	JS	2	356	12:18	10.65	12:10	9.71	10.18	-9%	OK	8/9/06 12:18 PM	8/11/06 12:10 PM	47:52	2872	29.24	y	
08/15/06	08/17/06	JS																
08/15/06	08/17/06	JS																
08/21/06	08/23/06	JS	1	399	10:58	9.65	12:11	8.57	9.11	-11%	OK	8/21/06 10:58 AM	8/23/06 12:11 PM	49:13	2953	26.90	y	
08/21/06	08/23/06	EK	2	422	10:46	10.2	11:10	9.19	9.70	-10%	OK	8/21/06 10:46 AM	8/23/06 11:10 AM	48:24	2904	28.15	y	
08/27/06	08/29/06	JS																
08/27/06	08/29/06	JS																
09/02/06	09/04/06	EK	1	426	11:00	9.18	10:30	8.7	8.94	-5%	OK	9/2/06 11:00 AM	9/4/06 10:30 AM	47:30	2850	25.48	y	
09/02/06	09/04/06	JS	2	412	10:35	1.6	10:45	2.02	1.81	26%	OK	9/2/06 10:35 AM	9/4/06 10:45 AM	48:10	2890	5.23	n	
09/08/06	09/10/06	JS	1	421	11:26	8.23	10:17	8.18	8.21	-1%	OK	9/8/06 11:26 AM	9/10/06 10:17 AM	46:51	2811	23.06	n	
09/08/06	09/10/06	JS	2	408	11:11	10.8	10:04	1.76	6.28	-84%	OK	9/8/06 11:11 AM	9/10/06 10:04 AM	46:53	2813	17.67	n	
09/14/06	09/16/06	JS	1	382	11:16	9.65	11:05	8.44	9.05	-13%	OK	9/14/06 11:16 AM	9/16/06 11:05 AM	47:49	2869	25.95	y	
09/14/06	09/16/06	JS	2	384	10:55	10.46	10:50	9.85	10.16	-6%	OK	9/14/06 10:55 AM	9/16/06 10:50 AM	47:55	2875	29.20	y	
09/20/06	09/22/06	JS	1	398	10:11	8.26	9:40	8.1	8.18	-2%	OK	9/20/06 10:11 AM	9/22/06 9:40 AM	47:29	2849	23.30	n	
09/20/06	09/22/06	JS	2	402	10:23	10.31	9:54	9.72	10.02	-6%	OK	9/20/06 10:23 AM	9/22/06 9:54 AM	47:31	2851	28.55	y	
09/26/06	09/28/06	JS	1	406	9:16	9.26	9:10	8.72	8.99	-6%	OK	9/26/06 9:16 AM	9/28/06 9:10 AM	47:54	2874	25.84	y	
09/26/06	09/28/06	JS	2	425	9:29	10.56	9:29	9.63	10.10	-9%	OK	9/26/06 9:29 AM	9/28/06 9:29 AM	48:00	2880	29.07	y	
10/02/06	10/04/06	JS	1	427	11:42	9.03	10:18	8.51	8.77	-6%	OK	10/2/06 11:42 AM	10/4/06 10:18 AM	46:36	2796	24.52	y	
10/02/06	10/04/06	JS	2	410	11:56	10.37	10:05	9.84	10.11	-5%	OK	10/2/06 11:56 AM	10/4/06 10:05 AM	46:09	2769	27.98	y	
10/08/06	10/10/06	JS	1	403	12:38	8.16	11:32	7.74	7.95	-5%	OK	10/8/06 12:38 PM	10/10/06 11:32 AM	46:54	2814	22.37	n	
10/08/06	10/10/06	JS	2	411	11:52	8.14	11:14	7.91	8.03	-3%	OK	10/8/06 11:52 AM	10/10/06 11:14 AM	47:22	2842	22.81	n	
10/14/06	10/16/06	EK	1	385	12:05	7.66	11:03	7.49	7.58	-2%	OK	10/14/06 12:05 PM	10/16/06 11:03 AM	46:58	2818	21.35	n	
10/14/06	10/16/06	EK	2	397	11:50	8.45	10:49	7.82	8.14	-7%	OK	10/14/06 11:50 AM	10/16/06 10:49 AM	46:59	2819	22.93	y	
10/20/06	10/22/06	JS	1	388	10:33	9.5	10:37	8.56	9.03	-10%	OK	10/20/06 10:33 AM	10/22/06 10:37 AM	48:04	2884	26.04	y	
10/20/06	10/22/06	JS	2	396	10:47	10.33	9:55	11.5	10.92	11%	OK	10/20/06 10:47 AM	10/22/06 9:55 AM	47:08	2828	30.87	y	
10/26/06	10/28/06	JS	1	395	10:22	7.75	12:26	7.6	7.68	-2%	NG	10/26/06 10:22 AM	10/28/06 12:26 PM	50:04	3004	23.06	n	
10/26/06	10/28/06	EK	2	393	10:37	10.8	12:13	10.44	10.62	-3%	NG	10/26/06 10:37 AM	10/28/06 12:13 PM	49:36	2976	31.61	n	
11/01/06	11/03/06	JS																
11/01/06	11/03/06	JS																
11/01/06	11/03/06	JS																
11/07/06	11/09/06	JS	1	440	7:44	8.48	8:15	9	8.74	6%	NG	11/7/06 7:44 AM	11/9/06 8:15 AM	48:31	2911	25.44	n	
11/07/06	11/09/06	JS	2	435	8:08	10.82	8:30	10.8	10.81	0%	NG	11/7/06 8:08 AM	11/9/06 8:30 AM	48:22	2902	31.37	n	
11/13/06	11/15/06	JS	1	434	9:49	8.01	9:10	11.37	9.69	42%	OK	11/13/06 9:49 AM	11/15/06 9:10 AM	47:21	2841	27.53	n	
11/13/06	11/15/06	JS	2	432	10:56	7.46	10:30	11.12	9.29	49%	OK	11/13/06 10:56 AM	11/15/06 10:30 AM	47:34	2854	26.51	n	
11/19/06	11/21/06	EK	1	430	11:31	9.23	9:43	9.02	9.13	-2%	OK	11/19/06 11:31 AM	11/21/06 9:43 AM	46:12	2772	25.29	y	
11/19/06	11/21/06	EK	2	433	10:51	11.17	8:51	11.04	11.11	-1%	OK	11/19/06 10:51 AM	11/21/06 8:51 AM	46:00	2760	30.65	y	
11/25/06	11/27/06	JS																
11/25/06	11/27/06	JS																
12/01/06	12/03/06	JS	1	457	11:00	9.58	13:11	8.88	9.23	-7%	OK	12/1/06 11:00 AM	12/3/06 1:11 PM	50:11	3011	27.79	y	No Teflon Filters
12/01/06	12/03/06	EK	2	450	11:15	11.64	12:25	11.04	11.34	-5%	OK	12/1/06 11:15 AM	12/3/06 12:25 PM	49:10	2950	33.45	y	
12/07/06	12/09/06	EK	1	484	14:57	1.80	11:49				OK	12/7/06 2:57 PM	12/9/06 11:49 AM	44:52	2692		n	No Power at Site 1- no final flow - not valid
12/07/06	12/09/06	EK	2	487	14:03	12.60	11:00	11.50	12.05	-9%	OK	12/7/06 2:03 PM	12/9/06 11:00 AM	44:57	2697	32.50	y	
12/13/06	12/15/06	JS	1	494	10:25	9.36	10:04	9.22	9.29	-1%	OK	12/13/06 10:25 AM	12/15/06 10:04 AM	47:39	2859	26.56	y	No Pump for Teflon @ Site 1
12/13/06	12/15/06	JS	2	479	10:39	11.67	10:16	11.29	11.48	-3%	OK	12/13/06 10:39 AM	12/15/06 10:16 AM	47:37	2857	32.80	y	
12/19/06	12/21/06	JS	1	493	10:06	8.99	10:05	8.84	8.92	-2%	OK	12/19/06 10:06 AM	12/21/06 10:05 AM	47:59	2879	25.67	y	
12/19/06	12/21/06	JS	2	491	10:25	11.46	10:20	11.31	11.39	-1%	OK	12/19/06 10:25 AM	12/21/06 10:20 AM	47:55	2879	32.78	y	

Table A 2 (continued)

			Quartz Filter																
Date Started	Date Ended	Operator	Site	ID (Qtz)	Time Started	Initial Flow	Time Ended	Final Flow	Average Flow (l/min)	% Flow Change	Post Leak Test	Time & Date Started	Time & Date Ended	Sample Duration	Duration (min)	Volume (m3)	Sample Validity	NOTES
12/25/06	12/27/06	JS	1	495	14:35	5.82	15:00	5.78	5.80	-1%	OK	12/25/06 2:35 PM	12/27/06 3:00 PM	48:25	2905	16.85	n	
12/25/06	12/27/06	JS	2	501	14:18	10.69	14:08	11.20	10.95	5%	OK	12/25/06 2:18 PM	12/27/06 2:08 PM	47:50	2870	31.41	y	
12/31/06	01/02/07	JS	1	504	11:10	5.72	9:10	5.62	5.67	-2%	OK	12/31/06 11:10 AM	1/2/07 9:10 AM	46:00	2760	15.65	n	
12/31/06	01/02/07	JS	2	509	11:47	11.07	9:47	10.27	10.67	-7%	OK	12/31/06 11:47 AM	1/2/07 9:47 AM	46:00	2760	29.45	y	
01/06/07	01/08/07	JS	1	476	13:58	9.70	13:40	9.17	9.44	-5%	OK	1/6/07 1:58 PM	1/8/07 1:40 PM	47:42	2862	27.00	y	
01/06/07	01/08/07	JS	2	477	13:41	13.40	13:23	12.67	13.04	-5%	OK	1/6/07 1:41 PM	1/8/07 1:23 PM	47:42	2862	37.31	y	
01/12/07	01/14/07	EK	1	463	11:13	8.90	11:33	8.96	8.93	1%	OK	1/12/07 11:13 AM	1/14/07 11:33 AM	48:20	2900	25.90	y	
01/12/07	01/14/07	EK	2	483	11:00	12.80	11:18	12.12	12.46	-5%	OK	1/12/07 11:00 AM	1/14/07 11:18 AM	48:18	2898	36.11	y	
01/18/07	01/20/07	JS	1	496	12:19	8.87	11:00	8.80	8.84	-1%	OK	1/18/07 12:19 PM	1/20/07 11:00 AM	46:41	2801	24.75	y	
01/18/07	01/20/07	EK	2	470	12:05	10.80	10:45	10.50	10.65	-3%	OK	1/18/07 12:05 PM	1/20/07 10:45 AM	46:40	2800	29.82	y	
01/24/07	01/26/07	JS	1	466	13:23	5.93	12:44	5.86	5.90	-1%	OK	1/24/07 1:23 PM	1/26/07 12:44 PM	47:21	2841	16.75	n	Site 2 Teflon filter ripped on unloading
01/24/07	01/26/07	JS	2	503	13:10	13.09	12:31	12.69	12.89	-3%	OK	1/24/07 1:10 PM	1/26/07 12:31 PM	47:21	2841	36.62	y	
01/30/07	02/01/07	JS	1	485	11:02	8.45	12:00	8.05	8.25	-5%	OK	1/30/07 11:02 AM	2/1/07 12:00 PM	48:58	2928	24.16	y	
01/30/07	02/01/07	JS	2	473	11:20	12.47	12:18	11.83	12.15	-5%	OK	1/30/07 11:20 AM	2/1/07 12:18 PM	48:58	2928	35.58	y	
02/05/07	02/07/07	JS	1	443	14:10	6.98	13:42	4.10	5.54	-41%	OK	2/5/07 2:10 PM	2/7/07 1:42 PM	47:32	2852	15.80	n	
02/05/07	02/07/07	JS	2	469	13:54	3.62	13:24	5.01	4.32	38%	OK	2/5/07 1:54 PM	2/7/07 1:24 PM	47:30	2850	12.30	n	
02/11/07	02/13/07	JS	1	444	11:35	7.84	13:24	7.78	7.81	-1%	OK	2/11/07 11:35 AM	2/13/07 1:24 PM	49:49	2989	23.34	n	
02/11/07	02/13/07	JS	2	458	11:15	11.50	13:11	11.04	11.27	-4%	OK	2/11/07 11:15 AM	2/13/07 1:11 PM	49:56	2996	33.76	y	
02/17/07	02/19/07	EK	1	447	11:30	3.70	13:11	4.23	3.97	14%	OK	2/17/07 11:30 AM	2/19/07 1:11 PM	49:41	2981	11.82	n	
02/17/07	02/19/07	JS	2	459	11:10	11.70	12:58	10.83	11.27	-7%	OK	2/17/07 11:10 AM	2/19/07 12:58 PM	49:48	2988	33.66	y	
02/23/07	02/25/07	JS	1	508	10:34	7.84	12:19	8.00	7.92	2%	OK	2/23/07 10:34 AM	2/25/07 12:18 PM	49:44	2984	23.63	n	
02/23/07	02/25/07	EK	2	511	10:03	13.13	12:05	12.70	12.92	-3%	OK	2/23/07 10:03 AM	2/25/07 12:05 PM	50:02	3002	38.77	y	
03/01/07	03/03/07	JS	1	528	13:54	8.73	13:15	8.50	8.62	-3%	OK	3/1/07 1:54 PM	3/3/07 1:15 PM	47:21	2841	24.48	y	No power at Site 2
03/07/07	03/09/07	JS	1	527	12:48	8.73	11:46	11.30	10.02	29%	OK	3/7/07 12:48 PM	3/9/07 11:46 AM	46:58	2818	28.22	n	No power at Site 2
			1 (duplicate)	526	12:48	10.43	11:46	9.46	9.95	-9%	OK	3/7/07 12:48 PM	3/9/07 11:46 AM	46:58	2818	28.03	y	
03/13/07	03/15/07	JS	1	498	12:07	9.15	10:45	8.80	8.98	-4%	OK	3/13/07 12:07 PM	3/15/07 10:45 AM	46:38	2798	25.11	y	No power at Site 2
03/13/07	03/15/07	JS										3/13/07 12:07 PM	3/15/07 10:45 AM					

Note
Quartz has same duration as Teflon

valid san	189
invalid s	44

Table A-3. Blank teflon filter weights Meadowlands, New Jersey

Sample ID	Site	Sampling Start Date	Sampling End Date	Initial Average Weight (mg)	Post Average Weight (mg)	Total Weight (mg)
T007	**Blank**	3/17/2005	3/19/2005	101.913	101.913	**-0.001**
T011	**Blank**	3/23/2005	3/25/2005	121.140	121.148	**0.008**
T017	**Blank**	4/22/2005	4/24/2005	101.220	101.211	**-0.008**
T033	**Blank**	5/22/2005	5/24/2005	109.457	109.461	**0.004**
T045	**Blank**	5/24/2005	5/26/2005	105.769	105.768	**-0.001**
T048	**Blank**	6/27/2005	6/29/2005	114.747	114.746	**0.000**
T050	**Blank**	7/3/2005	7/5/2005	106.695	106.695	**0.000**
T051	**blank**	7/3/2005	7/5/2005	104.565	104.565	**-0.001**
T069	**Blank**	8/20/2005	8/22/2005	105.638	Not Received	
T088	**Blank**	10/7/2005	10/9/2005	106.176	106.175	**-0.002**
T094	**Blank**	10/19/2005	10/21/2005	103.065	103.064	**-0.001**
Mean						**-0.00005**
SD						**0.004**

Table A-4. Sample pairs - teflon filter weights Meadowlands, New Jersey

Sample ID	Site	Sampling Start Date	Sampling End Date	Initial Average Weight (mg)	Post Average Weight (mg)	Total Weight (mg)	Air Volume (m3)	Air Conc. (ug/m3)
T008	2	3/23/2005	3/25/2005	118.262	118.576	**0.314**	**30.60**	**10.26**
T010	**2 (dup)**	3/23/2005	3/25/2005	117.629	117.883	**0.255**	**29.30**	**8.69**
T029	2	5/16/2005	5/18/2005	108.419	108.652	**0.233**	**28.40**	**8.20**
T030	**2 (dup)**	5/16/2005	5/18/2005	114.354	114.639	**0.285**	**29.00**	**9.83**
T040	1	06/15/05	06/17/05	105.501	105.878	**0.376**	**27.25**	**13.81**
T042	**1 (dup)**	06/15/05	06/17/05	100.929	101.205	**0.275**	**27.24**	**10.11**
T128	2	01/23/06	01/25/06	97.422	97.624	**0.202**	**30.58**	**6.61**
T126	**2 (dup)**	01/23/06	01/25/06	107.668	107.986	**0.318**	**29.99**	**10.60**
T150	2	03/06/06	03/08/06	104.203	104.321	**0.118**	**30.77**	**3.84**
T151	**2 (dup)**	03/06/06	03/08/06	107.208	107.377	**0.169**	**29.71**	**5.69**
T160	2	04/05/06	04/07/06	109.209	109.408	**0.199**	**31.24**	**6.37**
T156	**2 (dup)**	04/05/06	04/07/06	113.999	114.205	**0.206**	**30.79**	**6.69**
T163	2	04/11/06	04/13/06	115.597	115.845	**0.248**	**29.44**	**8.42**
T168	**2 (dup)**	04/11/06	04/13/06	113.471	113.786	**0.315**	**29.01**	**10.86**
T172	1	05/05/06	05/07/06	101.367	101.575	**0.208**	**28.79**	**7.23**
T174	**1 (dup)**	05/05/06	05/07/06	106.694	106.850	**0.156**	**28.76**	**5.42**
Mean						**0.242**	**29.43**	**8.29**
SD						**0.069**	**1.206**	**2.546**
Air Conc. (ug/m3)								
	sample	**dup**	**d**	**d^2**				
1	10.26	8.69	1.58	2.48				
2	8.20	9.83	-1.62	2.64				
3	13.81	10.11	3.70	13.69				
4	6.61	10.60	-4.00	15.98				
5	3.84	5.69	-1.85	3.43				
6	6.37	6.69	-0.32	0.10				
7	8.42	10.86	-2.43	5.93				
8	7.23	5.42	1.80	3.24				
∑				47.50				
k				8				
mean	**8.29**							
Pooled SD=S_p= √(∑d_2/2K)=√(47.50/16)= 1.72								
Pooled SD=S_p= √(∑d_2/2K)								
k= # of pairs								
d=X_1-X_2								
d^2= $(X_1-X_2)^2$				**RSD% = CV*100 = (1.72/8.29)*100 = 21%**				

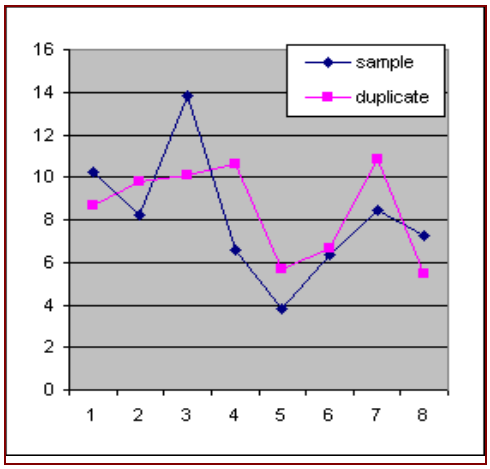


Figure A-1

Table A-5. Quality Control Analyses for Metals

Table A-5(a) is the method recovery data and Table A-1(b) shows results from calibration check for individual days runs

Table A-5(a). Recoveries from San Joaquin Soil to evaluate the acid digestion procedure. Six metal lechates values are provide by NIST and the amount recovered from the digestion procedure are compared to the reported values. The three different isotopes of lead (Pb) that are obtained by the ICP/MS are given.

Sample ID	52Cr	55Mn	59Co	60Ni	65Cu	206Pb	207Pb	208Pb
Run Date 20060516								
san joaquin 16/06/2006 13:37:23	77011	469374	9766	62965	25675	11919	11629	11910
NIST reported leach value	79000	470000	12000	78000	32000	13000	13000	13000
% recovery	97%	100%	81%	81%	80%	92%	89%	92%
run date 20060927								
san joaqui 0831	102292	442959	10857	70144	25054	12251	12009	12218
san joaquin 0804	107108	472761	11379	72593	26325	12353	12052	12321
average	104700	457860	11118	71369	25689	12302	12031	12270
NIST reported leach value	79000	470000	12000	78000	32000	13000	13000	13000
% recovery	133%	97%	93%	91%	80%	95%	93%	94%

Table A-5(b). NIST standards from daily runs are provided along with the spiked values. Values had to be within +/-20% to be considered acceptable for that metal in a particular run. This represents a subset of the QC samples run as these are reviewed by the operator each day to determine if they meet the criteria and no single table was created for the Meadowlands project as samples from several different projects are run in one day based on a single NIST run.

Table A-1(b) ***continued***

Sample ID	7Li	9Be	24Mg	27Al	47Ti	51V	52Cr	55Mn	56Fe	59Co	60Ni	65Cu
NIST SM1811 A or B Ad	NP	1.00	NA	NA	NP	10.00	10.00	10.00	NA	10.00	10.00	10.00
Run 20060322												
HPS nist AB 05/04/20C	<0.1	1.15	12.42	<0.3	<0.1	11.15	1.10	1.10	<0.7	10.85	10.89	11.08
QC 05/04/2006 13:14:1	<0.1	1.08	12.30	<0.3	<0.1	11.48	10.97	10.98	<0.7	10.78	10.63	11.07
QC 04/04/2006 17:23:2	<0.1	1.03	15.59	<0.3	0.11	10.62	10.80	10.86	<0.7	10.57	10.78	10.95
QC 04/04/2006 17:28:3	<0.1	1.05	13.40	<0.3	0.17	10.81	10.97	10.83	<0.7	10.82	10.94	11.22
Run 20060323												
nistab 22/03/2006 15:3	<0.3	0.88	8.41	<0.3	<0.5	9.57	0.76	0.74	<0.7	7.91	7.87	7.31
>nistab 22/03/2006 15:	<0.3	0.83	8.50	<0.3	<0.5	9.30	0.78	0.76	<0.7	7.97	7.95	7.28
>>nistab 22/03/2006 1(	<0.3	0.87	8.98	<0.3	<0.5	8.85	0.82	0.78	<0.7	8.37	8.20	7.49
QC 22/03/2006 19:11:0	<0	0.82	9.08	<0	<1	8.94	8.15	7.90	<1	8.25	8.03	7.51
QC 22/03/2006 19:16:0	<0	0.85	8.95	<0	<1	8.68	8.18	7.92	<1	8.28	8.07	7.58
nist ab qc	<0.3	0.85	11.86	<0.3	<0.3	11.68	0.95	0.87	<0.7	9.12	9.77	9.46
>qc	<0.3	0.80	10.47	<0.3	<0.3	10.57	0.88	0.81	<0.7	8.35	8.85	8.76
qc)	<0.3	0.76	33.89	0.48	1.50	9.93	0.84	0.83	<0.7	8.03	8.78	8.52
qc 3	<0.3	0.84	37.50	<0.3	<0.3	11.32	9.03	8.73	<0.7	8.63	9.38	9.12
qc 3	<0.3	0.85	30.08	<0.3	0.33	11.08	8.98	8.40	<0.7	8.58	9.32	9.08
Run 20060516												
HPS nist AB 15/06/20C	<0.1	0.96	9.02	4.89	<0.1	9.37	0.93	0.93	1.52	9.46	8.93	9.17
qc 16/06/2006 13:17:2	<0.1	1.08	9.95	5.71	<0.1	9.92	1.00	0.98	3.52	9.99	9.40	9.65
qc 16/06/2006 13:42:2	<0.1	1.02	10.99	6.95	0.44	9.60	0.97	0.95	9.62	9.68	9.21	9.41
qc 16/06/2006 13:57:2	<0.1	1.11	10.74	6.37	0.24	10.50	10.50	10.23	4.68	10.53	9.94	10.16
qc 2 16/06/2006 14:12:	<0	1.03	10.11	5.80	1.71	10.02	1.00	0.99	3.75	10.01	9.43	9.62
>qc 2 16/06/2006 14:1	<0	1.05	10.11	5.82	0.19	10.00	0.99	0.98	3.63	9.99	9.38	9.63
qc 16/06/2006 14:32:1	<0	0.91	9.33	4.95	<0	8.97	8.97	8.91	2.43	9.12	8.44	8.78
qc 16/06/2006 14:37:1	<0	0.96	9.28	5.01	<0	9.18	9.17	9.11	2.64	9.21	8.57	8.99
Run 2006 927												
nist ab qc	<0.3	0.85	11.86	<0.3	<0.3	11.68	0.95	0.87	<0.7	9.12	9.77	9.46
>qc	<0.3	0.80	10.47	<0.3	<0.3	10.57	0.88	0.81	<0.7	8.35	8.85	8.76
qc)	<0.3	0.76	33.89	0.48	1.50	9.93	0.84	0.83	<0.7	8.03	8.78	8.52
qc 3	<0.3	0.84	37.50	<0.3	<0.3	11.32	9.03	8.73	<0.7	8.63	9.38	9.12
Run T200's												
HPS nist AB)	0.96	4.91	<0.3	<0.3	9.72	0.95	0.95	<0.3	9.81	9.90		9.64
HPS nist AB	1.03	5.02	<0.3	<0.3	9.74	0.96	0.96	<0.3	10.00	9.97		9.78
qc	0.98	4.66	<0.3	<0.3	9.40	0.94	0.93	<0.3	9.57	9.54		9.45
qc	0.92	23.80	<0.3	1.13	9.03	0.90	1.02	77.52	9.26	9.24		9.27
qc 25/10/2006 21:28:2	0.95	16.91	<0.3	<0.3	8.86	0.89	0.97	38.64	9.10	9.14		9.09
qc 2 25/10/2006 22:03:	0.88	10.29	<0	<0	8.53	0.85	0.90	<0	8.83	8.81		8.84
qc	0.94	9.95	<0	<0	8.84	0.88	0.92	2.51	9.63	9.01		9.06
qc	0.97	8.55	<0	<0	8.63	8.47	8.97	<0	8.89	8.74		8.83
qc 3	0.93	9.62	<0	<0	8.53	8.53	9.00	<0	8.83	8.79		8.73

NP - not present in standard
NA - interferent in ICP-MS Analysis

Table A-5(b) *continued*

Sample ID	66Zn	69Ga	75As	77Se	78Se	82Se	85Rb	88Sr	107Ag	111Cd	115In	133Cs
NIST SM1811 A or B Ad	NA	NP	20.00	50.00	50.00	50.00	NP	1.00	10.00	10.00	NP	NP
Run 20060322												
HPS nist AB 05/04/20	<0.3	0.45	1.06	61.29	56.58	54.14	<0.1	1.12	10.28	11.41	<0.1	<0.1
QC 05/04/2006 13:14:	<0.3	0.42	22.05	61.44	56.04	54.57	<0.1	1.12	10.20	11.56	<0.1	<0.1
QC 04/04/2006 17:23:	<0.3	0.40	20.99	57.98	53.19	54.45	<0.1	1.10	10.06	11.17	<0.1	<0.1
QC 04/04/2006 17:28:	<0.3	0.41	20.75	59.77	55.61	53.85	<0.1	1.11	10.33	11.28	<0.1	<0.1
Run 20060323												
nistab 22/03/2006 15:3	<0.3	0.27	0.82	80.04	56.31	50.58	<0.1	0.80	8.38	8.40	<0.1	<0.1
>nistab 22/03/2006 15:	<0.3	0.28	0.86	77.93	57.44	52.83	<0.1	0.81	8.48	8.27	<0.1	<0.1
>>nistab 22/03/2006 1	<0.3	0.28	0.89	73.45	57.54	53.83	<0.1	0.86	9.02	8.69	<0.1	<0.1
QC 22/03/2006 19:11:	<0	0.27	17.84	68.55	53.71	52.69	<0	0.86	8.96	8.98	<0	<0
QC 22/03/2006 19:16:	<0	0.29	17.77	67.82	53.63	52.15	<0	0.87	8.91	8.87	<0	<0
nist ab qc	<0.3	<0.5	0.89	45.68	57.46	44.72	<0.3	1.04	9.49	9.93	<0.1	<0.1
>qc	<0.3	<0.5	0.82	42.21	51.01	40.71	<0.3	0.89	8.65	9.16	<0.1	<0.1
qc)	<0.3	<0.5	0.80	39.86	48.90	39.94	<0.3	1.04	8.06	8.32	<0.1	<0.1
qc 3	<0.3	<0.5	16.90	42.44	53.50	42.46	0.31	1.78	8.15	8.88	<0.1	<0.1
qc 3	<0.3	<0.5	16.41	42.63	52.94	41.72	<0.3	1.20	8.27	8.67	<0.1	<0.1
Run 20060516												
HPS nist AB 15/06/20	5.62	0.44	0.95	49.90	52.96	49.85	<0.1	1.06	9.38	9.53	<0.1	<0.1
qc 16/06/2006 13:17:2	6.00	0.47	0.99	49.58	53.77	50.79	<0.1	1.08	9.53	9.55	<0.1	<0.1
qc 16/06/2006 13:42:2	12.39	0.46	0.94	47.75	51.36	48.60	<0.1	1.05	9.21	9.14	<0.1	<0.1
qc 16/06/2006 13:57:2	6.59	0.50	20.16	52.58	55.53	51.34	<0.1	1.14	9.93	9.70	<0.1	<0.1
qc 2 16/06/2006 14:12:	6.37	0.47	1.00	50.74	53.70	52.12	<0	1.13	9.80	9.80	<0	<0
>qc 2 16/06/2006 14:1	6.33	0.47	0.98	49.71	53.45	50.14	<0	1.10	9.67	9.63	<0	<0
qc 16/06/2006 14:32:1	22.83	0.41	18.33	45.68	47.91	47.18	<0	1.06	9.40	9.61	<0	<0
qc 16/06/2006 14:37:1	11.27	0.43	18.48	47.57	49.57	47.92	<0	1.08	9.55	9.69	<0	<0
Run 2006 927												
nist ab qc	<0.3	<0.5	0.89	45.68	57.46	44.72	<0.3	1.04	9.49	9.93	<0.1	<0.1
>qc	<0.3	<0.5	0.82	42.21	51.01	40.71	<0.3	0.89	8.65	9.16	<0.1	<0.1
qc)	<0.3	<0.5	0.80	39.86	48.90	39.94	<0.3	1.04	8.06	8.32	<0.1	<0.1
qc 3	<0.3	<0.5	16.90	42.44	53.50	42.46	0.31	1.78	8.15	8.88	<0.1	<0.1
Run T200's												
HPS nist AB)	<0.3	0.38	0.97	51.09	52.54	53.01	<0.3	<3	10.17	10.20	<0.1	<0.1
HPS nist AB	<0.3	0.38	0.99	51.69	52.60	53.28	<0.3	<3	10.18	10.26	<0.1	<0.1
qc	<0.3	0.35	1.00	50.11	51.31	52.91	<0.3	<3	9.85	10.14	<0.1	<0.1
qc	<0.3	0.38	0.96	49.49	50.28	52.75	<0.3	<3	9.94	10.21	<0.1	<0.1
qc 25/10/2006 21:28:2	<0.3	0.36	0.95	49.04	50.23	51.30	<0.3	<3	9.89	10.06	<0.1	<0.1
qc 2 25/10/2006 22:03:	<0	0.31	0.91	47.18	47.60	48.55	<0	<3	9.43	9.86	<0	<0
qc	<0	0.35	0.94	49.05	49.75	51.48	<0	<3	9.75	10.15	<0	<0
qc	<0	0.31	18.15	48.64	49.24	49.68	<0	<3	9.56	9.89	<0	<0
qc 3	<0	0.31	18.49	47.63	47.89	49.97	<0	<3	9.45	9.71	<0	<0

NP - not present in stand
NA - interferent in ICP-M

Table A-5(b) *continued*

Sample ID	137Ba	200Hg	202Hg	205Tl	206Pb	207Pb	208Pb	209Bi	238U
NIST SM1811 A or B Ad	10.00	NP	NP	10.00	10.00	10.00	10.00	NP	NP
Run 20060322									
HPS nist AB 05/04/20C	11.05	4.07	0.95	10.69	10.78	10.87	1.12	<0.1	<0.1
QC 05/04/2006 13:14:1	11.12	4.13	0.96	10.76	10.76	10.96	11.17	<0.1	<0.1
QC 04/04/2006 17:23:2	10.83	3.68	3.73	10.53	10.67	10.85	10.98	<0.1	<0.1
QC 04/04/2006 17:28:3	10.92	3.76	3.88	10.52	10.72	10.74	10.99	<0.1	<0.1
Run 20060323									
nistab 22/03/2006 15:3	7.78	58.15	20.23	7.74	7.71	7.68	0.79	<0.1	<0.3
>nistab 22/03/2006 15:	7.96	41.88	2.44	7.83	7.66	7.82	0.80	<0.1	<0.3
>>nistab 22/03/2006 1	8.42	1.13	<0.5	8.24	8.14	8.32	0.85	<0.1	<0.3
QC 22/03/2006 19:11:0	8.45	<1	<1	8.45	8.36	8.52	8.67	<0	<0
QC 22/03/2006 19:16:0	8.50	<1	<1	8.42	8.33	8.51	8.65	<0	<0
nist ab qc	11.98	<0.3	<0.3	9.11	9.52	9.79	0.98	<0.1	<0.1
>qc	11.05	<0.3	<0.3	8.77	9.26	9.50	0.95	<0.1	<0.1
qc)	11.02	<0.3	<0.3	8.11	8.64	8.77	0.88	<0.1	<0.1
qc 3	13.38	<0.3	<0.3	8.45	8.92	9.06	9.09	<0.1	<0.1
qc 3	11.28	<0.3	<0.3	8.18	8.58	8.86	8.87	<0.1	<0.1
Run 20060516									
HPS nist AB 15/06/20C	9.27	<0.1	<0.1	9.23	9.11	9.15	0.94	<0.3	<0.3
qc 16/06/2006 13:17:2	9.26	<0.1	<0.1	9.22	9.02	9.12	0.93	<0.3	<0.3
qc 16/06/2006 13:42:2	8.81	<0.1	<0.1	8.97	8.83	8.86	0.91	<0.3	<0.3
qc 16/06/2006 13:57:2	9.45	<0.1	<0.1	9.39	9.22	9.27	9.50	<0.3	<0.3
qc 2 16/06/2006 14:12:	9.55	<0	<0	9.80	9.60	9.73	0.99	<0	<0
>qc 2 16/06/2006 14:1	9.46	<0	<0	9.63	9.46	9.54	0.97	<0	<0
qc 16/06/2006 14:32:1	9.43	<0	<0	9.97	9.86	9.94	10.14	<0	<0
qc 16/06/2006 14:37:1	9.65	<0	<0	10.08	9.91	10.01	10.22	<0	<0
Run 2006 927									
nist ab qc	11.98	<0.3	<0.3	9.11	9.52	9.79	0.98	<0.1	<0.1
>qc	11.05	<0.3	<0.3	8.77	9.26	9.50	0.95	<0.1	<0.1
qc)	11.02	<0.3	<0.3	8.11	8.64	8.77	0.88	<0.1	<0.1
qc 3	13.38	<0.3	<0.3	8.45	8.92	9.06	9.09	<0.1	<0.1
Run T200's									
HPS nist AB)	9.57	<0.3	<0.3	9.77	9.84	9.17		1.01	
HPS nist AB	9.63	17.64	<0.3	9.66	9.65	9.30		0.99	
qc	9.25	<0.3	<0.3	9.56	9.58	9.00		0.99	
qc	10.97	18.93	<0.3	10.07	10.08	9.56		1.04	
qc 25/10/2006 21:28:2	10.41	46.12	<0.3	10.03	10.07	9.47		1.04	
qc 2 25/10/2006 22:03:	9.58	<0	<0	9.45	9.48	8.93		0.97	
qc	9.79	<0	<0	9.81	9.88	9.39		1.03	
qc	9.39	<0	<0	9.48	9.51	8.98		9.67	
qc 3	9.50	<0	<0	9.28	9.32	8.85		9.71	

NP - not present in stand
NA - interferent in ICP-M

Table A-6. MDL metals Meadowlands, New Jersey

Name	Average MDL Air Concentration (ng/m^3)
Li	0.2
Be	0.1
Mg	24.1
Al	3.5
Ti	1.6
V	0.7
Cr	1.0
Mn	0.6
Fe	53.0
Co	0.2
Ni	0.4
Cu	1.4
Zn	10.3
Ga	0.4
As	0.4
Se	1.8
Rb	0.2
Sr	0.7
Ag	0.1
Cd	0.2
In	0.7
Cs	0.7
Ba	1.7
Hg	0.2
Tl	0.7
Pb	0.5
Bi	0.2
U	0.7

Table A-7. Blank teflon filter OC/EC Meadowlands, New Jersey

				ug/cm2			ug / filter		
#	Sample ID	Collection Date	Site Sample Type	Actual OC_manual	Actual EC_manual	Actual TC_manual	OC	EC	TC
1	**Qtz 003**	03/17/05	**Blank**	0.12	0.00	0.12	0.79	0.00	0.79
2	**Qtz 006**	03/23/05	**Blank**	0.14	0.00	0.14	0.91	0.00	0.91
3	**Qtz 016**	04/10/05	**Blank**	0.35	0.00	0.35	2.32	0.00	2.32
4	**Qtz 026**	05/10/05	**Blank**	0.11	0.00	0.11	0.76	0.00	0.76
5	**Qtz037**	06/09/05	**Blank**	0.26	0.00	0.26	1.69	0.00	1.69
6	**Qtz049**	06/27/05	**Blank**	0.19	0.00	0.19	1.25	0.00	1.25
	Qtz054	7/3/2005	**Blank**						
7	**Qtz055**	7/3/2005	**Blank**	0.20	0.00	0.20	1.32	0.00	1.32
8	**Qtz124**	10/07/05	**Blank**	0.18	0.00	0.18	1.22	0.00	1.22
9	**Qtz133**	10/19/05	**Blank**	0.26	0.00	0.26	1.73	0.00	1.73
10	**BLANK**			0.21	0.00	0.21	1.41	0.00	1.41
	Min			**0.11**	**0.00**	**0.11**	0.76	0.00	0.76
	Max			**0.35**	**0.00**	**0.35**	2.32	0.00	2.32
	Mean			**0.20**	**0.00**	**0.20**	1.34	0.00	1.34
	Q1			**0.15**	**0.00**	**0.15**	0.99	0.00	0.99
	Median			**0.18**	**0.00**	**0.18**	1.16	0.00	1.16
	Q3			**0.24**	**0.00**	**0.24**	1.62	0.00	1.62

Table A-8. MDL for VOCs Meadowlands, New Jersey

Name	MDL of Instrument (pg injection)	MDL Air Concentration ($\mu g/m^3$)
Chloromethane - NOT VALID	612	4.58
Vinyl chloride - NOT VALID	191	1.63
Bromomethane - NOT VALID	0.00	0.00
Chloroethane - NOT VALID	0.00	0.00
Trichloroflouromethane - NOT VALID	679	7.11
Methylene Chloride - NOT VALID	2100	19.64
1,1-Dichloroethene - NOT VALID	0.00	0.00
t-1,2-Dichloroethene - NOT VALID	0.00	0.00
1,1-Dichloroethane - NOT VALID	9.3	0.10
2,2-Dichloropropane - NOT VALID	6.8	0.08
cis-1,2-Dichloroethene - NOT VALID	7.9	0.08
Bromochloromethane - NOT VALID	0.00	0.00
Chloroform	6.4	0.07
1,1,1-Trichloroethane	4.7	0.05
Carbon Tetrachloride	15.	0.17
1,1-Dichloropropene	7.0	0.08
Benzene	25	0.24
1,2-Dichloroethane	7.2	0.08
Trichloroethene	49.	0.55
1,2-Dichloropropane	2.4	0.03
Dibromoethane	7.0	0.07
Bromodichloromethane	100.	1.12
cis-1,3-Dichloropropene	6.3	0.07
Toluene	13.	0.14
trans-1,3-Dichloropropene	5.4	0.06
1,1,2-Trichloroethane	5.8	0.07
Tetrachloroethene	2.6	0.03
1,3-Dichloropropane	16	0.18
Dibromochloromethane	18	0.20
1,2-Dibromoethane	7.2	0.08
Chlorobenzene	650	7.7
Ethylbenzene	28	0.35
1,1,1,2-Tetrachloroethane	4.2	0.05
m, p-Xylene	100	1.3
o-Xylene	29	0.36
Styrene	7.5	0.09
Bromoform	12	0.14
Isopropylbenzene	1.9	0.03
1,1,2,2-Tetrachloroethane	12	0.15
Bromobenzene	13	0.16
Propylbenzene	7.6	0.11
1,2,3-Trichloropropane	9.7	0.12
2-Chlorotoulene	1.7	0.02
1,3,5-Trimethylbenzene	2.6	0.03
4-Chlorotoluene	2.0	0.03
tert-Butylbenzene	6.2	0.10
1,2,4-Trimethylbenzene	9.9	0.14
sec-Butylbenzene	1.2	0.02
p-Isopropyltoluene	11	0.18
1,3-Dichlorobenzene	31	0.39
1,4-Dichlorobenzene	15	0.19
n-Butylbenzene	19	0.30
1,2-Dichlorobenzene	2.4	0.03
1,2-Dibromo-3-Chloropropane	4.2	0.06
1,2,4-Trichlorobenzene	1.8	0.03
Hexachloro-1,3,-Butadiene	2.9	0.04
Naphthalene	1.5	0.02
1,2,3-Trichlorobenzene	2.2	0.03

Table A-9. Precision for VOCs based on paired samples from fixed ambient air sites, Meadowlands, NJ

Compounds	%RSD
Carbon Tetrachloride	44%
Benzene	49%
Trichloroethene	37%
Toluene	19%
Tetrachloroethene	108%
Ethyl benzene	37%
m,p-Xylene	37%
o-Xylene	55%
Styrene	32%
Propylbenzene	85%
1,3,5-Trimethylbenzene	83%
1,2,4-Trimethylbenzene	92%
p-Isopropylbenzene	60%
1,4-Dichlorobenzene	55%
n-Butylbenzene	70%
Napthalene	104%

Table A-10. Precision For VOCs from Intensive Sampling Based on Paired Samples

	Sum of differences	Count	Pooled Standard Deviation	Mean	%RSD
chloroform	0.10	5	0.10	0.37	27%
toluene	13.6	17	0.63	3.40	16%
benzene	230	17	2.60	3.89	58%
ethylbenzene	0.80	16	0.16	0.49	35%
m,p-xylene	1.26	15	0.20	1.01	22%
o-xylene	0.11	13	0.064	0.40	15%
tetrachloroethene	0.039	6	0.057	0.46	15%
1,2,4-trimethylbenzene	0.039	12	0.040	0.19	21%
sec-butylbenzene	0.071	6	0.077	0.33	23%
trichlorofluoromethane	9.19	15	0.55	1.00	57%
methylene chloride	42.9	14	1.24	1.83	66%
carbon tetrachloride	0.082	9	0.067	0.41	16%
Iso propylbenzene	0.78	5	0.28	0.61	46%

Table A-11. Mean calculated concentration (ng on trap) from external standard for an injection of 2ng of each compound (results from 2005 sampling period)

Compound	Mean Calculated Concentration	Compound	Mean Calculated Concentration	Compound	Mean Calculated Concentration
butadiene	2.1±0.9	2 chlorotoluene	1.3±0.5	trichloroethene	2.1±0.4
chloroform	2.5±0.2	1,2,4 trimethyl benzene	0.9±0.4	dibromomethane	1.1±0.4
bromodichloromethane	2±0.4	*tert*-butyl benzene	1.3±0.5	cis 1,3 dichloropropene	1.6±0.5
dibromochloromethane	1.8±0.1	4-isopropyl toluene	1±0.3	trans 1,3 dichloropropene	1.1±0.7
bromoform	2.4±0.6	n-butyl benzene	1.1±0.2	1,2 dibromoethane	1.2±1.3
toluene	2.3±0.7	sec-butyl benzene	1.9±0.4	chlorobenzene	1.5±0.2
benzene	2±0.6	trichloroflurometh ane (freon)	3.7±2.5	1,1,2,2 tetrachloroethane	2.3±0.8
ethyl benzene	2.2±0.4	1,1 dichloroethene	2±0.6	bromobenzene	2±0.3
m,p xylene	2.7±0.5	methylene chloride	2.9±0.6	1,3 dichlorobenzene	1.6±1.1
styrene	1.8±0.5	1,1 dichloroethane	1.7±0.6	1,4 dichlorobenzene	0.8±0.5
o-xylene	1.7±0.4	cis-1,2 dichloroethene	1.9±0.5	1,2 dichlorobenzene	1.4±0.8
isopropyl benzene	2.2±0.2	2,2 dichloropropane	1.7±0.2	1,2,4 trichlorobenzene	1.1±0.7
n-propyl benzene	1±0.4	bromochloromethane	2.2±0.7	1,2,3 trichlorobenzene	1.6±1
tetrachloroethene	1.5±0.2	1,1,1 trichloroethane	1.5±0.1	naphthalene	2.1±1.2
1,3 dichloropropane	1.8±0.3	carbon tetrachloride	1.2±0.8	1,2 dichloropropane	1.6±1.1
1,1,2 trichloroethane	1.3±0.9	1,2 dichloroethane	1.4±0.3	trans 1,2 dichloroethene	1.6±0.9
		1,1 dichloropropene	2±0.7		

Appendix B Detailed Description of Modeling Approach and Methods

This modeling study employs methods, approaches, and databases approved by, or consistent with those used, by federal and state agencies such as the US Environmental Protection Agency (USEPA) and Department of Transportation (DOT), the New Jersey Departments of Environmental Protection (NJDEP) and of Transportation (NJDOT), and by professional organizations such as the American Meteorological Society (AMS). These computational tools are currently available within EOHSI's state-of-the-art Modeling ENvironment for Total Risk studies (MENTOR), a modular system that supports comprehensive environmental exposure and risk assessments, and have in fact been used to examine and analyze many air pollution issues in the State and the Region over the past 10 years. Information, reports and other details on this national program can be found on our web site: www.ccl.rutgers.edu.

B.1 Developing geodatabases of local and regional emissions and aerometric information utilizing existing inventories and standard modeling approaches

Emission databases employed in this project utilize the latest version of USEPA's National Emissions Inventory (NEI - USEPA, 2006c) and the latest compilations of up-to-date emissions information by NJDEP and NJDOT. A Geographic Information System (GIS) based emissions database is being developed from our extensive emissions library for New Jersey and neighboring States and "customized" for the specific needs of this project. Data and information relevant to current activities at the Meadowlands are being incorporated in the above database in coordination with relevant components of the Meadowlands District Plan. An air quality database (also GIS-based) is being developed to incorporate all available (historic) air quality monitor data for the last 15 years from all air quality monitors that have operated at locations within a 10 km radius from the Meadowlands; observational data being collected by the present study is also incorporated in this GIS database system. This system is being used both to optimize the design of the modeling analyses as well as to evaluate its outcomes through a series of statistical comparison tests. Weather data from all National Weather Service (NWS) and Automated Surface Observing Systems (ASOS) stations within a 25 km radius from the Meadowlands are also incorporated in this geodatabase.

B.2 Performing iterations of air quality modeling employing a hierarchy of approaches

Both long-term (for the development of seasonal and annual average estimates) and short term (for the development of "peak" daily/weekly estimates) computational modeling analyses are being performed to study the relative contributions of emission sources to locations in the vicinity of the Meadowlands District. Further details of the modeling steps are provided in the following sub-sections.

B.2.1 Estimation of background levels of air toxics

For many toxic air pollutants, outdoor concentrations should include "background" components attributable to long-range transport, unidentified emission sources, and natural emission sources. To accurately estimate outdoor total ambient concentrations of air toxics, it is necessary to account for these background concentrations that are not represented by atmospheric modeling of local anthropogenic emissions. The background levels of the selected air toxics can be characterized by the averages of the ambient concentrations measured at the nearest air quality monitoring stations located upwind from the receptors.

B.2.2 Preprocessing of emission inventories for use in local-scale air quality models

The Emissions Modeling System for Hazardous Air Pollutants Version 3 (EMS-HAP - Strum et al., 2002, 2004) was used to process the 1999 National Emission Inventory version 3.0 data (NEI99-v3.0 - USEPA, 2001, 2006c) for the subsequent ambient air quality modeling using the Industrial Source Complex Short Term Version 3 (ISCST3 - USEPA, 1995), the AMS/EPA Regulatory Model (AERMOD - USEPA, 2004b), and the Assessment System for Population Exposure Nationwide (ASPEN - USEPA, 2000). Major functions of EMS-HAP include the selection of pollutants and pollutant groups for modeling, the spatial allocation of county-level stationary and mobile source emissions to census tract level, the allocation of county-level aircraft emissions to airport locations, and the temporal allocation of annual emissions to seasonal and day-type specific hourly emission rates. An overview of EMS-HAP processing for ASPEN is shown schematically in Figure B-1.

The emissions estimates from NEI are enhanced by using USEPA's LandGEM, the Landfill Gas Emissions Model (Pelt et al., 1998; Alexander et al., 2005) to account for emissions from landfills within the Meadowlands District.

B.2.3 Preprocessing of local meteorology information

The hourly surface and upper air meteorological data collected at the nearby meteorological stations located in the vicinity of the study area were used as inputs for local meteorology preprocessing. The outputs of local meteorology preprocessing are then used as the meteorological inputs to the subsequent ambient air quality models (such as ISCST3 and AERMOD).

B.2.4 Estimation of local ambient concentrations of the air toxics of concern through applications of local-scale air quality models

Both of the ISCST3 and AERMOD models are used to calculate local ambient concentrations of the air toxics of concern at selected receptor locations. The applications of the ISCST3 and AERMOD models use the NEI99-v3.0 emission data processed by EMS-HAP as above, NCDC meteorological data, and the background concentrations extracted from the 1999 NATA database. The data for the complete modeling period are organized in standardized databases for this project. Summary overviews of components and information flows in the ISCST3 and AERMOD models are shown schematically in Figure B-2 and Figure B-3.

B.3 Evaluating performance of local and regional modeling through diagnostic analyses

Comparisons with the measurement data tests the performance of the modeling system to estimate actual contributions from a variety of sources to the ambient levels measured during the field study. These comparisons are performed by calculating the summary statistics values (such as the total average and seasonal averages) based on field measurements and model predictions.

Diagnostic evaluation of model estimates is conducted by examining the impacts of using different inputs of contributing factors (wind speeds and directions, proximity of sources, types of sources, etc.) on the predicted ambient concentrations of the air toxics.

B.4 Characterizing contributions of local and remote sources to airborne contaminant levels in the Meadowlands District

The modeling system developed and tested/refined from above three steps will then be used to characterize contributions of local and remote sources to airborne contaminant levels in the Meadowlands District. Finally, this modeling system will be implemented with the inputs from MERI for the analysis of scenarios corresponding to alternative future source activities and land uses, in order to assess and quantify relative differences of the impact of these alternatives on future levels of air toxics in the Meadowlands District.

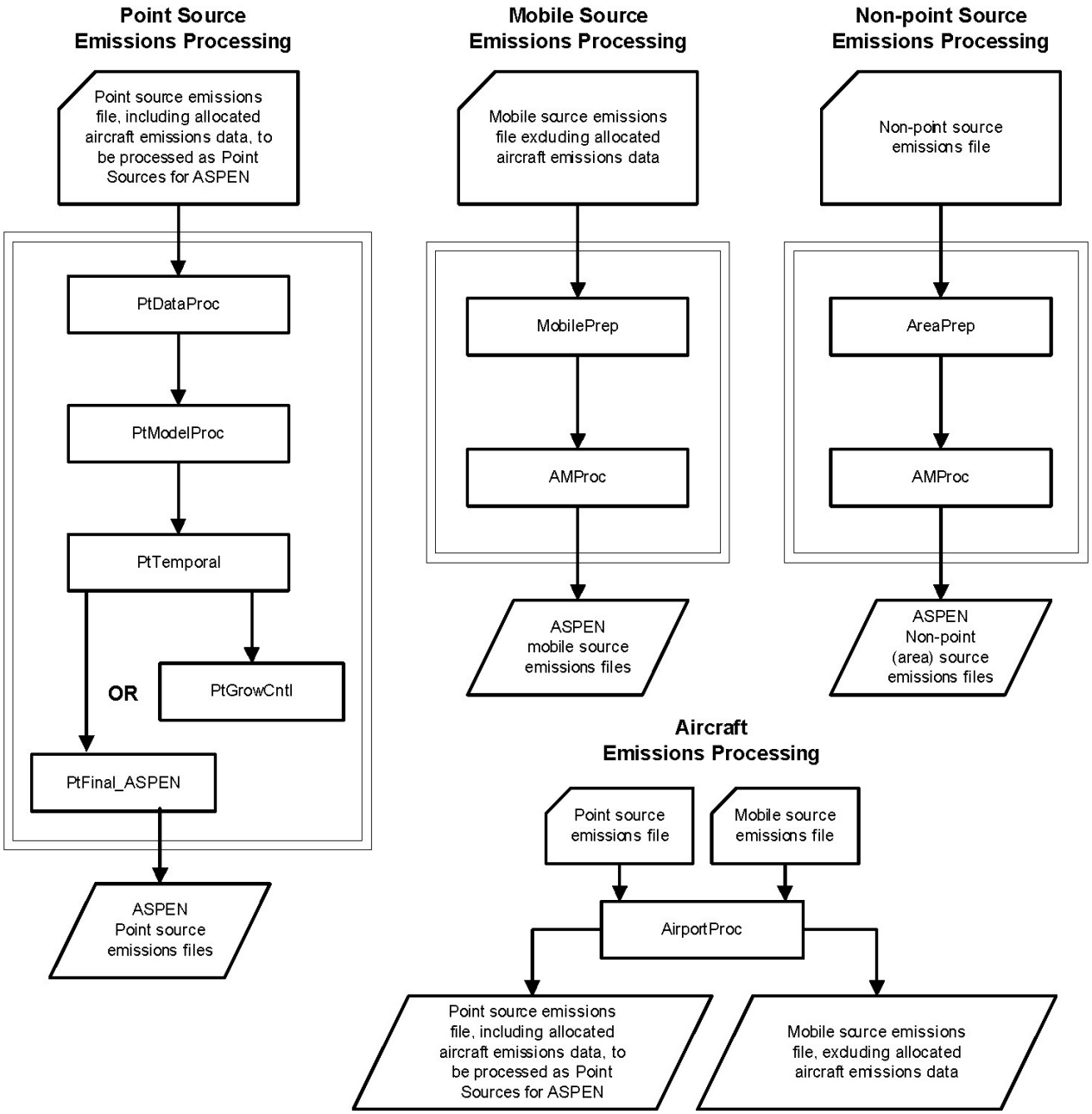


Figure B-1. Overview of the Emission Modeling System for Hazardous Air Pollutants (EMS-HAP) processing for the Assessment System for Population Exposure Nationwide (ASPEN) model (adapted from Strum et al., 2002)

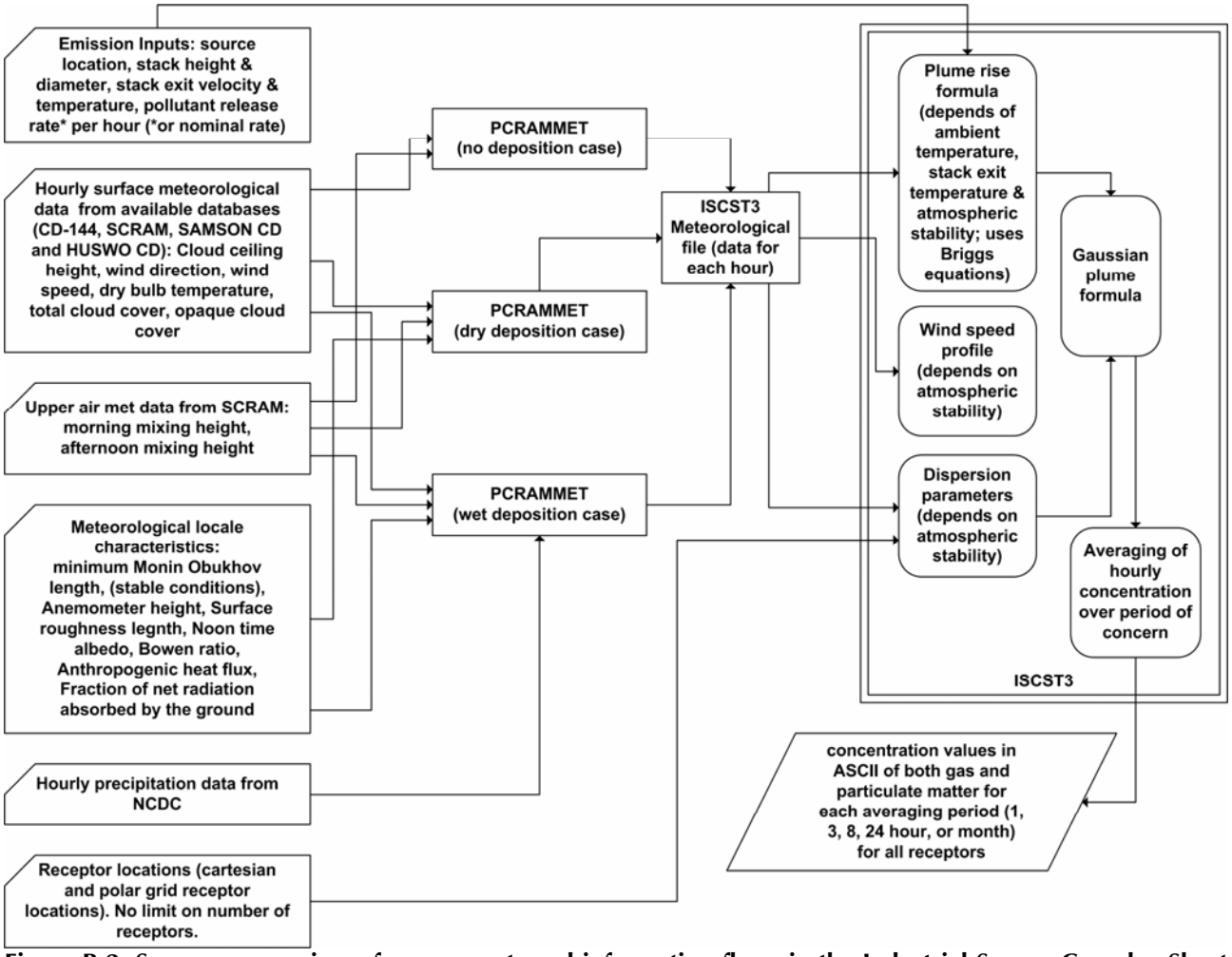


Figure B-2. Summary overview of components and information flows in the Industrial Source Complex Short term Version 3 (ISCST3) model

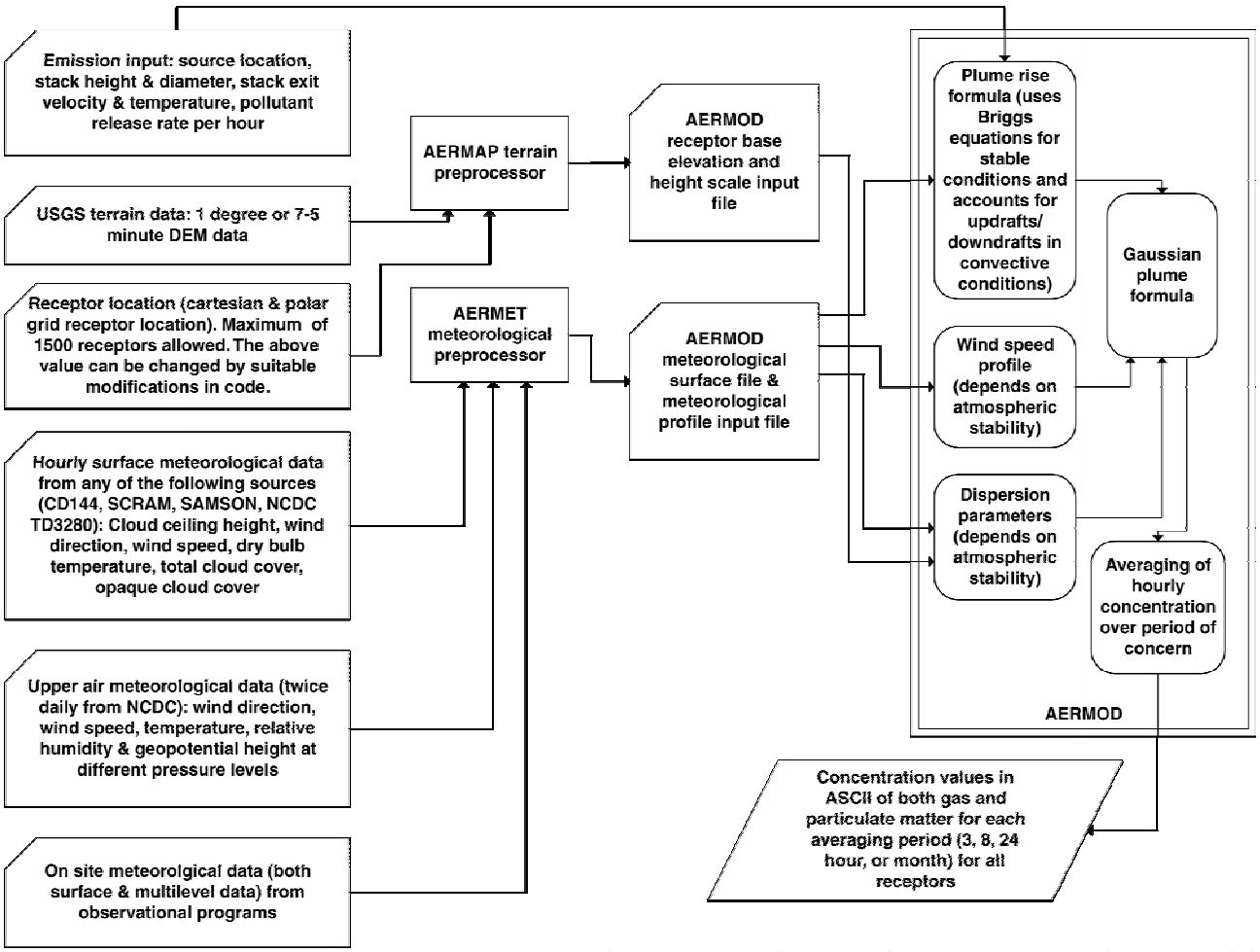


Figure B-3. Summary overview of components and information flows in the AMS/EPA Regulatory Model (AERMOD) modeling system

Appendix C Results of Geodatabases Development

C.1 Results of geodatabases development

C.1.1 A GIS-based air quality database

A prototype GIS-based air quality database has been developed for the Meadowlands District and is currently under testing and being refined. This geodatabase incorporates available (historic) air quality monitor data, as well as related meteorological data, collected at monitors that have operated within and in the vicinity of the Meadowlands District. The database is structured to also incorporate observational data collected from the measurement study. Figure C-1 shows the geographical distributions of air quality monitors and meteorological monitors in the vicinity of Meadowlands District. Figure C-2 shows the wind roses plots which summarize the wind speed and wind direction measurements collected from the following meteorological stations for the period of March 17 - November 8, 2005 (period in which VOCs and PM samples were collected at fixed site monitors in the long-term sampling study):

(a) MERI's EMS station at Kingsland Impoundment
(b) Teterboro Airport (ASOS met station number 94741)
(c) Newark Airport (ASOS met station number 14734)

The protocols used for wind measurement at MERI and ASOS stations are listed in Table C-1 (below).

Table C-1. Protocols used for wind measurement at meteorological stations

MERI LOCAL STATION	ASOS STATIONS
Observations are recorded every 5 minutes; hourly data are the average at the end of each hour	Observations are recorded every 10 minutes; hourly data are average at the end of each hour
Elevation is approximately sea level	Elevation is 2.1 meters (Newark) and 2.7 meters (Teterboro) above sea level
Wind speed is recorded in meter/second	Wind speed is recorded in knots

Figure C-3 to Figure C-6 show the boxplots of monitored ambient concentrations of the 7 air toxics (benzene, formaldehyde, TCE, PERC, arsenic, lead, and mercury) at the Elizabeth, NJ station for the 2000 to 2005 period. To facilitate the comparison between boxplots of monitored air toxic concentrations, conversion factors of concentration units (ppb to $\mu g/m^3$) are listed in Table C-2 (below).

Table C-2. Unit conversion factors for year 2005 - ppb to µg/m3

Chemical	Quarter1	Quarter 2	Quarter 3	Quarter 4
Formaldehyde	1.33	1.26	1.23	1.30
Benzene	3.47	3.28	3.19	3.38
TCE	5.83	5.52	5.37	5.69
PERC	7.36	6.97	6.77	7.18
Arsenic	3.32	3.15	3.06	3.24
Lead	9.19	8.70	8.46	8.97
Mercury	8.90	8.43	8.19	8.68

C.1.2 A GIS-based emissions database

A prototype local/background geodatabase of air toxics emissions affecting the Meadowlands district has been developed and currently under testing and being refined. This geodatabase incorporates data for all New Jersey and New York counties that are within a 25 km radius from the Meadowlands District. The data are being obtained from federal and state agencies such as USEPA,

CDC, and NJDEP. Air toxics emissions data from the following sources have been incorporated into this geodatabase:

- USEPA's National Toxics Inventory (NTI) for 1996 (USEPA, 2006d)
- USEPA's National Emissions Inventory (NEI) for 1999 and 2002 (USEPA, 2006c)
- USEPA's Toxics Release Inventory (TRI) for 2002 and 2003 (USEPA, 2006f)
- ATSDR's Hazardous Substance Release and Health Effects Database (HazDat) (ATSDR, 2006)
- USEPA's Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) (USEPA, 2006e)
- NJDEP's Known Contaminated Sites in NJ (KCS-NJ) (NJDEP, 2006)

Based on the 1999 NEI data, Figure C-7 to Figure C-9 show the emission estimates of the 7 air toxics of concern (benzene, formaldehyde, TCE, PERC, arsenic, lead, and mercury) from point, area, mobile on-road, and mobile non-road sources as well as their respective percentage contributions to the annual total emissions for the US and NJ. Figure C-10 shows a comparison of annual total emission estimates of the 7 air toxics of concern and the percentage contributions from different sources within a 20 km radius of the Meadowlands District, extracted from 1996 NTI and 1999 NEI. Figure C-11 shows a comparison similar to that of Figure C-10, for each of the ten New Jersey and New York counties that are within a 25 km radius from the Meadowlands.

Figure C-12 shows the geographical distribution of facilities located in the vicinity of the Meadowlands District, which are included in TRI (2002 and 2003) and 1999 NEI. Figure C-13 shows the geographical distribution of the known contaminated sites within a 10km radius of the Meadowlands District. Figure C-14 shows the geographical distribution of the major hazardous waste sites in the vicinity of Meadowlands District based on the information from HazDat and CERCLIS. Figure C-15 shows the aerial view of NEI, TRI facilities, and HazDat sites in the vicinity of Meadowlands District. Figure C-16 shows the aerial view of the Known Contaminated Sites (KCS) in the vicinity of the Meadowlands District. Table C-3 summarizes information about the facilities within the Meadowlands District, including the names of the facilities and chemicals released into air based on NEI, TRI, HazDat and also the updates from MERI. Table C-4 summarizes the same information as in Table C-3 for the facilities in the immediate vicinity of the Meadowlands District. Table C-5 provides the annual emissions estimates of the 7 air toxics of concern from the facilities within and in the immediate vicinity of the Meadowlands District based on 1999 NEI.

Table C-3. Summary table of atmospheric emission sources within the Meadowlands District (incorporating MERI information); information provided by MERI and merged with USEPA database is shown with yellow background

Facilities that are in both NEI and TRI		
Sitename	***Metals***	***Organics***
Bergen Generating Station	**TRI:** Hg	**NEI:** aldehydes, aromatics, PAHs; **TRI:** PAHs
Owens Corning Kearny Plant	**NEI:** As, Be, Cd, Cr, Hg, Mn, Ni, Pb, Sb	**NEI:** aldehydes, 1,3-butadiene, aromatics, chlorinated hydrocarbons, PAHs; **TRI:** aromatics, PAHs
Honeywell International, Inc.	**NEI:** Pb; TRI:Pb	
PSE&G - Hudson Generating Station	**NEI:** As, Be, Cd, Cr, Co, Hg, Mn, Ni, Pb, Sb **TRI:** As, Ba, Cr, Cu, Hg, Mn, Ni, Pb, V, Zn	**NEI:** alkanes, aldehydes, ketones, dioxins, aromatics, chlorinated hydrocarbons, PAHs; **TRI:** aromatics, dioxin, PAHs
Facilities that are only in NEI		
Bergen County Utilities Authority Landfill	Hg	Alkanes, aromatics, ketones, chlorinated hydrocarbons
Cosan Chemical Corp.		Aromatics, chlorinated hydrocarbons
United Wire Hanger Corporation	Pb	
Kearny Methane Recovery Facility		aldehydes, aromatics, PAHs
Teterboro Airport	Pb	Aldehydes, aromatics, PAHs
Transcontinental Gas Pipeline		Aldehydes, aromatics, PAHs
Water Pollution Control		Aldehydes, aromatics, PAHs
Facilities that are only in TRI		
Coates Screen Inc.	Pb	Ethers
Sika Corp.		Aldehydes, aromatics, organic acids
Facilities that are in HazDat (Superfund Sites, all media)		
Arsynco, Inc.		
Avon Sanitary Landfill		
Bendix Teterboro Facility		
Benedict Miller Inc		
Keegan Landfill		
Koppersco Inc/Seaport plant		
P & M Sanitation		
Scientific Chemical Processing Inc.	As, Be, Ca, Cr, Cu, Hg, Ni, Pb, Zn	Aromatics, ketones, chlorinated hydrocarbons, PCBs
Standard Chlorine Chemco Inc		
Ventron Velsicol	As, Ca, Ni, Pb, Hg, Zn	

Table C-4. Summary table of atmospheric emission sources in the immediate vicinity of the Meadowlands District (incorporating MERI information); information provided by MERI and merged with USEPA database is shown with yellow background

Facilities that are in both NEI and TRI		
Sitename	***Metals***	***Organics***
Facilities that are only in NEI		
Dower Finishing & Research CO.		Chlorinated hydrocarbons
Essex County Energy Recovery Facility	As, Be, Ca, Cr, Hg, Mn, Ni, Pb	Aldehydes, aromatics, PAHs
Essex Generating Station		Aldehydes, aromatics, PAHs
Summit Plaza Total Energy Plant	As, Be, Ca, Cr, Hg, Mn, Pb	Aldehydes, aromatics, PAHs
Facilities that are only in TRI		
Anchor Concrete Prods.	Pb	
Clean Earth of North Jersey Inc.	Pb, Zn	
Facilities that are in HazDat (Superfund Sites, all media)		
Diamond Alkali Company		Aromatics, chlorinated hydrocarbons, pesticides
PJP Landfill	As, Cr, Pb	Aromatics, chlorinated hydrocarbons, pesticides
Syncon Resins	Ba, Ca, Cr, Ni, Pb, Zn	Aromatics, chlorinated hydrocarbons, PCBs
Universal Oil Products Incorporated	As, Mn, Pb	Aromatics, chlorinated hydrocarbons
Conrail-Meadows Yard		
Becton Dickinson & Company		
Standard Coating Corp		

Table C-5. Annual emissions from facilities within and in the immediate vicinity of Meadowlands District (from 1999 NEI) (incorporating MERI information)

	Annual Emission (short tons/year)						
Sites Within Meadowlands District	**Benzene**	**HCHO**	**TCE**	**PERC**	**As**	**Pb**	**Hg**
Bergen County Utilities Authority Landfill	5.01E-01		4.28E-01	3.57E-01			3.38E-05
Cosan Chemical Corp	7.00E-03		3.40E-04				
Kearny Methane Recovery Facility	2.11E-01	6.19E+00					
Honeywell International, Inc.						7.00E-02	
Owens Corning Kearny Plant	2.37E+00	6.85E-02		2.16E-01	1.60E-03	2.00E-02	2.73E-05
PSE&G - Hudson Generating Station	4.68E-01	8.13E-02		1.55E-02	8.84E-02	4.21E-02	5.38E-02
Teterboro	2.63E+00	1.15E+00				3.15E+00	
Transcontinental Gas Pipeline	1.29E-01	3.77E+00					
Water Pollution Control	3.24E-05	2.70E-03					
Sites in Immediate Vicinity of Meadowlands District	**Benzene**	**HCHO**	**TCE**	**PERC**	**As**	**Pb**	**Hg**
Bergen Generating Station	7.87E-03	6.56E-01					
Dower Finishing & Research Co.			5.94E+00				
Essex Generating Station	7.77E-03	6.49E-01					
Essex County Energy Recovery Facility	1.76E-03	2.03E-04			8.24E-06		6.08E-06
Summit Plaza Total Energy Plant	5.93E-02	1.55E+00			3.02E-05	6.47E-05	2.23E-05
United Wire Hanger Corporation						1.00E-02	

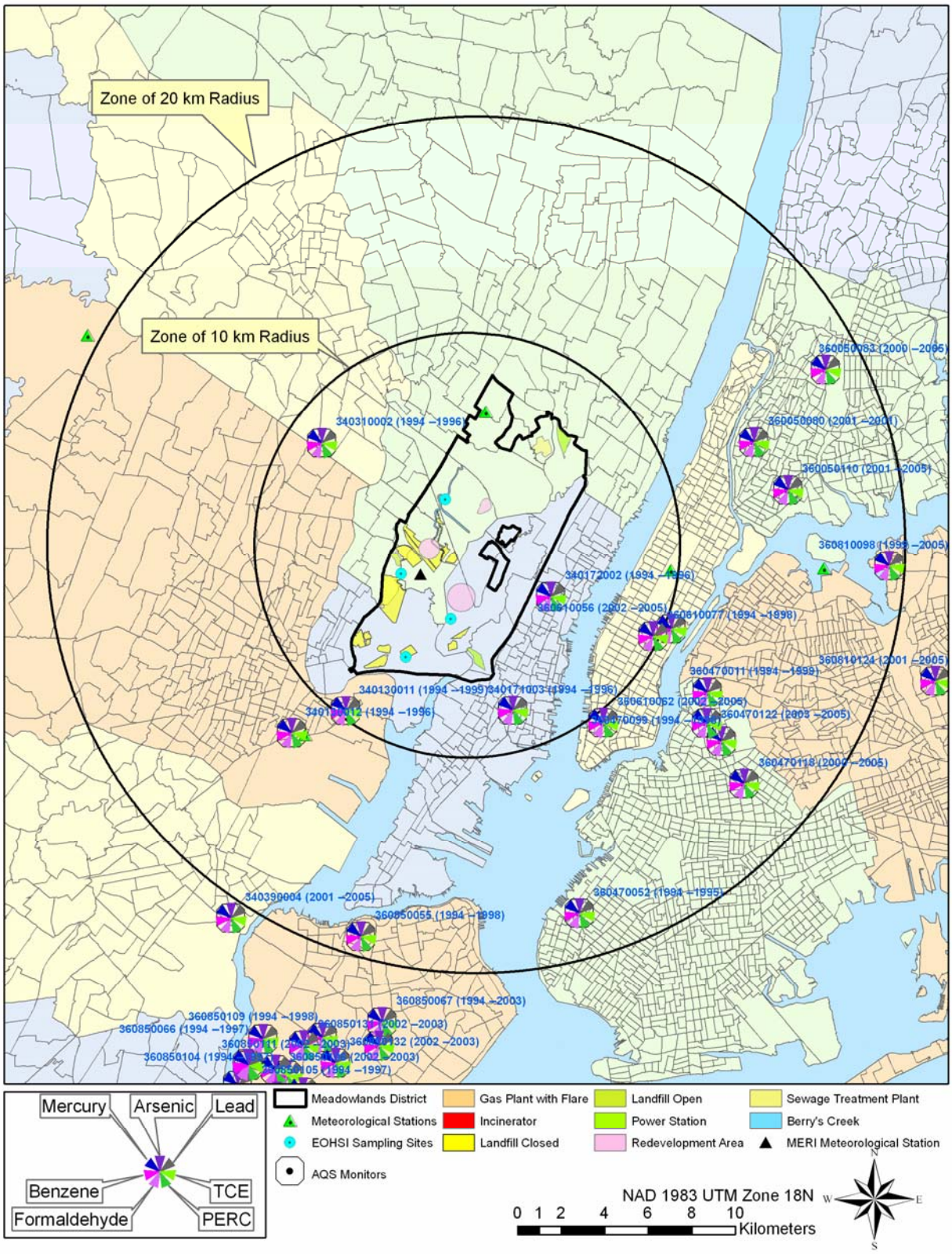


Figure C-1. Geographical distribution of air quality monitors and meteorological monitors in the vicinity of Meadowlands District

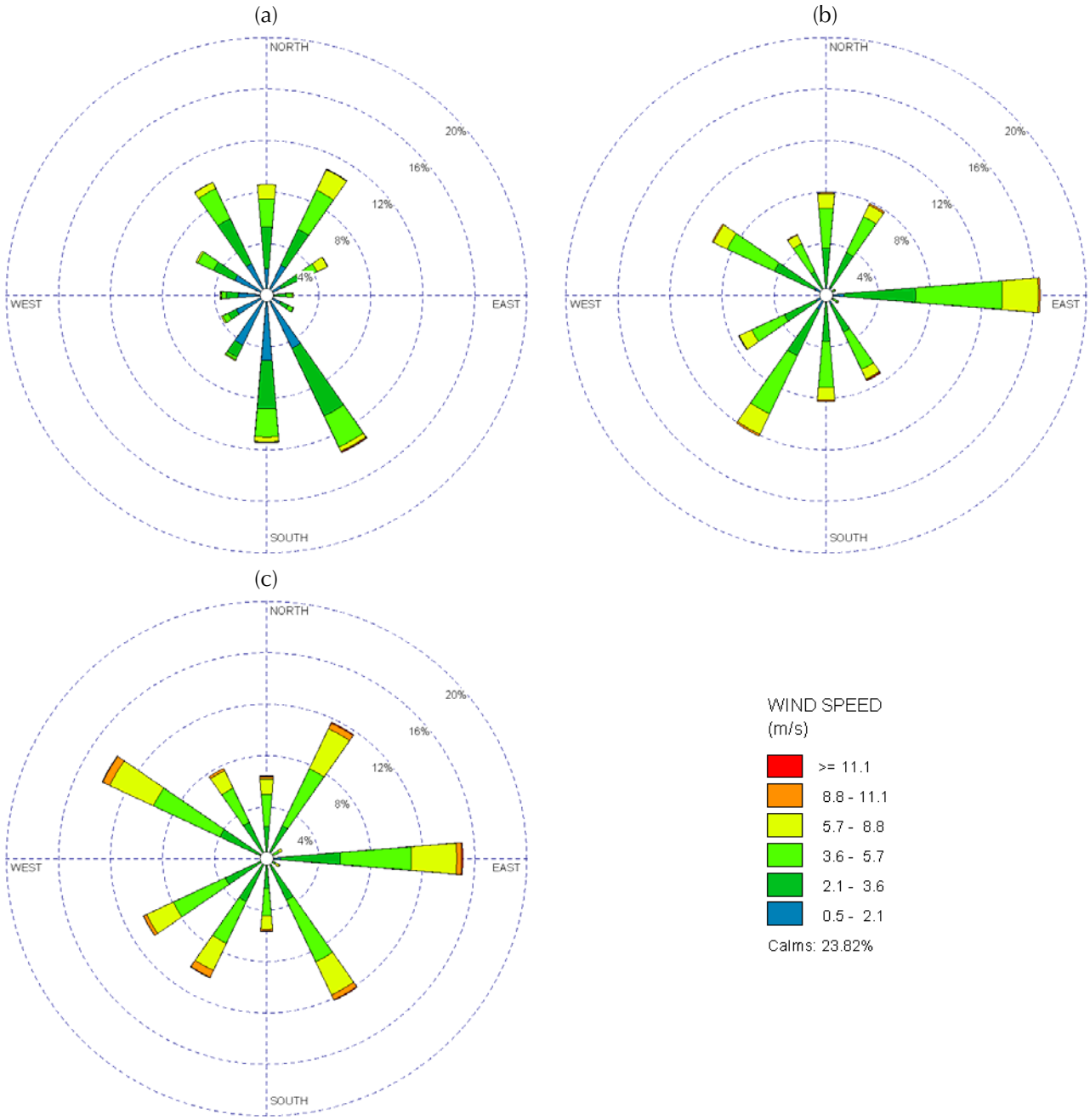
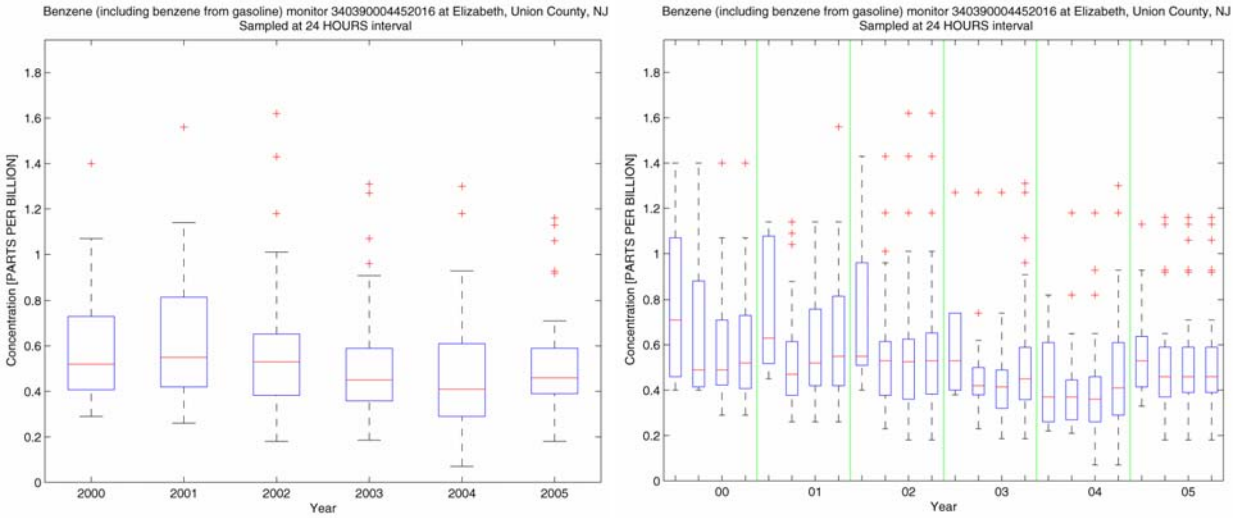


Figure C-2. Wind rose plots for: (a) Meadowlands Region (measured at MERI's EMS station at Kingsland Impoundment), (b) Teterboro Airport (met station number 94741), and (c) Newark Airport (met station number 14734) for the period of Mar 17 - Nov 8, 2005 (period in which VOCs and PM samples were collected). The direction of winds shown is the direction from which the wind is blowing.

From Benzene Monitor ID 340390004452016



From Benzene Monitor ID 340390004452017

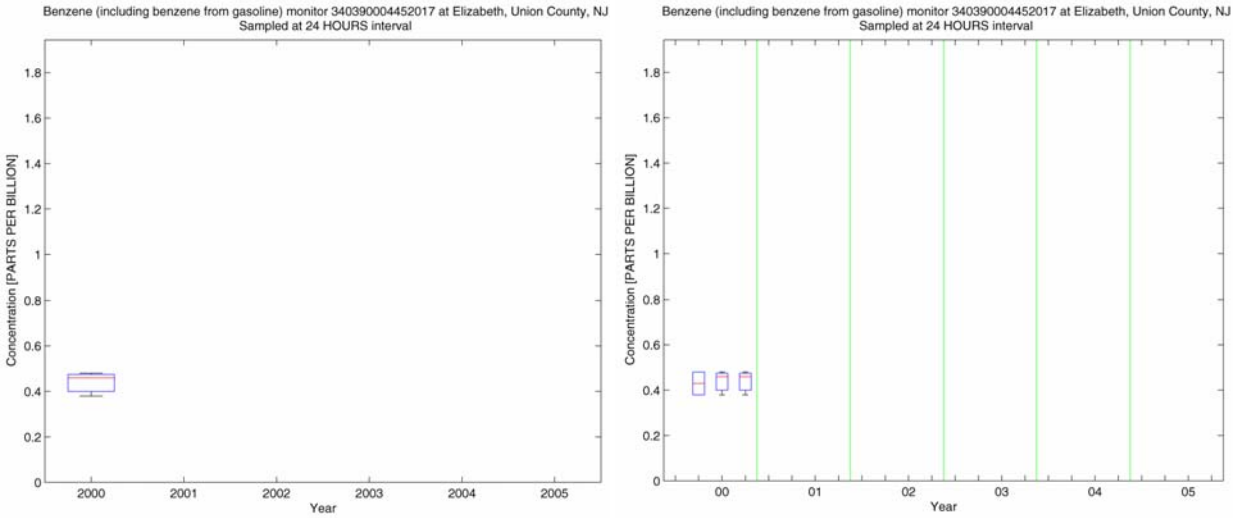
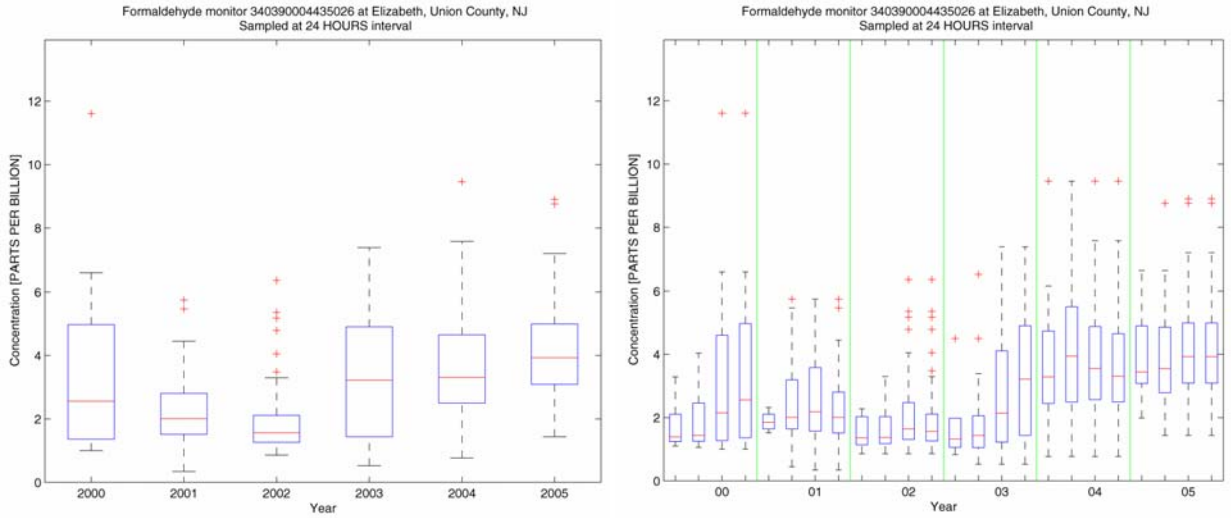


Figure C-3. Annual (left) and quarterly (right) boxplots showing monitored airborne concentrations of benzene at the Elizabeth NJ monitoring station

From Formaldehyde Monitor ID 340390004435026



From Formaldehyde Monitor ID 340390004435027

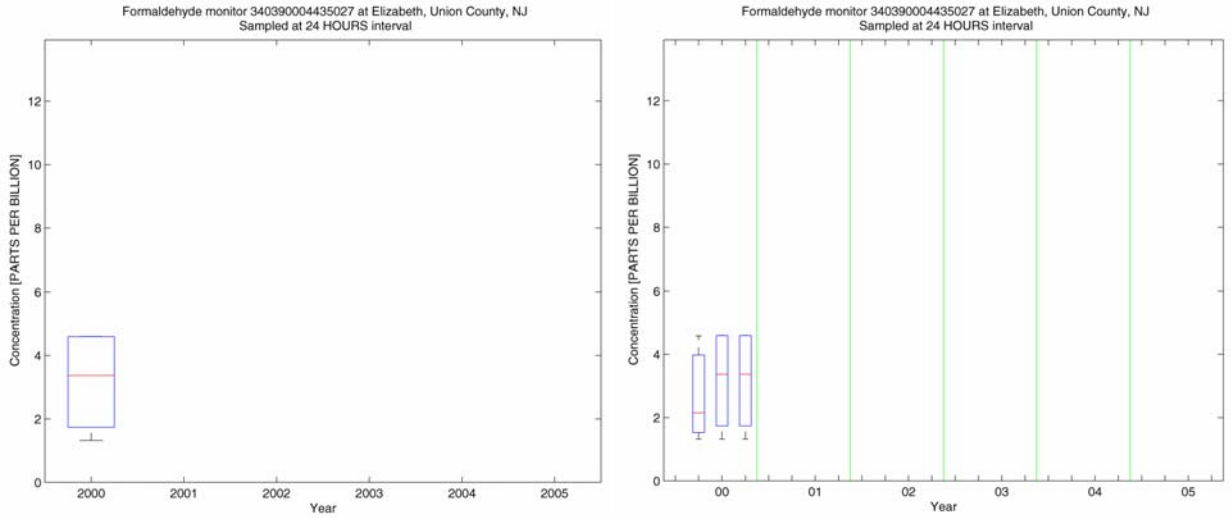
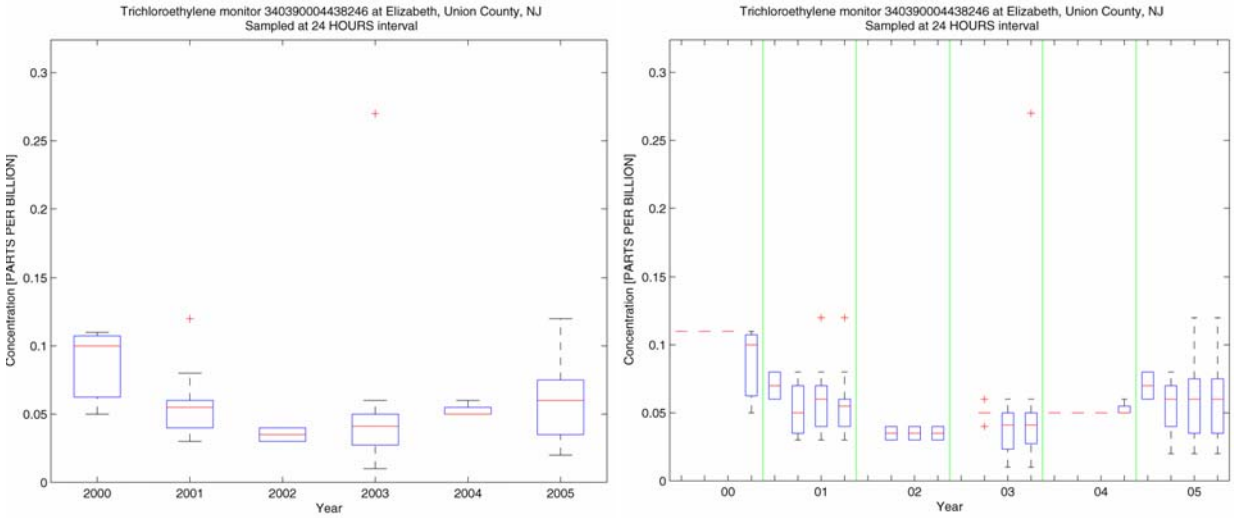


Figure C-4. Annual (left) and quarterly (right) boxplots showing monitored airborne concentrations of formaldehyde at the Elizabeth NJ monitoring station

From TCE Monitor ID 340390004438246



From PERC Monitor ID 340390004438176

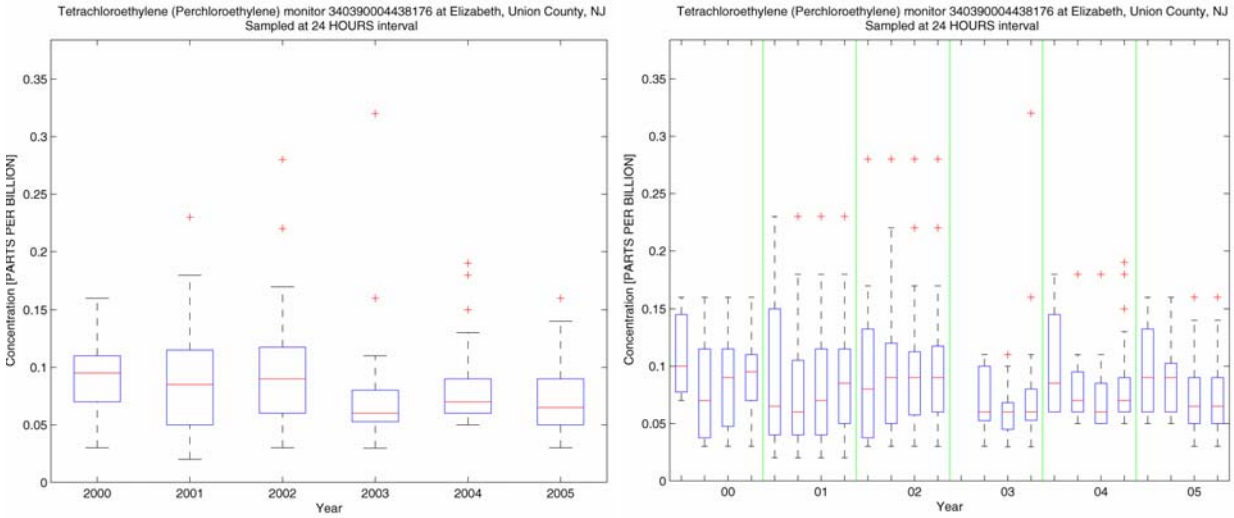
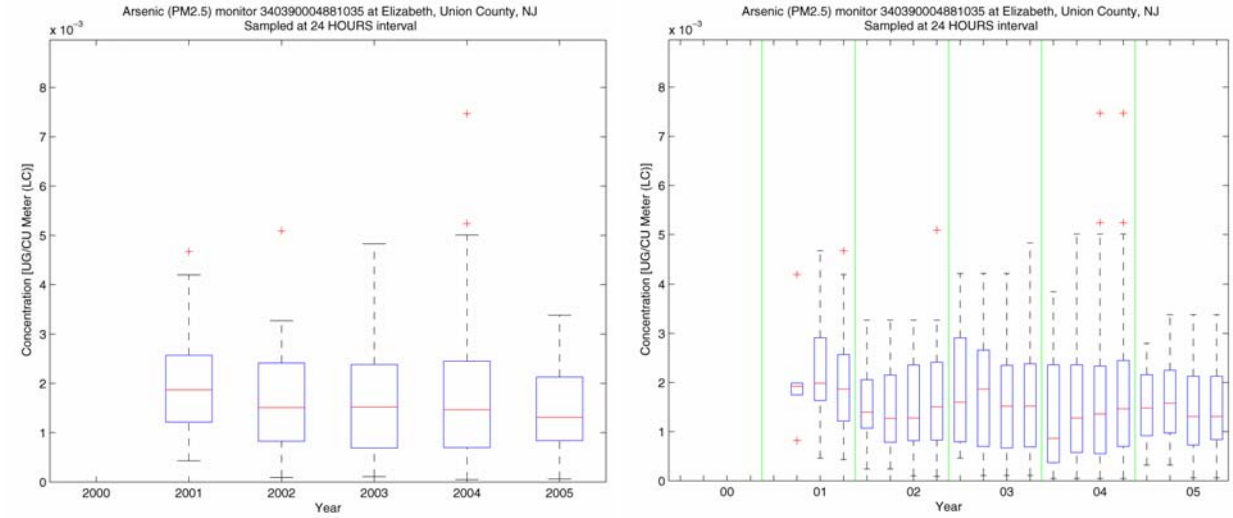
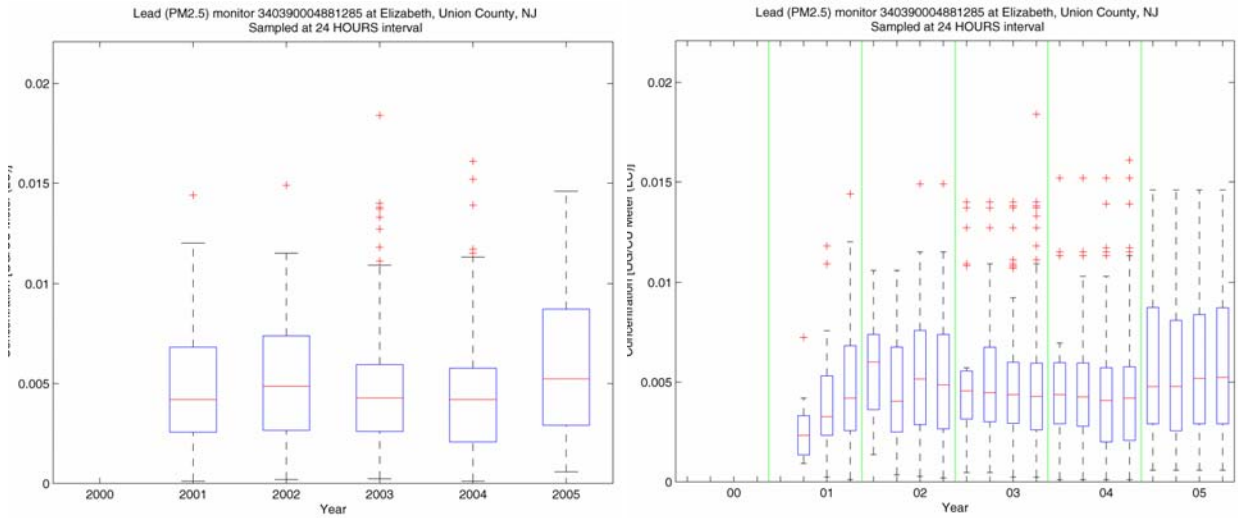


Figure C-5. Annual (left) and quarterly (right) boxplots showing monitored airborne concentrations of TCE and PERC at the Elizabeth NJ monitoring station

From Arsenic Monitor ID 340390004881035



From Lead Monitor ID 340390004881285



From Mercury Monitor ID 340390004881425

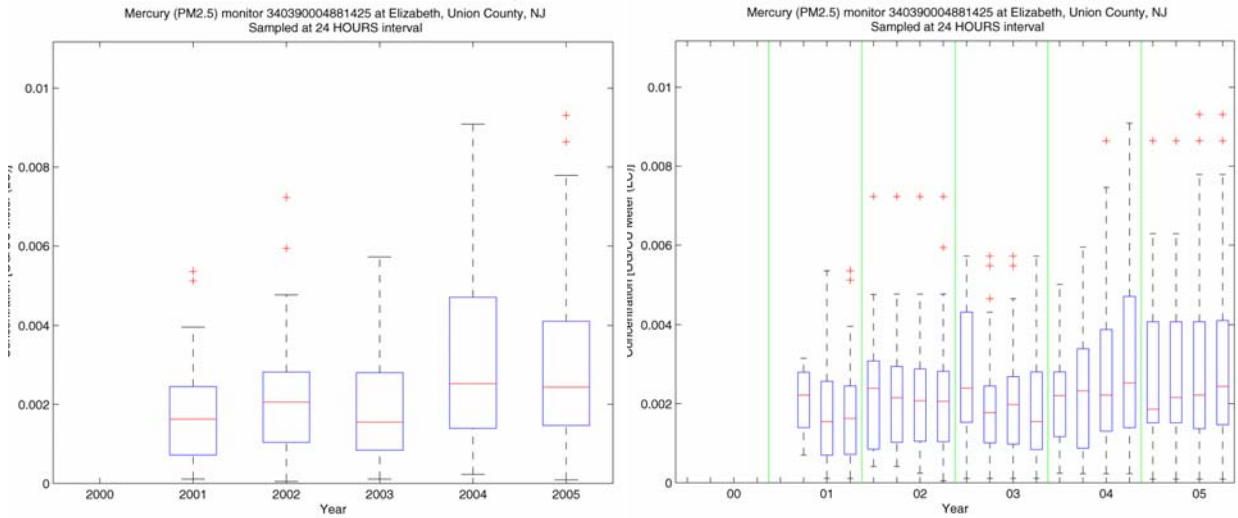


Figure C-6. Annual (left) and quarterly (right) boxplots showing monitored airborne concentrations of Arsenic, Lead, and Mercury at the Elizabeth NJ monitoring station

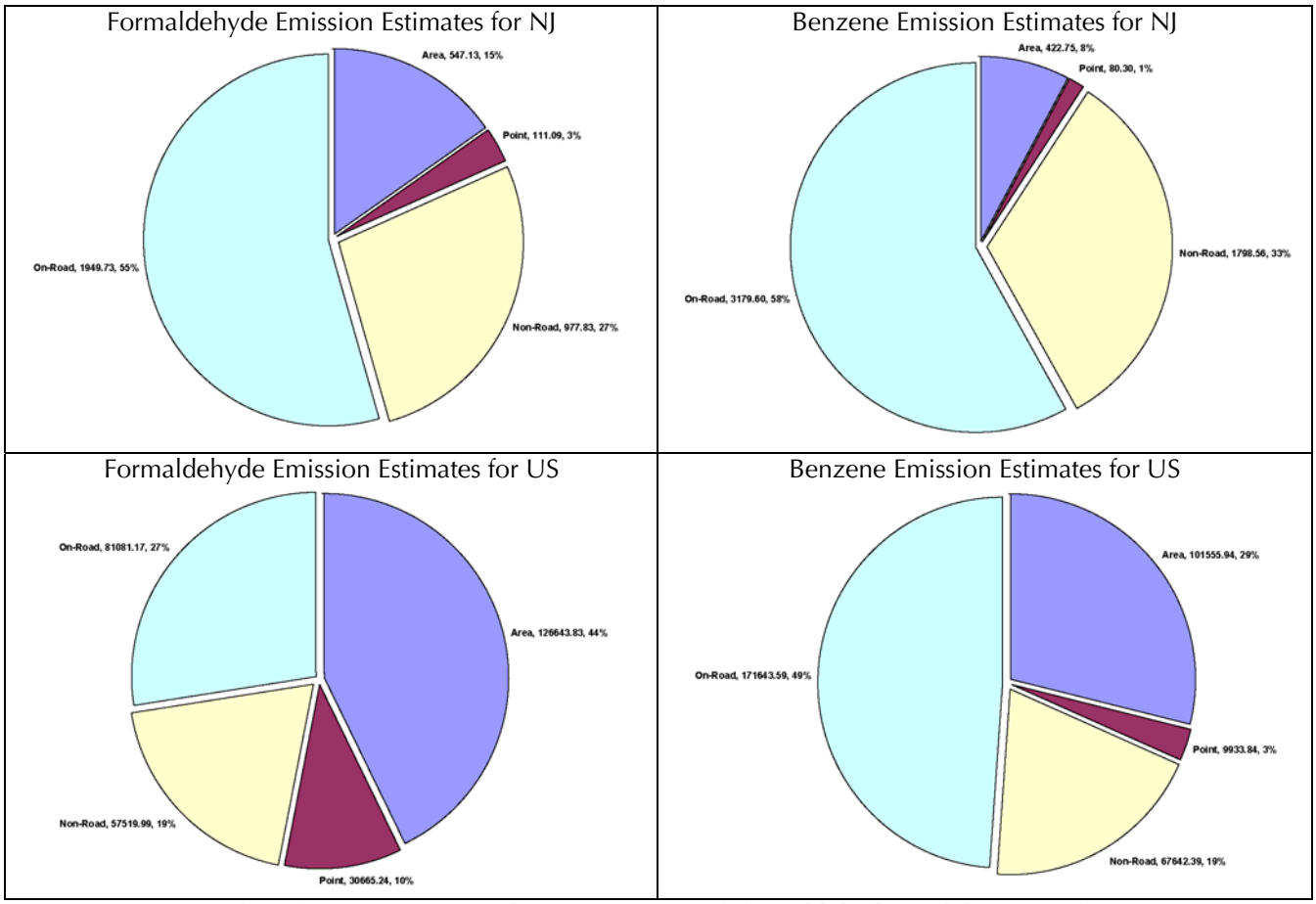


Figure C-7. Annual emission estimates (short tons/year) of formaldehyde and benzene from point, area, mobile on-road, and mobile non-road sources as well as their respective percentage contributions to the annual total emissions for the US and NJ using 1999 NEI, Final Version 3

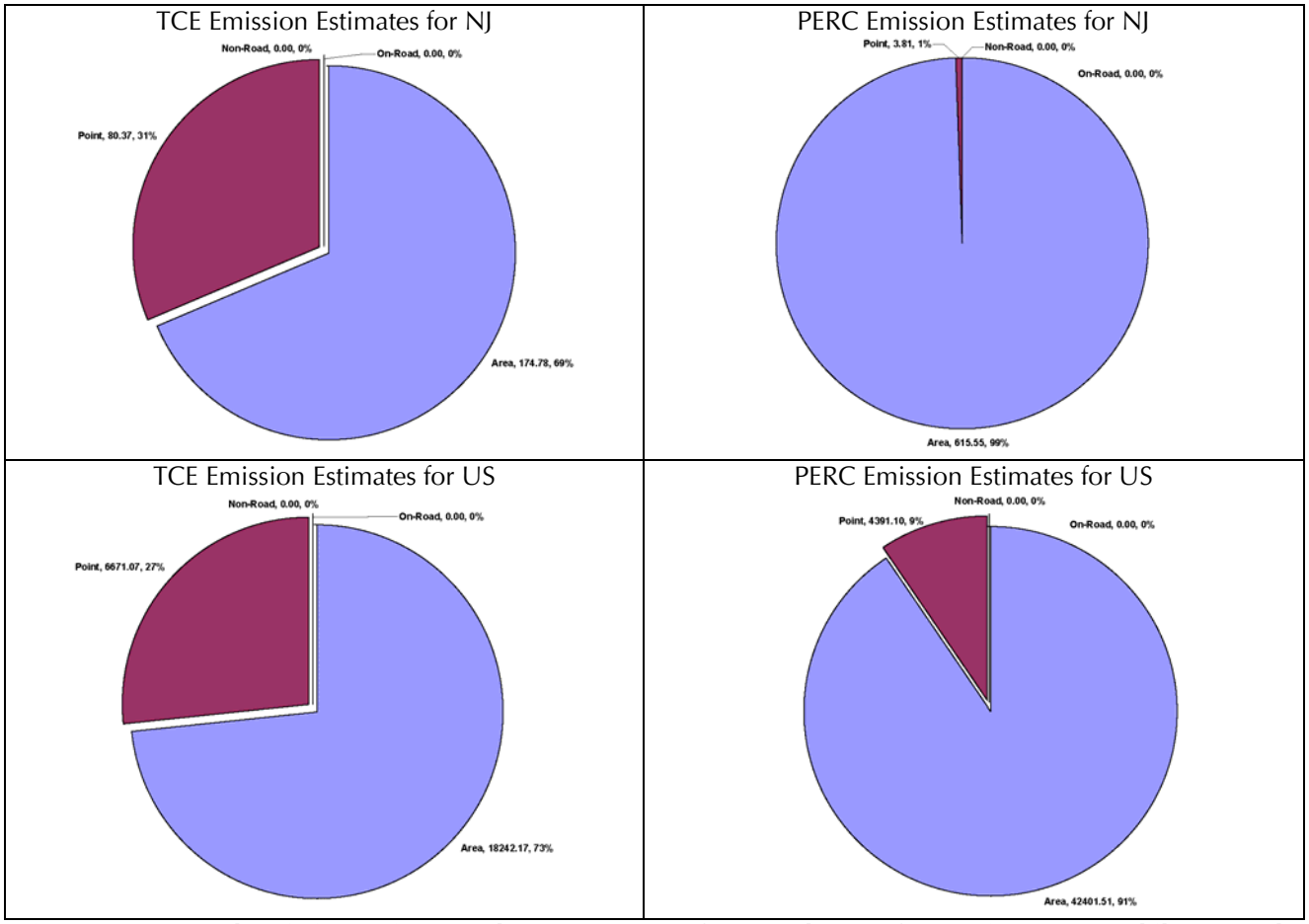


Figure C-8. Annual emission estimates (short tons/year) of TCE and PERC from point, area, mobile on-road, and mobile non-road sources as well as their respective percentage contributions to the annual total emissions for the US and NJ using 1999 NEI, Final Version 3

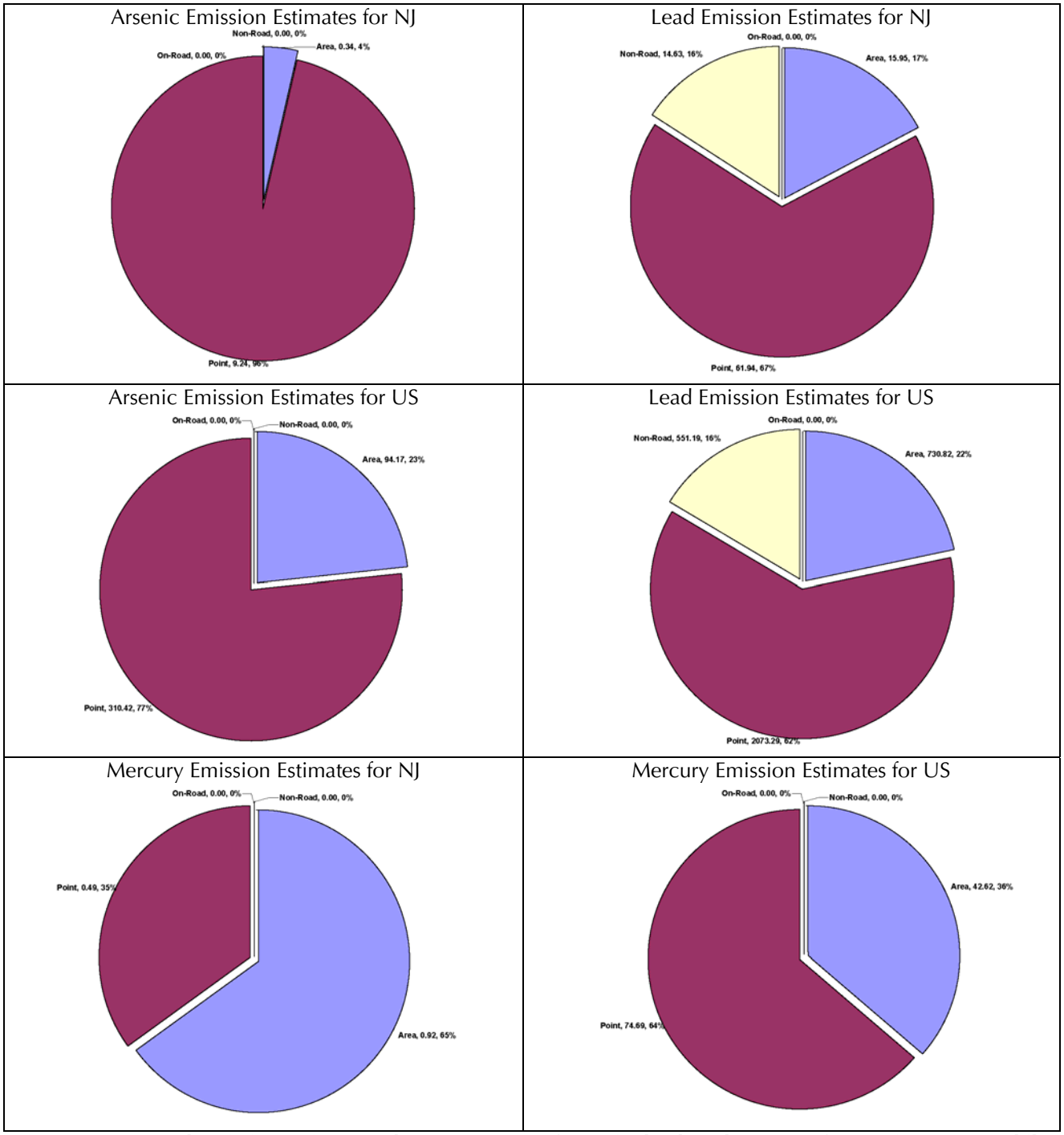


Figure C-9. Annual emission estimates (short tons/year) of arsenic, lead, and mercury from point, area, mobile on-road, and mobile non-road sources as well as their respective percentage contributions to the annual total emissions for the US and NJ using 1999 NEI, Final Version 3

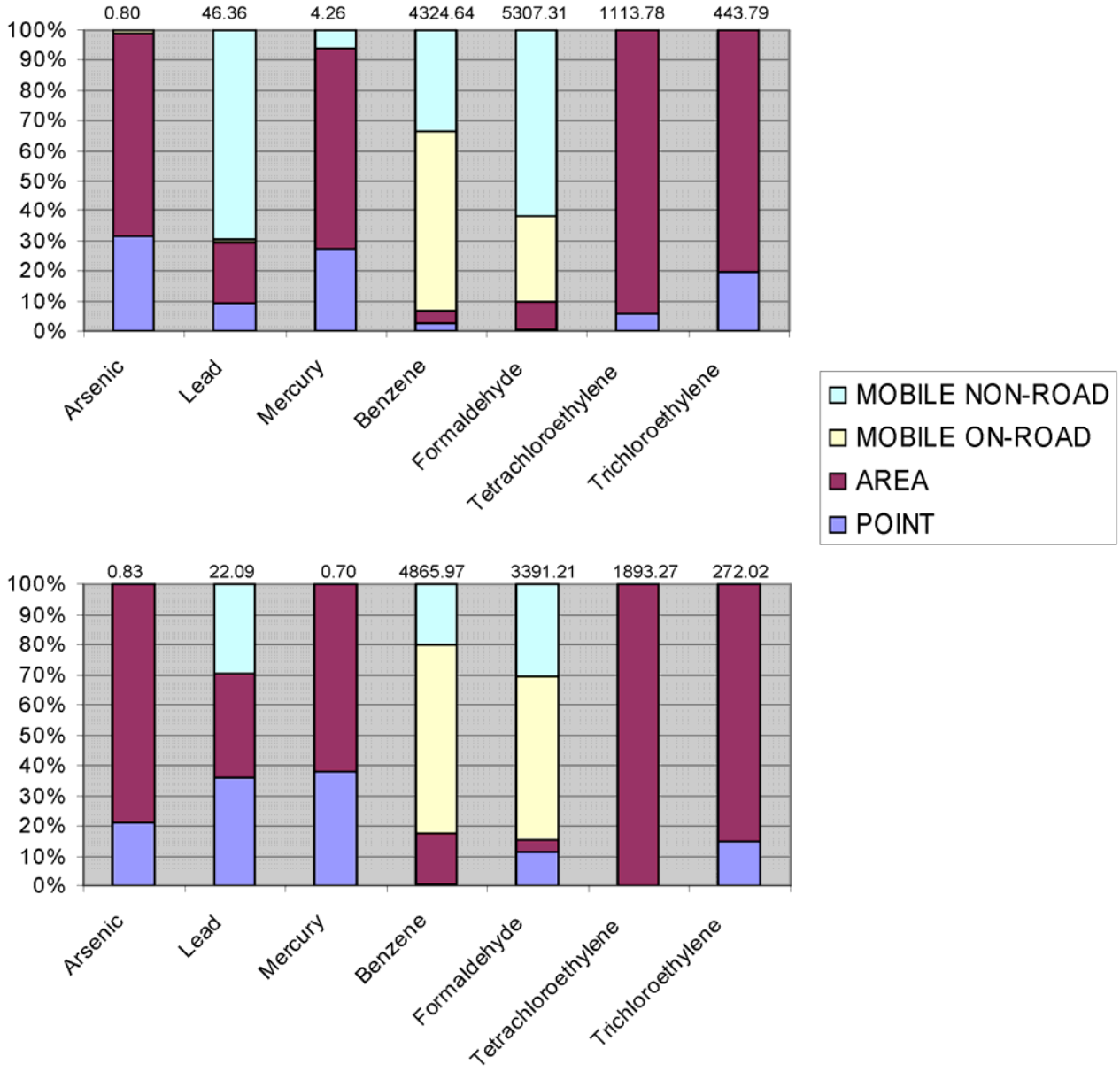


Figure C-10. Percentage of annual total emissions (short tons/yr) of the 7 air toxics (arsenic, lead, mercury, benzene, formaldehyde, PERC, TCE) from point, area, mobile on-road, and mobile non-road sources within 20km of Meadowlands District, from 1996 NTI (top) and from 1999 NEI (bottom)

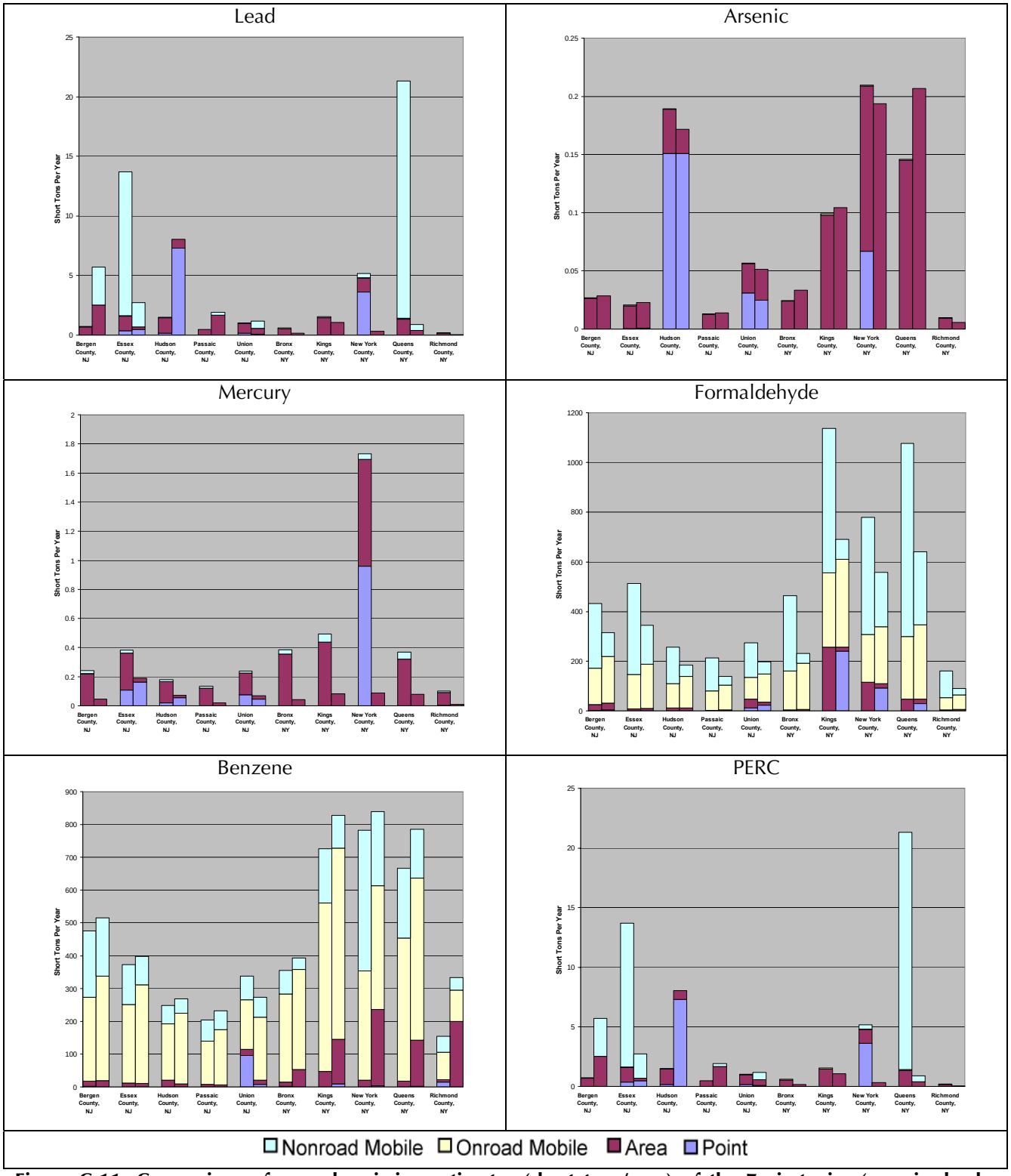


Figure C-11. Comparison of annual emission estimates (short tons/year) of the 7 air toxics (arsenic, lead, mercury, benzene, formaldehyde, PERC, TCE) in the ten New Jersey and New York counties that are within a 25km radius of the Meadowlands District from 1996 (NTI) and 1999 (NEI); for each county shown in these charts, the left bar represents data from 1996 NTI and the right bar represents data from 1999 NEI

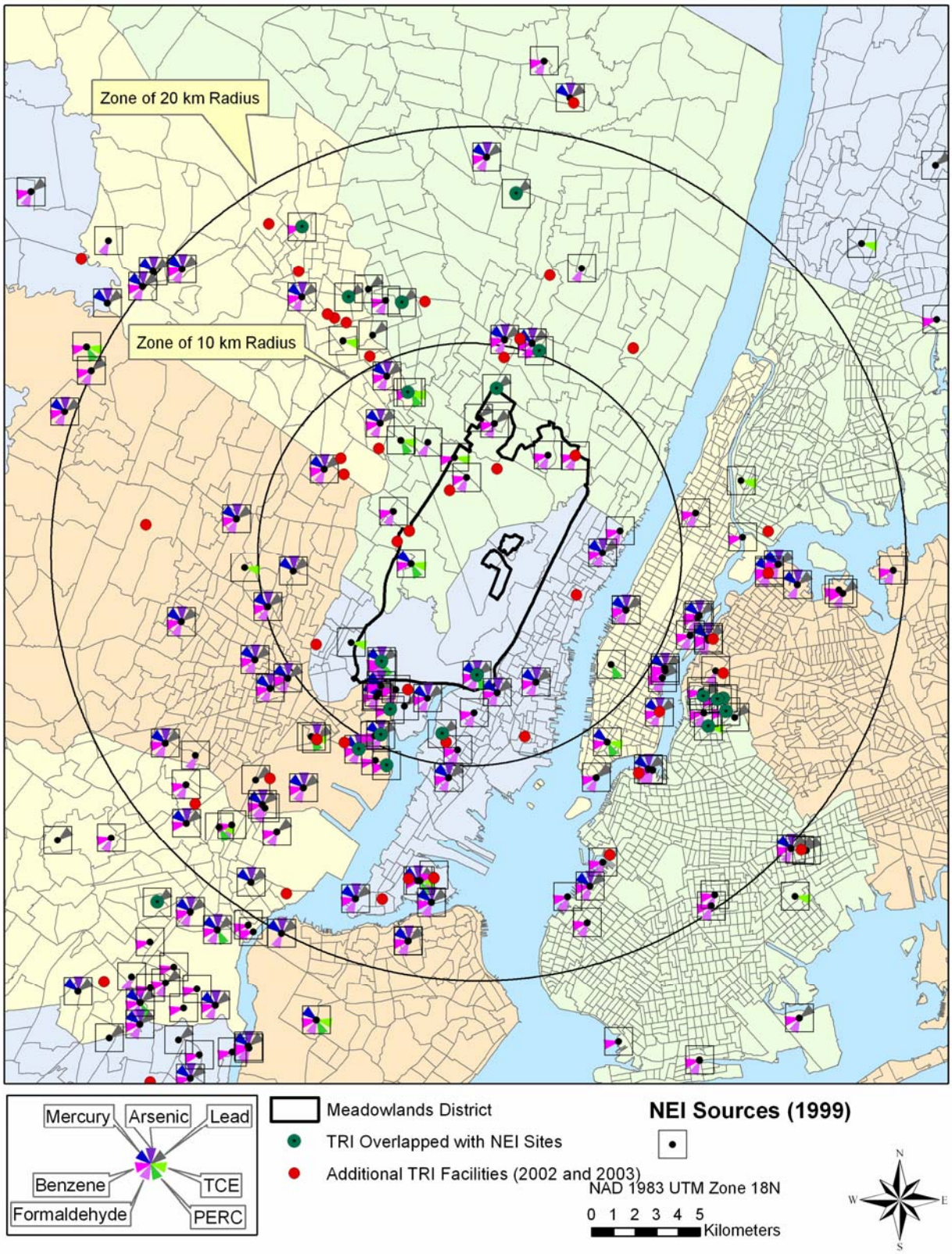


Figure C-12. Geographical distribution of facilities located in the vicinity of the Meadowlands District, which are included in the TRI (2002 and 2003) and 1999 NEI

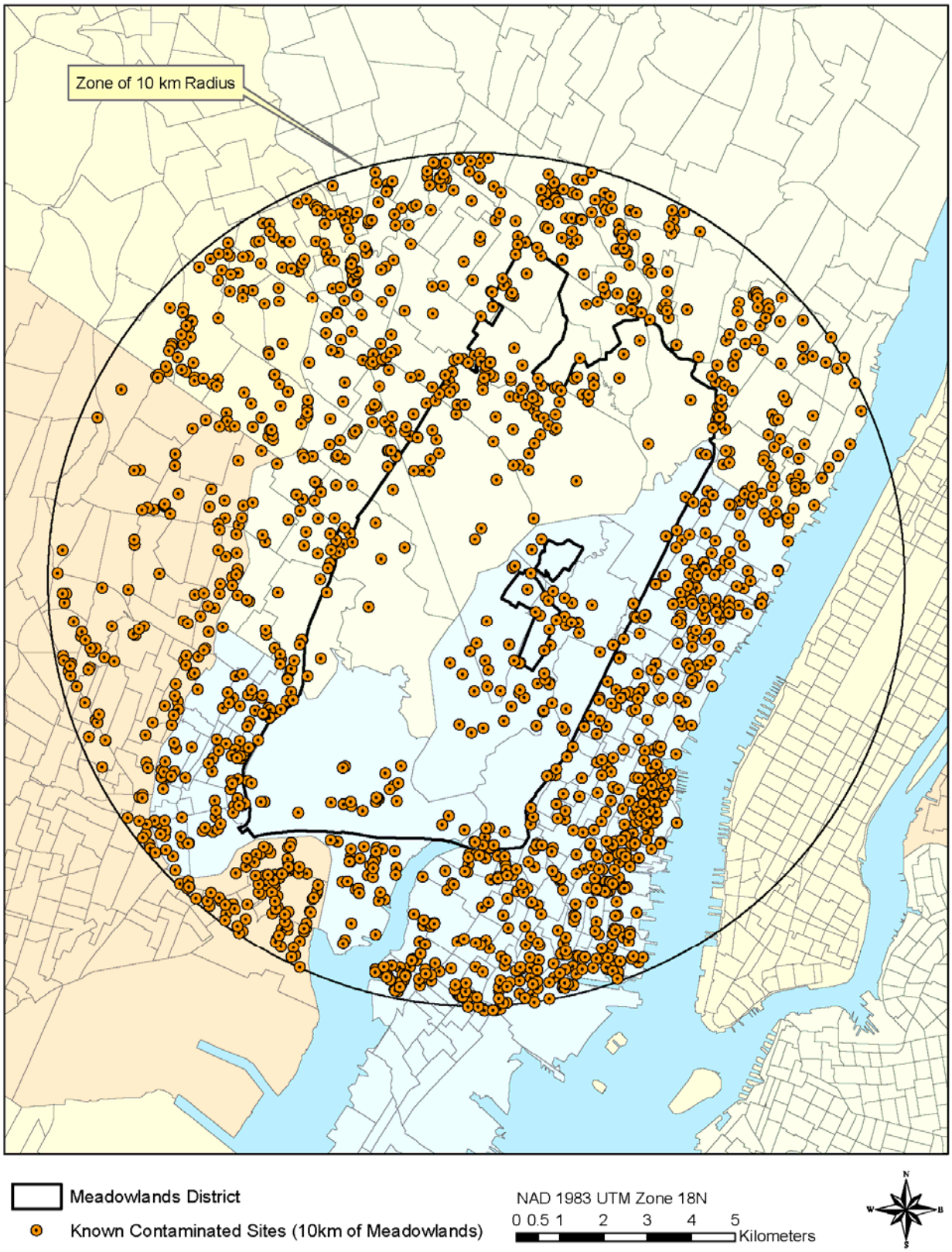


Figure C-13. Geographical distribution of the Known Contaminated Sites (KCS) that are within a 10km radius from the Meadowlands District

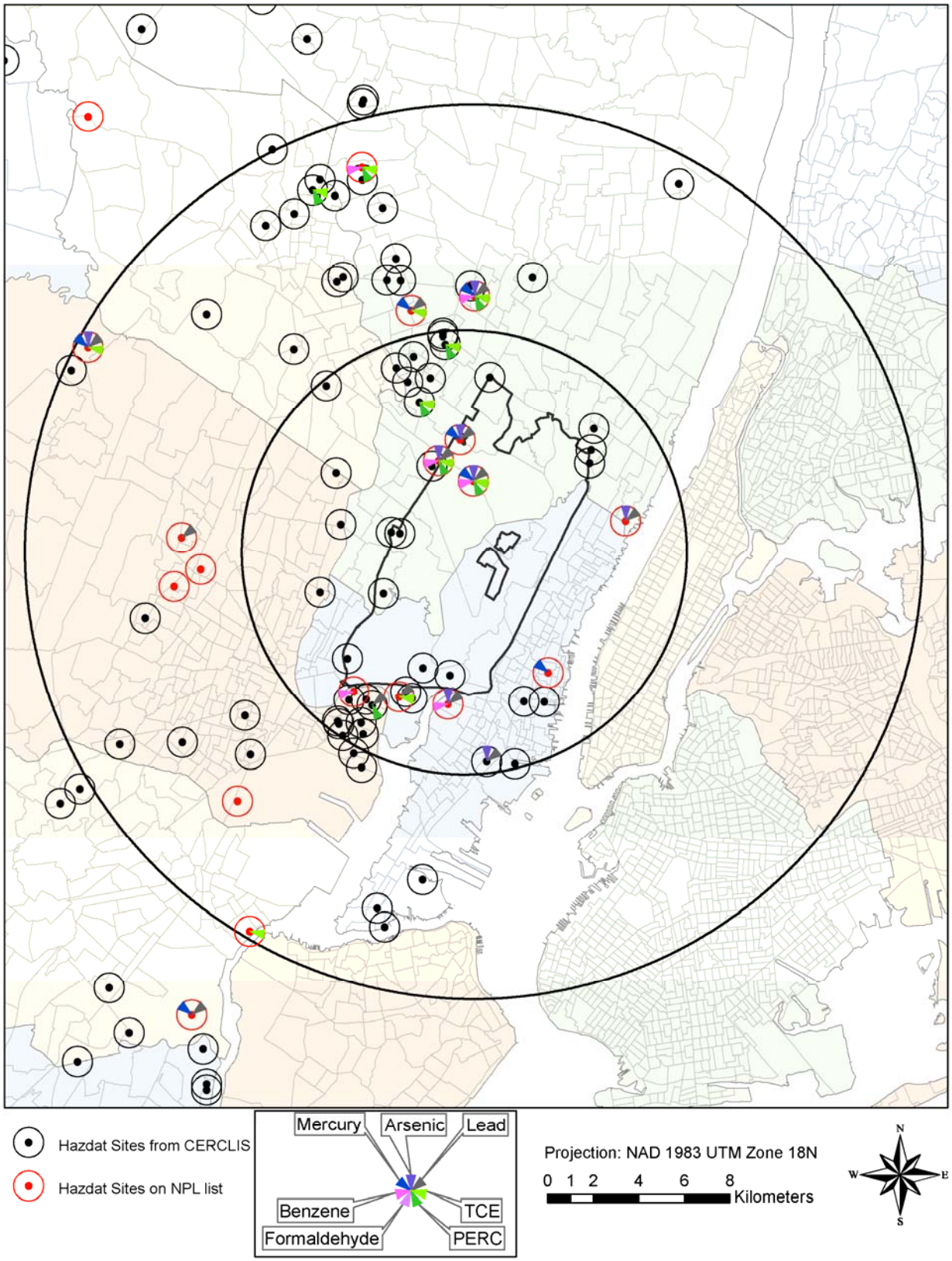


Figure C-14. Geographical distribution of the major hazardous waste sites in the vicinity of Meadowlands District based on HazDat and CERCLIS

Figure C-15. Aerial view of Meadowlands District showing NEI and TRI facilities and HazDat Sites

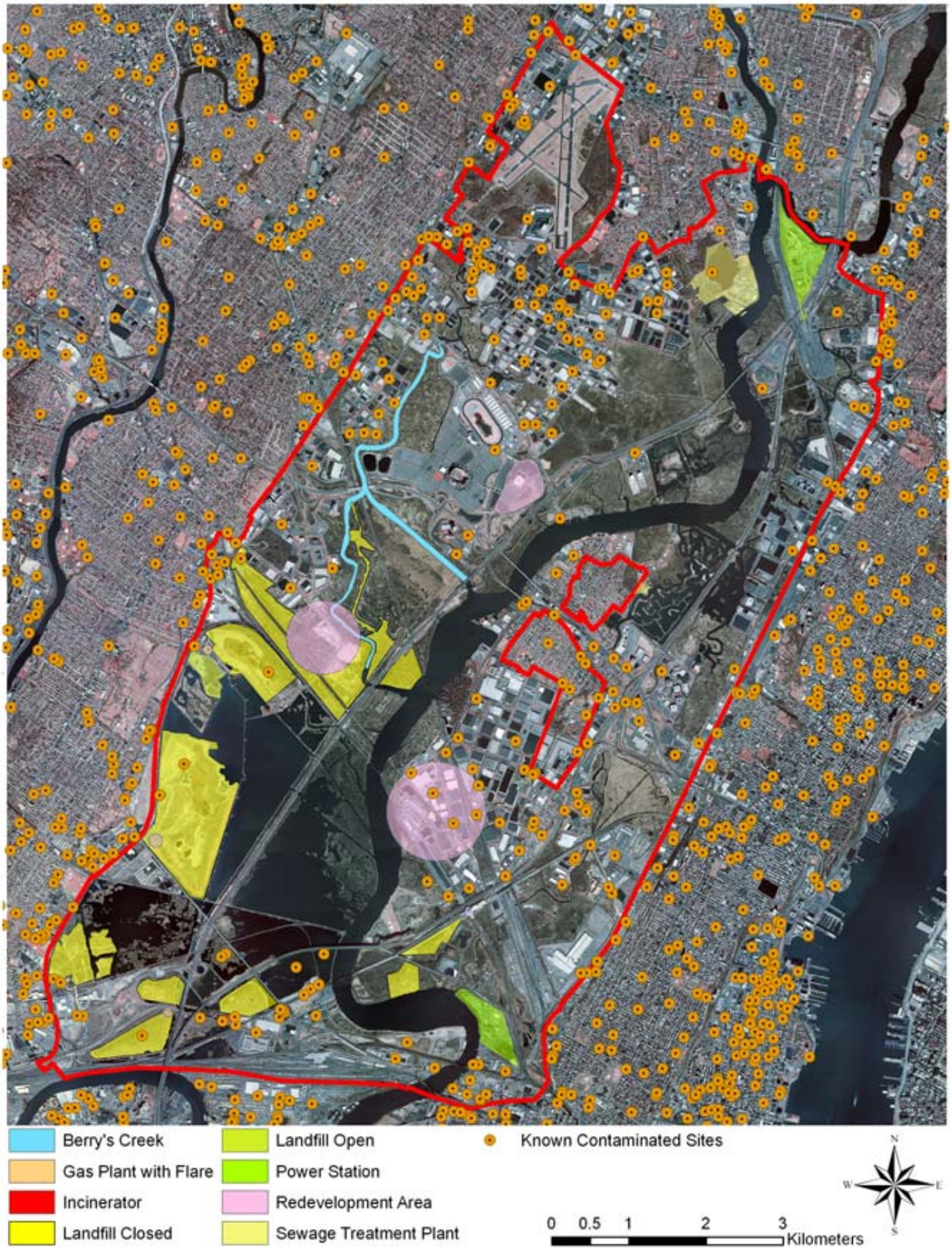


Figure C-16. Aerial view of Meadowlands District showing Known Contaminated Sites (KCS)

Appendix D Results of 2002 NEI emission modeling and 1999 NEI landfill emission modeling

D.1 Results of emission modeling

Presented in this section are the emission modeling results for processing the recent NEI-2002 data through the EMS-HAP program for fine scale allocation of emissions at census tract level, in the area within a 25km radius of the Meadowlands District. Four types of source categories (i.e., point, area, mobile on-road, and mobile non-road emissions) are included separately for the emissions domain considered. Figure D-1 to Figure D-11 show the maps of 2002 annual emissions of the 11 air toxics of concern from all sources within a 25km radius from the Meadowlands District. It should be noted that PERC, TCE, 1,4 dichlorobenzene, and As (Figure D-1 to Figure D-4) contain only point and area sources, and Hg (Figure D-5) contains only point sources. Benzene, Toluene, Ethylbenzene, Xylene, and Formaldehyde (Figure D-6 to Figure D-10) have the ambient sources from all of the four categories, while the ambient emissions of Pb (Figure D-11) are from mobile non-road, area, and point sources. The processed NEI-2002 data were then used as one of the emissions input options for the subsequent applications of air quality dispersion models such as ISCST3 and AERMOD.

D.1.1 Results of landfill emissions modeling

The landfill emission modeling results from running LandGEM (version 3.02) with the site-specific input data provided by MERI for 11 landfills within the Meadowlands District are presented in Figure D-12. The LandGEM modeling results of the Benzene, TCE, and PERC annual emission estimates for the landfill site of Bergen County Utilities Authority (BCUA) were compared with those estimates in the 1999 National Emission Inventory (NEI-1999). As shown in Figure D-12, the emission estimates of the LandGEM modeling results are about a factor of 4 to 5 less than the NEI-1999 estimates for the BCUA landfill site. However, the NEI-1999 did not include the emission estimates of the other 10 landfill sites (Rutherford, Lyndhurst, Avon, Erie, 1-E, Malanka, Keegan, 15W, 1-A, 1-D) in the Meadowlands District, for which we have the LandGEM modeling results using the site-specific information provided by MERI.

Two different sets of emissions inputs (NEI-1999 versus NEI-1999 with landfills emissions adjustments from LandGEM) were used in the subsequent ISCST3 predictions to examine their impacts on predicted ambient concentrations. As shown in Figure D-13 to Figure D-15, the time-series profiles of the predicted ambient concentrations using the two different emission inputs have very minor differences. This was mainly due to the dominance of other emissions (such as mobile, point, and area sources) in affecting the predicted ambient concentrations, while the differences in relatively small landfill emissions could only affect minor changes. Based on this experience learned from the 1999 NEI data, the landfills emissions adjustments for the NEI-2002 data was not performed.

(a) (b)

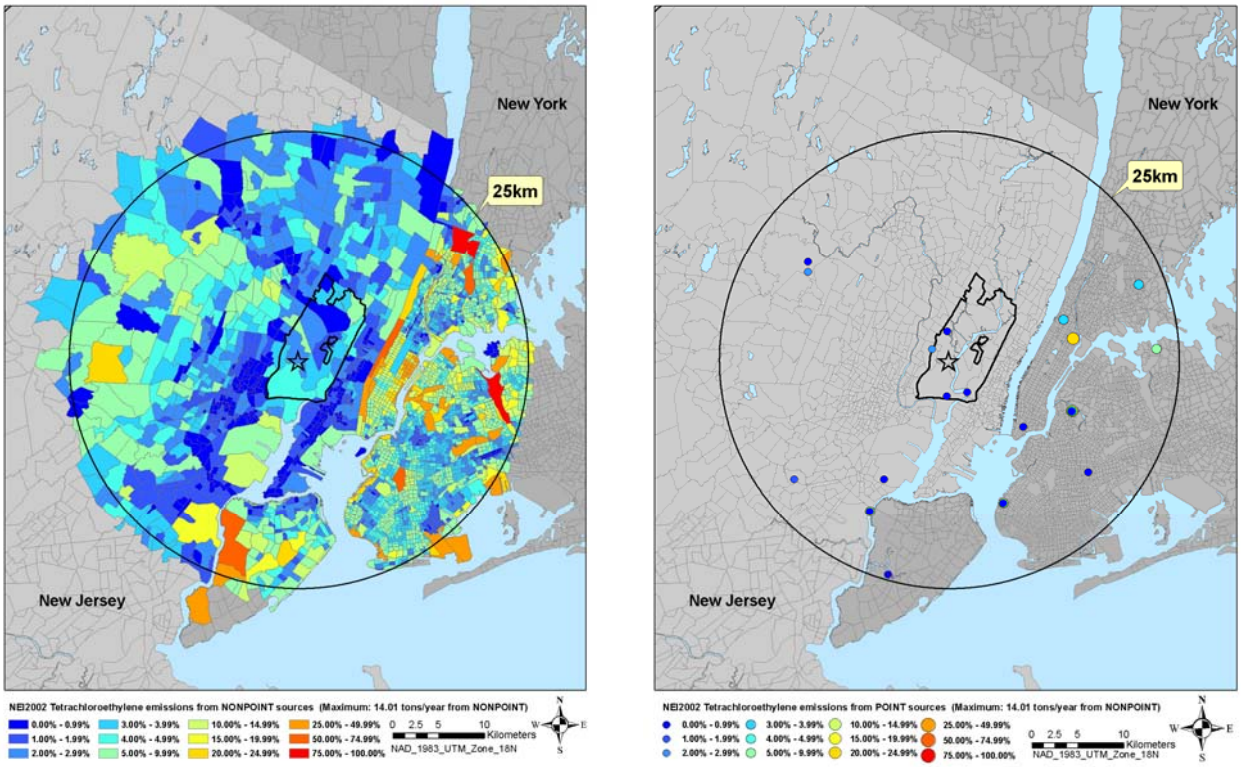


Figure D-1. Maps of 2002 annual PERC emissions from all sources located within a 25km radius from the Meadowlands District. The two panels show, respectively, the spatial distribution and strength of (a) area sources and (b) point sources. County level data from the 2002 NEI were processed by EMS-HAP, and area sources were allocated per census tract.

(a) (b)

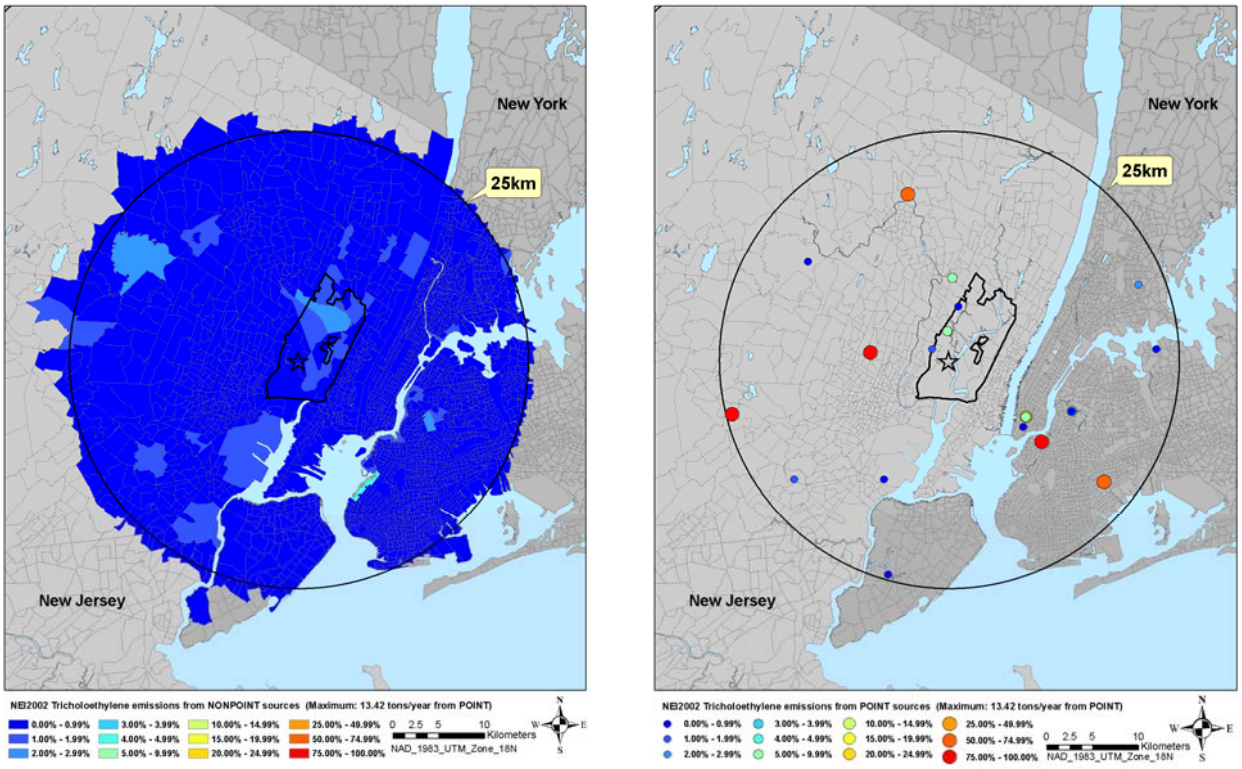


Figure D-2. Maps of 2002 annual TCE emissions from all sources located within a 25km radius from the Meadowlands District. The two panels show, respectively, the spatial distribution and strength of (a) area sources and (b) point sources. County level data from the 2002 NEI were processed by EMS-HAP, and area sources were allocated per census tract.

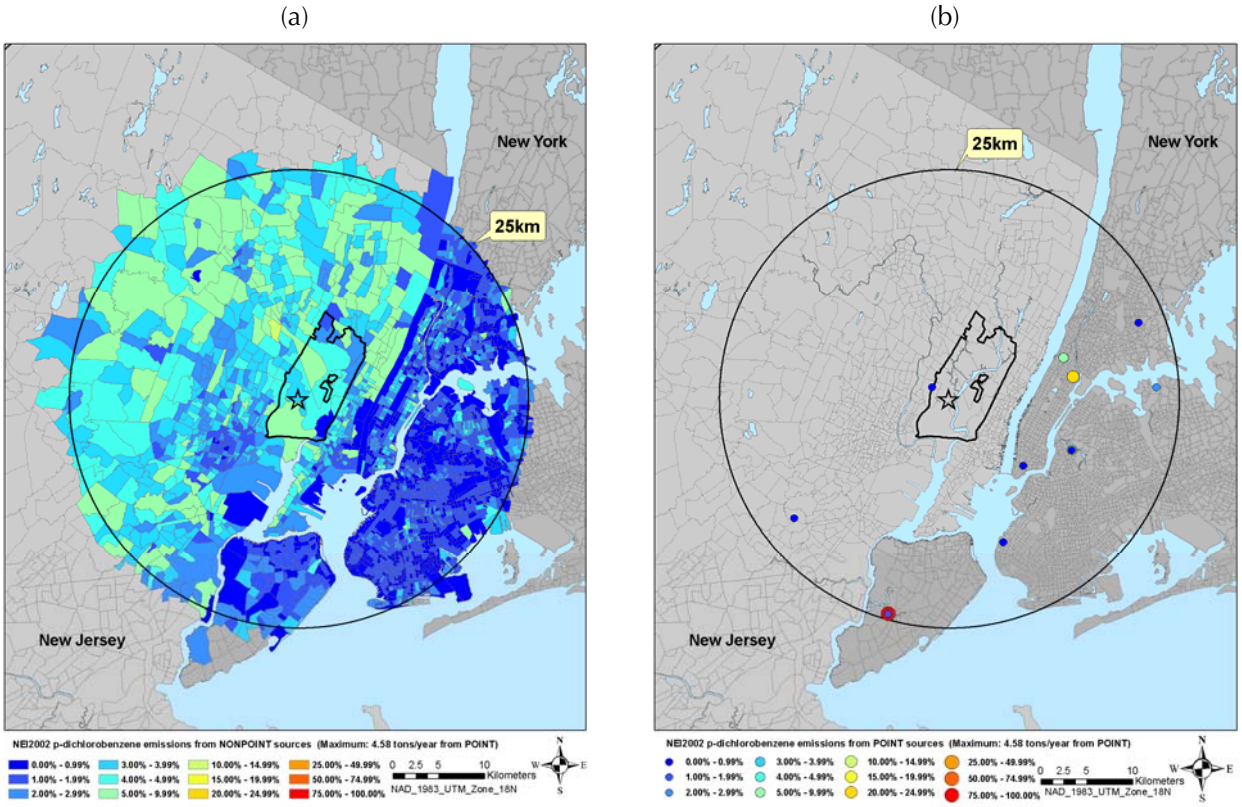


Figure D-3. Maps of 2002 annual 1,4 dichlorobenzene emissions from all sources located within a 25km radius from the Meadowlands District. The two panels show, respectively, the spatial distribution and strength of (a) area sources and (b) point sources. County level data from the 2002 NEI were processed by EMS-HAP, and area sources were allocated per census tract.

(a) (b)

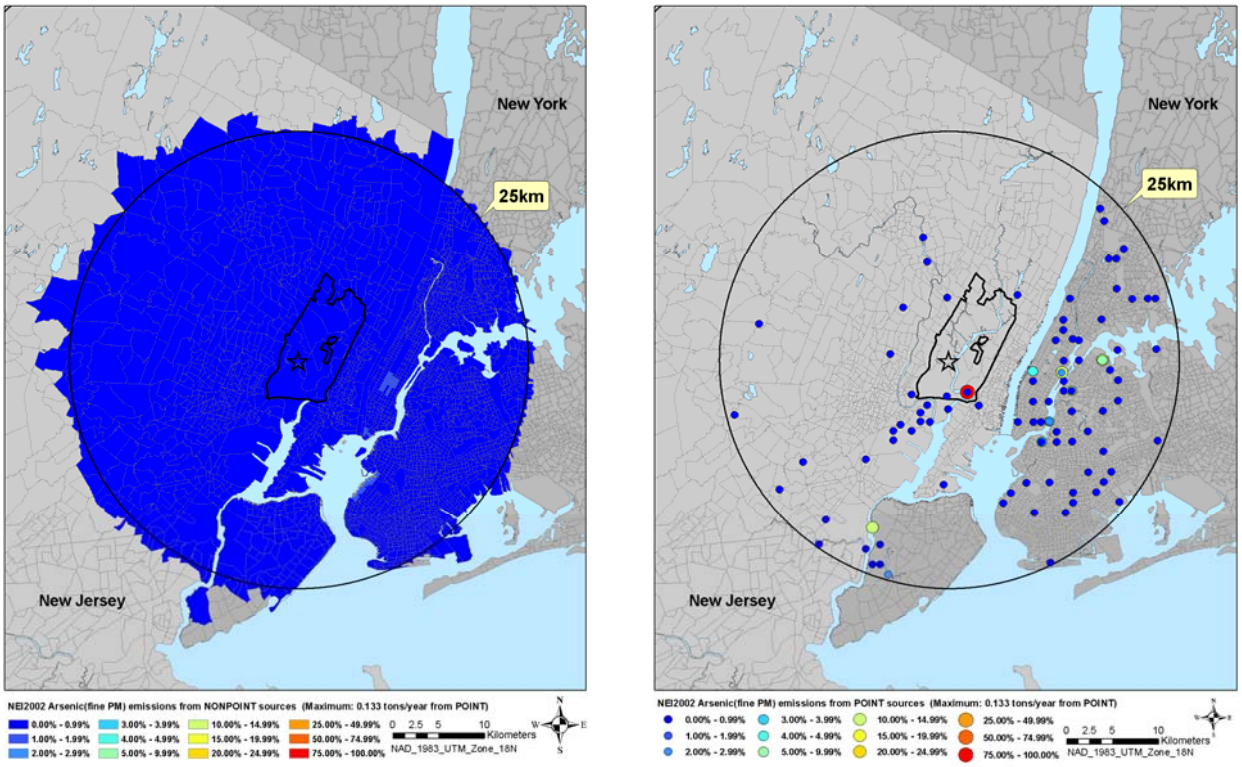


Figure D-4. Maps of 2002 annual arsenic emissions (fine PM) from all sources located within a 25km radius from the Meadowlands District. The two panels show, respectively, the spatial distribution and strength of (a) area sources and (b) point sources. County level data from the 2002 NEI were processed by EMS-HAP, and area sources were allocated per census tract.

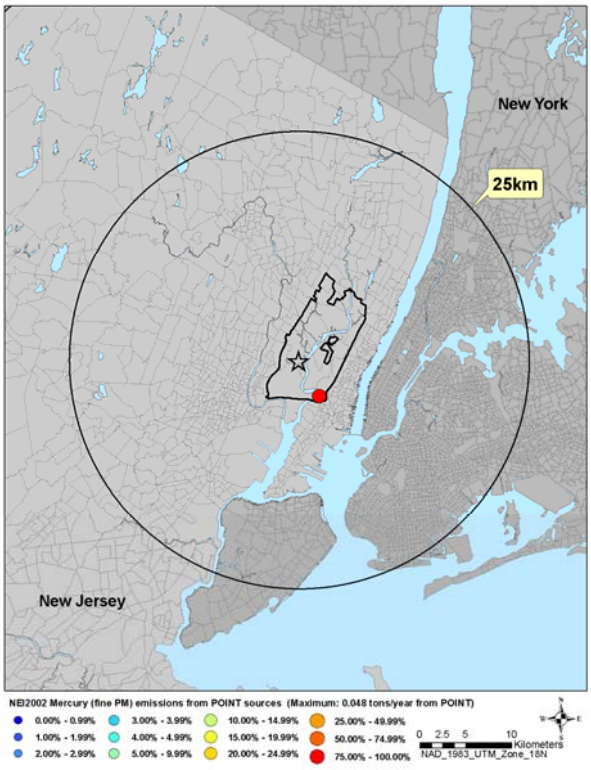


Figure D-5. Map of 2002 annual mercury emissions from all sources located within a 25km radius from the Meadowlands District. The panel shows the spatial distribution and strength of point sources. County level data from the 2002 NEI were processed by EMS-HAP.

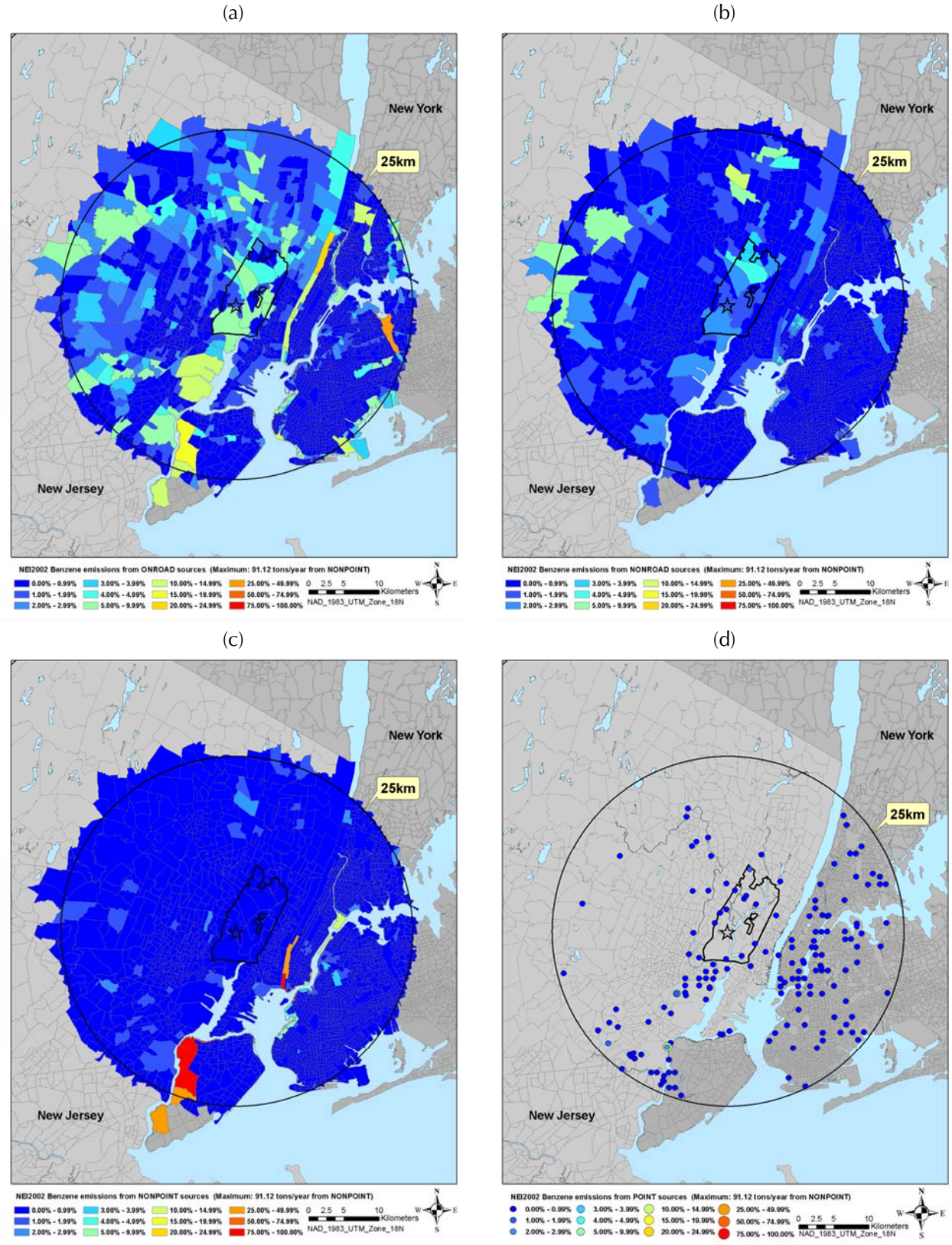


Figure D-6. Maps of 2002 annual benzene emissions from all sources located within a 25km radius from the Meadowlands District. The four panels show, respectively, the spatial distribution and strength of (a) mobile on-road sources, (b) mobile non-road sources, (c) area sources, and (d) point sources. County level data from the 2002 NEI were processed by EMS-HAP, and mobile and area sources were allocated per census tract.

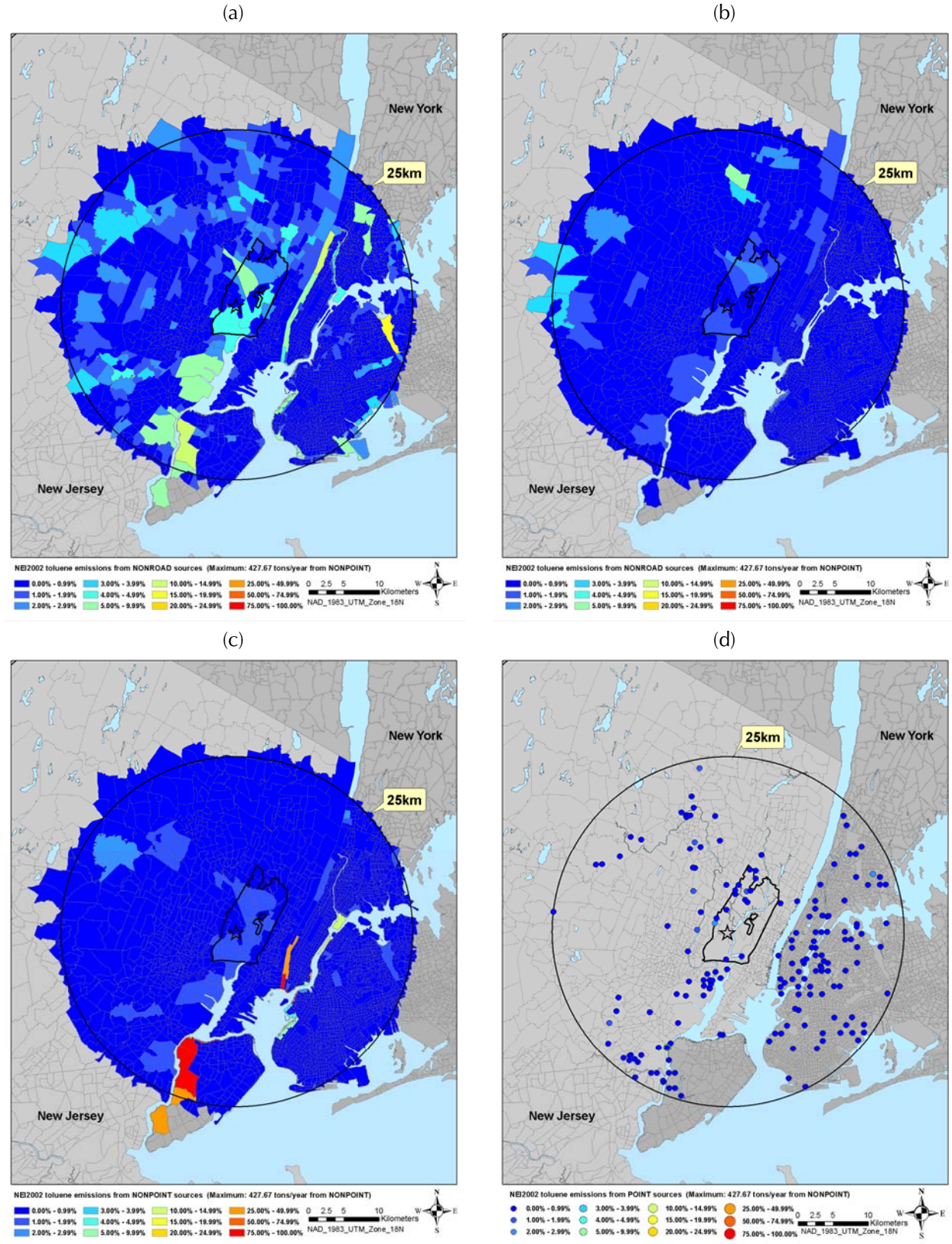


Figure D-7. Maps of 2002 annual toluene emissions from all sources located within a 25km radius from the Meadowlands District. The four panels show, respectively, the spatial distribution and strength of (a) mobile on-road sources, (b) mobile non-road sources, (c) area sources, and (d) point sources. County level data from the 2002 NEI were processed by EMS-HAP, and mobile and area sources were allocated per census tract.

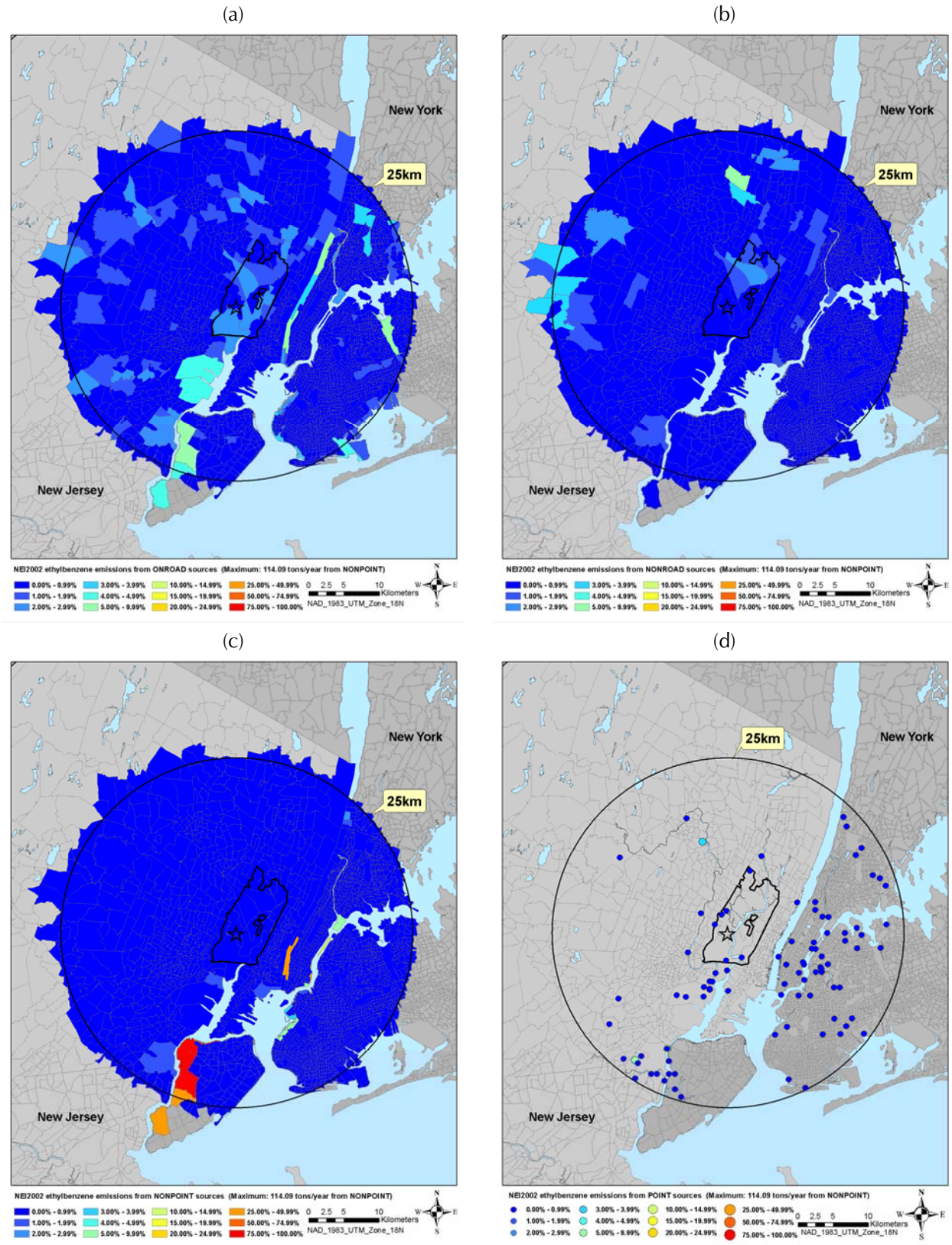


Figure D-8. Maps of 2002 annual ethylbenzene emissions from all sources located within a 25km radius from the Meadowlands District. The four panels show, respectively, the spatial distribution and strength of (a) mobile on-road sources, (b) mobile non-road sources, (c) area sources, and (d) point sources. County level data from the 2002 NEI were processed by EMS-HAP, and mobile and area sources were allocated per census tract.

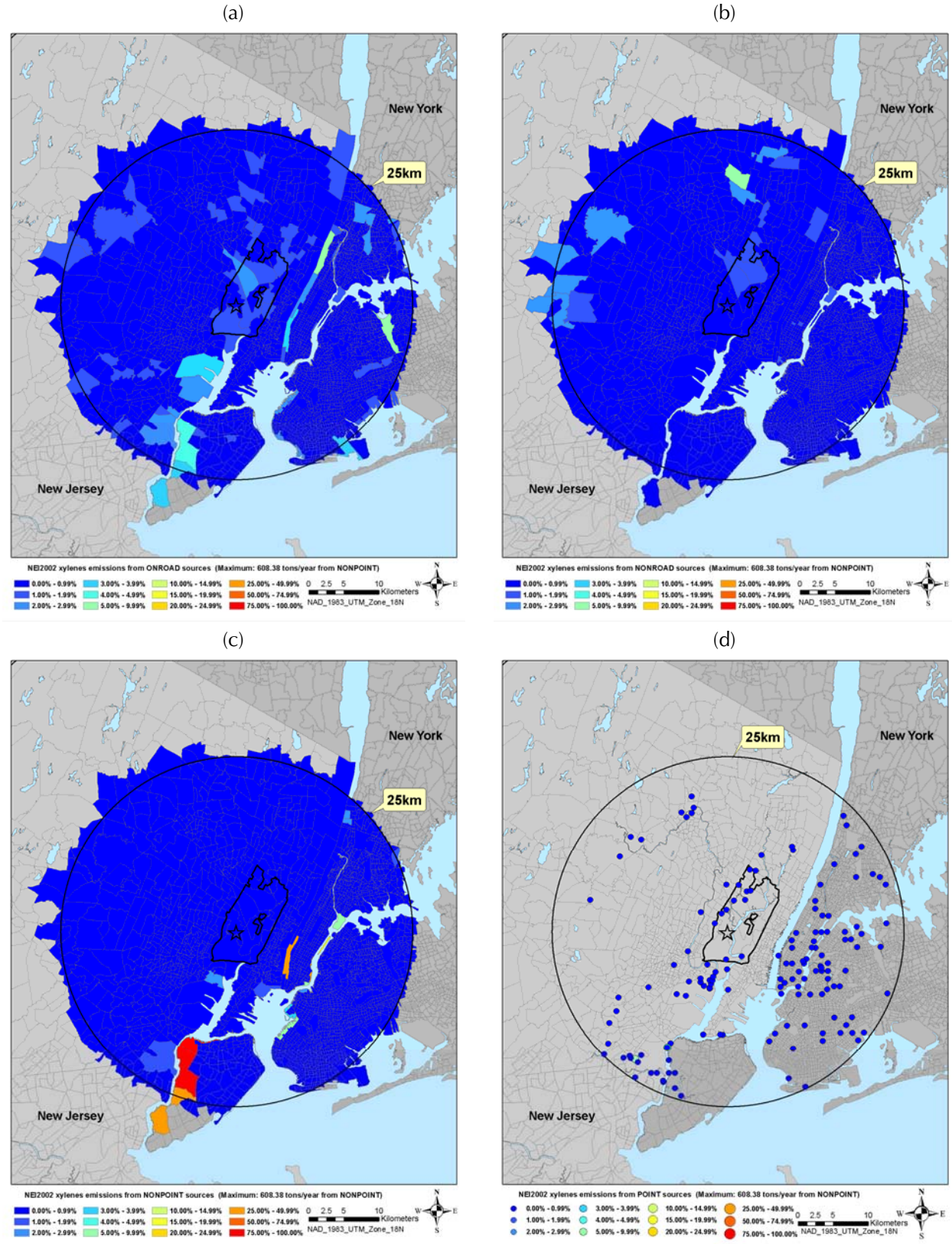


Figure D-9. Maps of 2002 annual xylene emissions from all sources located within a 25km radius from the Meadowlands District. The four panels show, respectively, the spatial distribution and strength of (a) mobile on-road sources, (b) mobile non-road sources, (c) area sources, and (d) point sources. County level data from the 2002 NEI were processed by EMS-HAP, and mobile and area sources were allocated per census tract.

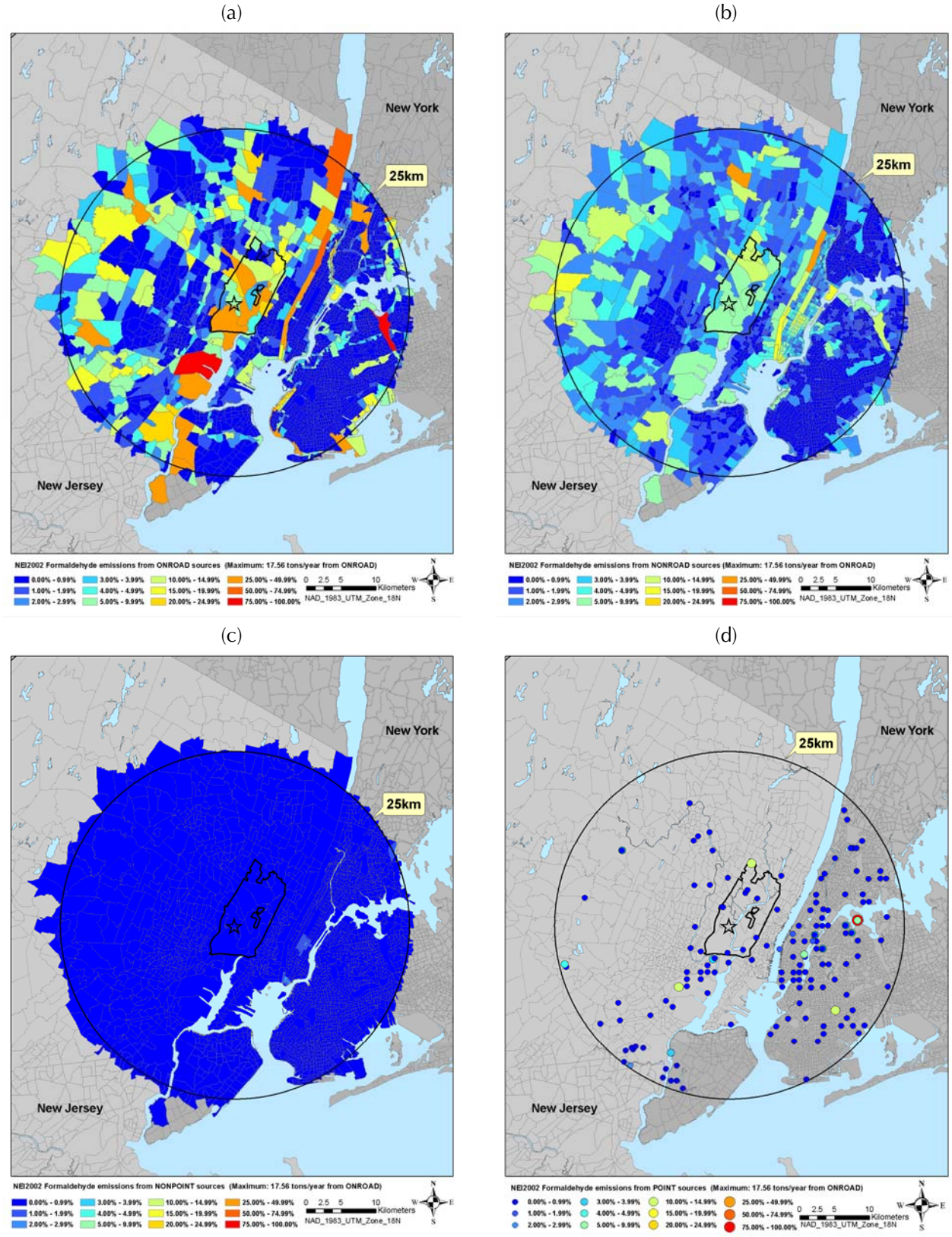
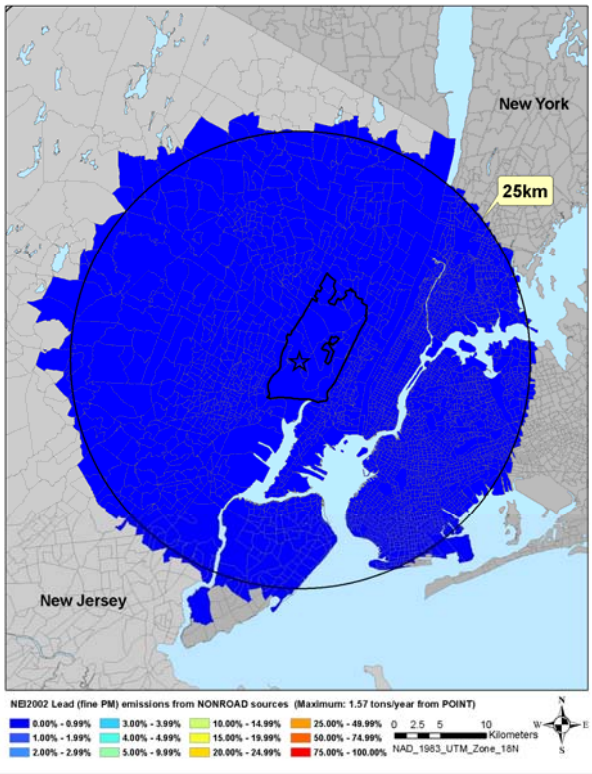
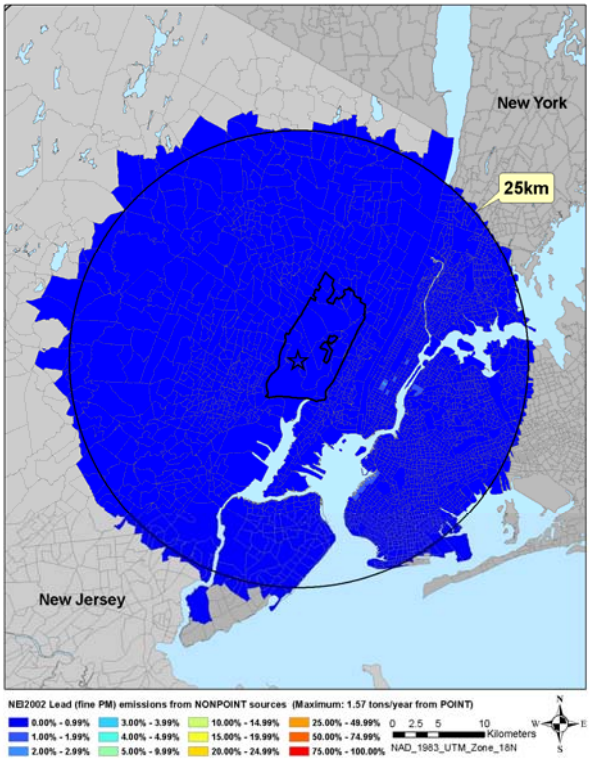


Figure D-10. Maps of 2002 annual formaldehyde emissions from all sources located within a 25km radius from the Meadowlands District. The four panels show, respectively, the spatial distribution and strength of (a) mobile on-road sources, (b) mobile non-road sources, (c) area sources, and (d) point sources. County level data from the 2002 NEI were processed by EMS-HAP, and mobile and area sources were allocated per census tract.

(a)



(b)



(c)

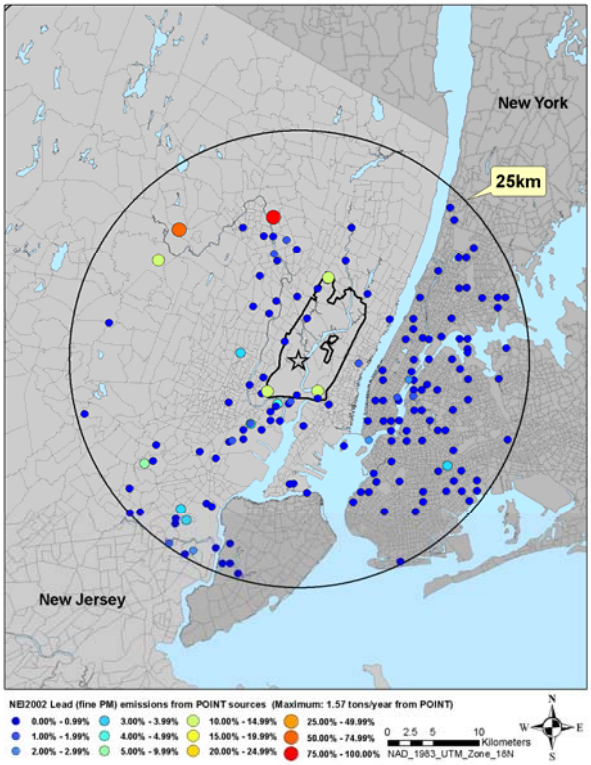


Figure D-11. Maps of 2002 annual lead (fine PM) emissions from all sources located within a 25km radius from the Meadowlands District. The three panels show, respectively, the spatial distribution and strength of (a) mobile non-road sources, (b) area sources, and (c) point sources. County level data from the 2002 NEI were processed by EMS-HAP, and mobile and area sources were allocated per census tract.

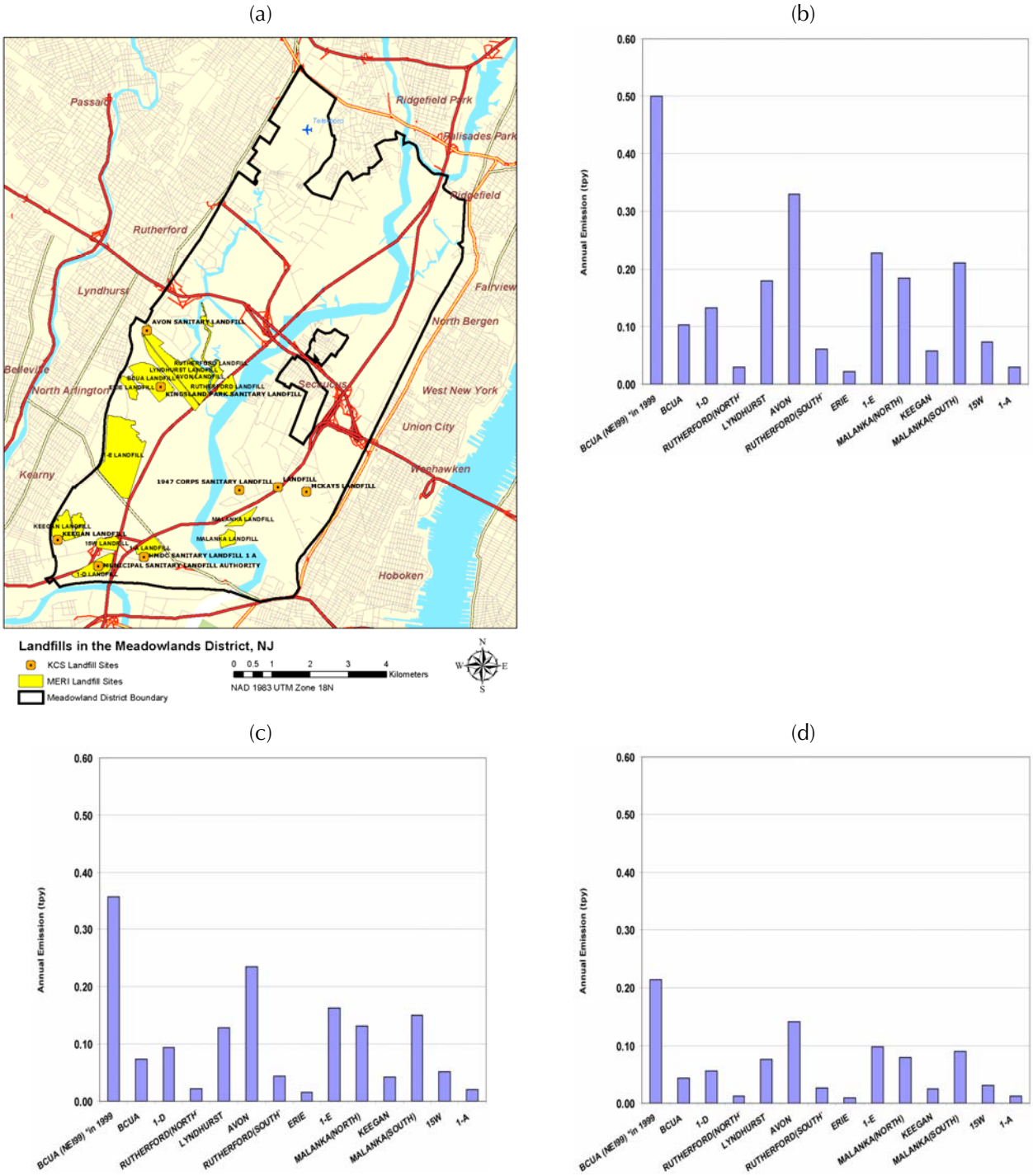


Figure D-12. Geographical distribution of landfills in the Meadowlands District (shown in (a)) and the associated 2005 annual emissions estimates of (b) benzene, (c) TCE, and (d) PERC modeled using the LandGEM model

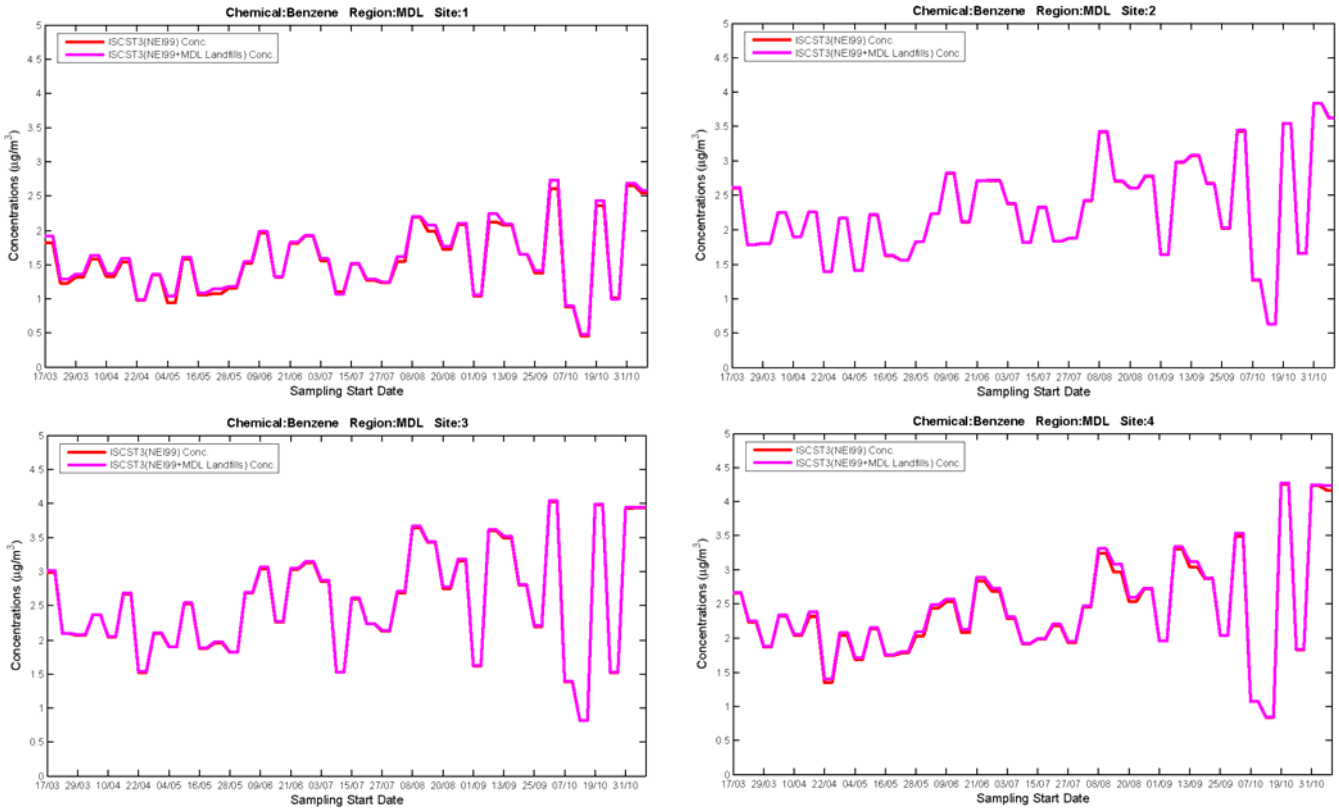


Figure D-13. Comparison of time-series profiles of ambient benzene concentrations estimated by ISCST3 simulations using 1999 NEI data (red line) and combined 1999 NEI and Meadowlands landfill emission estimates (magenta line) at the receptor locations of 4 fixed site monitors in the Meadowlands District from March 17, 2005 to November 6, 2005; MERI met data were used for these simulations.

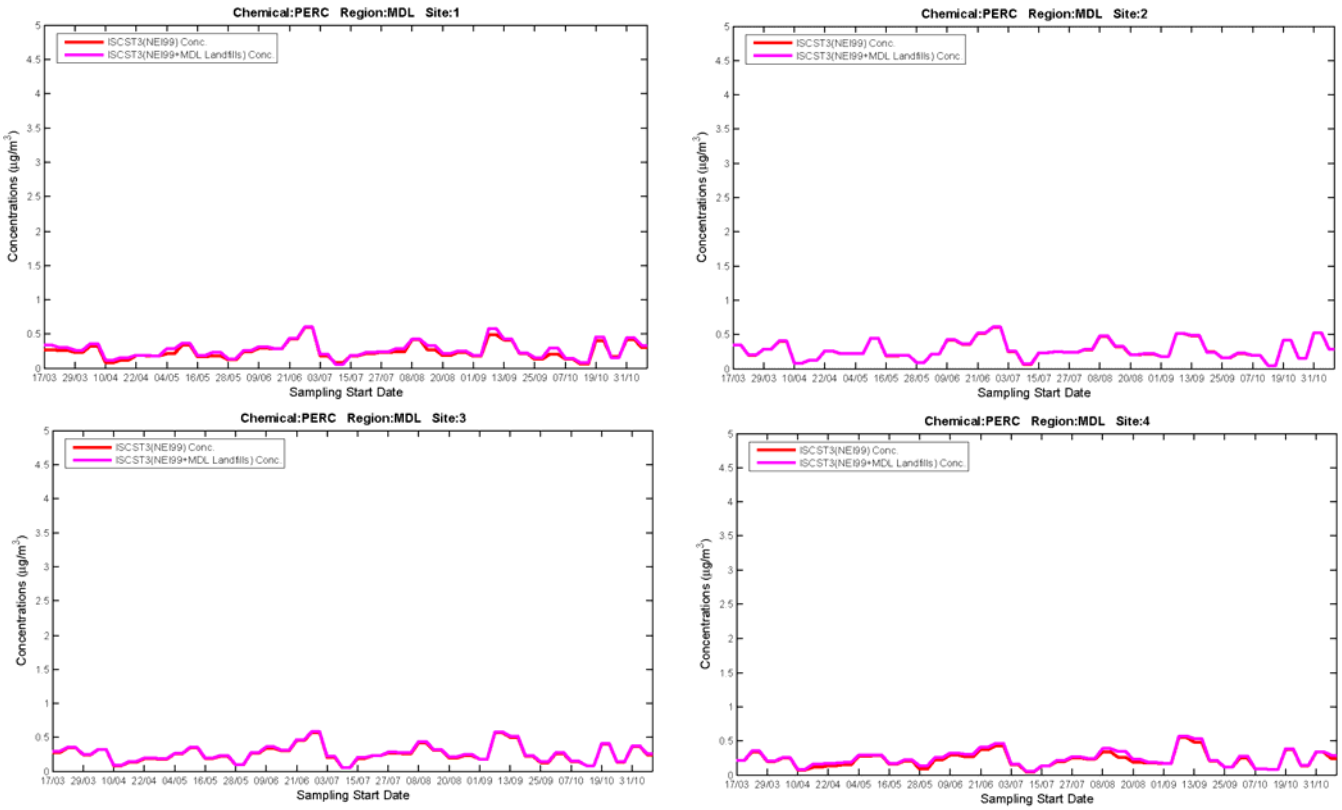


Figure D-14. Comparison of time-series profiles of ambient PERC concentrations estimated by ISCST3 simulations using 1999 NEI data (red line) and combined 1999 NEI and Meadowlands landfill emission estimates (magenta line) at the receptor locations of 4 fixed site monitors in the Meadowlands District from March 17, 2005 to November 6, 2005; MERI met data were used for these simulations.

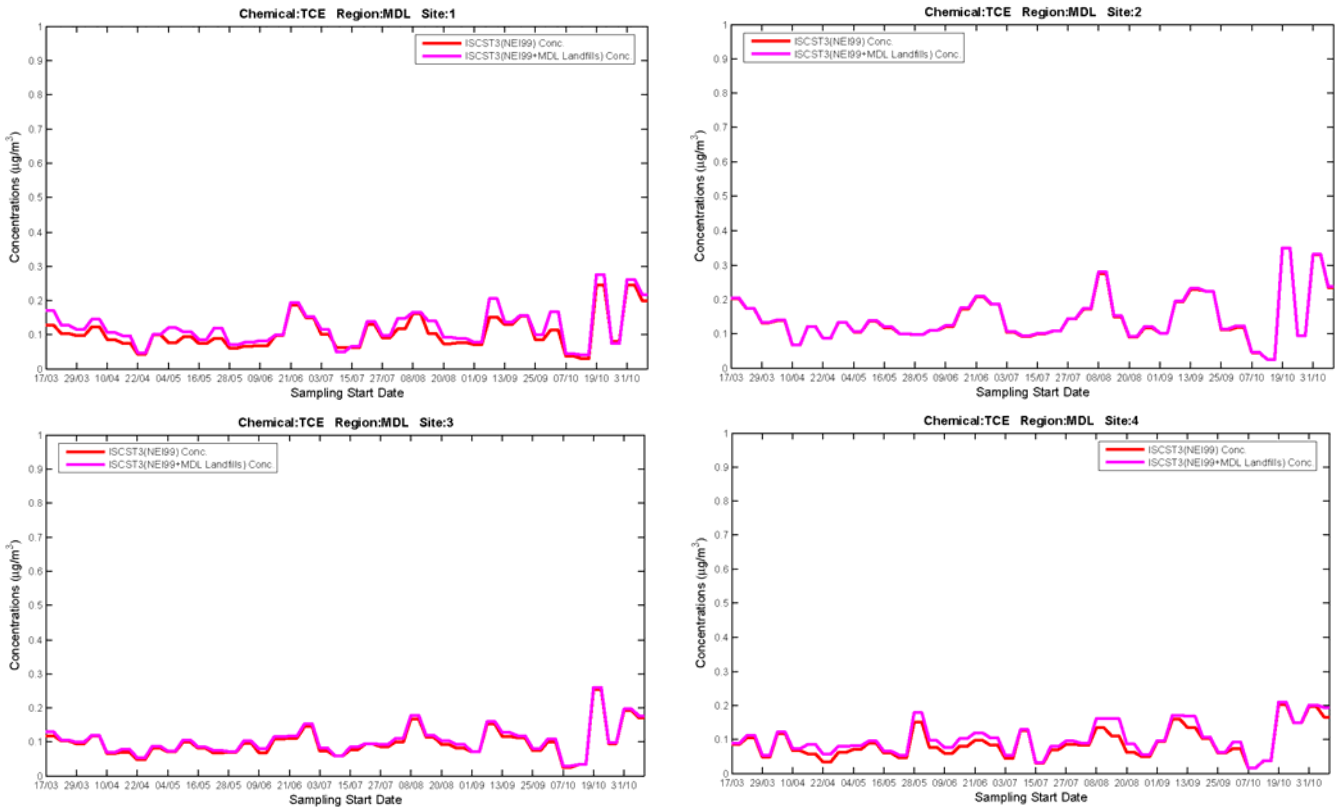


Figure D-15. Comparison of time-series profiles of ambient TCE concentrations estimated by ISCST3 simulations using 1999 NEI data (red line) and combined 1999 NEI and Meadowlands landfill emission estimates (magenta line) at the receptor locations of 4 fixed site monitors in the Meadowlands District from March 17, 2005 to November 6, 2005; MERI met data were used for these simulations.

Appendix E Results of the 1st set of sensitivity runs

E.1 Results of the air quality dispersion modeling analyses

Presented here are the dispersion modeling analyses using both the ISCST3 and AERMOD models with four different combinations of emissions (1999 NEI versus 2002 NEI) and meteorology (Newark Airport data versus MERI data) for all of the seven air toxics. The specific details are described below:

- The dispersion modeling analyses were performed at 4 receptor locations of the fixed site monitoring stations within the Meadowlands district (see Figure E-1 for the locations of the 4 fixed site monitors) for 20 sets of 3-day periods from March 17, 2005 to November 6, 2005, corresponding to the field sampling dates of these monitors.
- The sensitivity runs of the eight different modeling options (listed in Table E-1 below) were conducted for the 4 receptor locations and modeling time periods mentioned above.
- For the three metal species (As, Pb, and Hg), there are emissions data available for two modes (coarse PM and fine PM for As and Pb, fine PM and gas phase for Hg) in both the NEI-1999 and NEI-2002. The dispersion modeling analyses were conducted for each of the two modes. However, the fixed site monitors only collected data for the metal species in the fine PM mode. Therefore, the dispersion modeling results for the three metal species in the fine PM mode were used for model performance evaluation.

Table E-1. The 1st set of sensitivity simulations with 8 different combinations of dispersion models, emissions inputs, and meteorology inputs.

RunID	Dispersion model	Emission inputs	Meteorology inputs
ISCST3[1]	ISCST3	NEI-1999	Newark Airport
ISCST3[2]	ISCST3	NEI-1999	MERI station
ISCST3[3]	ISCST3	NEI-2002	Newark Airport
ISCST3[4]	ISCST3	NEI-2002	MERI station
AERMOD[1]	AERMOD	NEI-1999	Newark Airport
AERMOD[2]	AERMOD	NEI-1999	MERI station
AERMOD[3]	AERMOD	NEI-2002	Newark Airport
AERMOD[4]	AERMOD	NEI-2002	MERI station

The results of dispersion modeling analyses are presented in graphical form for the time-series profiles. Several 4-panel figures present comparisons of modeling results across different modeling options, along with the available field measurements for each of the 7 air toxics and each of the 4 receptor locations of the fixed-site monitors. Specifically, in each of these figures:

- Panel (a) shows the time-series profiles of ISCST3 and AERMOD calculations with the emission inputs of NEI-1999 and meteorology inputs from Newark airport.
- Panel (b) shows the time-series profiles of ISCST3 and AERMOD calculations with the same emission inputs in (a) and meteorology inputs from MERI station.
- Panel (c) shows the time-series profiles of ISCST3 and AERMOD calculations with the emission inputs of NEI-2002 and the same meteorology inputs in (a).
- Panel (d) shows the time-series profiles of ISCST3 and AERMOD calculations with the same emission inputs in (c) and the same meteorology inputs in (b).
- The same time-series profile of the available field measurements was placed in each of the 4 panels above to evaluate the performance of using the 4 different modeling input options. For the three metal species (As, Pb, and Hg), the field measurement data were only available in two fixed-site monitors. For the species of Formaldehyde, there is no field measurement available from the 4 fixed-site monitors.

Different pairs of the comparisons in the 4-panel figures can examine the sensitivity of impacts of using different modeling input options on the dispersion model calculations. By comparing the modeling results in each of the two parallel sets of panels (i.e., (a) and (b); (c) and (d)), the sensitivity of the impact for using the two different meteorology inputs (Newark Airport versus MERI station) on dispersion model predictions is revealed, where the emissions inputs were kept the same (i.e., NEI-1999 for (a) and (b); NEI-2002 for (c) and (d)). By comparing the modeling results in each of the two vertical sets of panels (i.e., (a) and (c); (b) and (d)), the sensitivity of the impact for using the two different emission inputs (NEI-1999 versus NEI-2002) on dispersion model predictions is revealed, where the meteorology inputs were kept the same (i.e., Newark Airport for (a) and (c); MERI station for (b) and (d)).

The 4-panel figures for the 4 VOCs (Benzene, PERC, TCE, and Formaldehyde) at the 4 fixed-site monitor locations (MDL1, MDL2, MDL3, and MDL4) are shown in Figure E-2 to Figure E-17. The 4-panel figures for the 3 metals (As, Pb, and Hg) at the 2 fixed-site monitor locations (MDL1 and MDL2) are shown in Figure E-18 to Figure E-29. The results of sensitivity comparisons of using different modeling input options are summarized below.

- For Benzene (see Figure E-2 to Figure E-5), the impact of using the two different meteorology inputs is greater than that of using the two different emissions inputs. The ISCST3 and AERMOD model predictions with the meteorology inputs of the MERI station are over-estimated, while those predictions with the Newark Airport data have better agreement with the field measurements. The impact of using the two different emissions inputs is minor on both the ISCST3 and AERMOD predictions. The model predictions with the emissions inputs of NEI-2002 are a bit lower than those predictions with the emissions inputs of NEI-1999, such that the agreement with the field measurement is better, especially for the sites of MDL3 and MDL4.
- For PERC (see Figure E-6 to Figure E-9), the impact of using the 4 different modeling input options are very minor on both the ISCST3 and AERMOD predictions. The contribution of the background concentration to the total model predictions is important and also improves agreement with the field measurements.
- For TCE (see Figure E-10 to Figure E-13), similar model performance was observed as in the case of PERC, where the sensitivity of using different modeling input options is small and the contribution of background concentration is essential and also improves the performance.
- For As (see Figure E-18 and Figure E-19), the time-series profiles of both the ISCST3 and AERMOD model predictions were under-estimated, regardless of which modeling input options were used. A peak appeared in the time-series profiles of the field measurements around mid-September of 2005 for both sites of MDL1 and MDL2. The time-series profiles of model predictions could not pick up this peak for both sites, and still showed a relatively flat pattern during the corresponding time period. This may be due to the effect of the localized sources on the measured ambient concentrations, while the emission modeling processes of spatial and temporal allocation of the NEI data could not detect this localized effect.
- For Pb (see Figure E-22 and Figure E-23), the 4 different modeling input options have obvious impacts on both the ISCST3 and AERMOD model calculations. For the sensitivity of using the two different meteorology data, a similar trend was observed as in the case of Benzene, where the model predictions with the meteorology inputs of the MERI station are over-estimated and those predictions with the Newark Airport data have better agreement with the field measurements. This sensitivity lessened when the NEI-2002 emission inputs were used. For the sensitivity of using the two different emission inputs, the impact on the

dispersion model predictions was clearly revealed, where the model predictions with the NEI-1999 were over-estimated and those predictions with the NEI-2002 have better agreement with the field measurements.

- For Hg, all of the field measurements were below the detection limits. Therefore, half of the detection limits were used for plotting the time-series profiles of the field measurements. All of the model predictions were below half of the detection limits as shown in Figure E-26 and Figure E-27. However, this did not mean that these model predictions are under-estimated, since the actual values of the field measurements were also unknown. Qualitatively, it should be noted that the model predictions were in good agreement with field measurements, since they both were below the detection limits.

E.2 Results of evaluating performance of the air quality dispersion modeling

A more rigorous model performance evaluation was conducted through point-by-point comparison between model predictions and field measurements. These comparison results are summarized in the ratio box-plots[1]. The other assessment of model performance evaluation was conducted through Q-Q plots.

E.2.1 Results of ratio box-plot

The ratio box-plots for the 3 VOCs (Benzene, PERC, and TCE) at the 4 fixed-site monitor locations are shown in Figure E-30 to Figure E-41. The ratio box-plots for the two metals (As and Pb) at the 2 sites (MDL1 and MDL2) are shown in Figure E-42 to Figure E-45. The ratio box-plots for the species of Hg were not generated, since all of the measurements were below the detection limits and the corresponding model-to-measurement ratios, where half of the detection limits were used for the non-detect values, will not reflect the actual agreements. Two horizontal lines of half and double model-to-measurement ratios are highlighted in each of the box plots to facilitate the visualization of the "within a factor of 2" agreement. If the model predictions are consistently agreeing well with the measurement data for the pollutant, the box plots will be short, and centered at 1.

- For Benzene (see Figure E-30 to Figure E-33), the modeling option of AERMOD[3], corresponding to the combination of the NEI-2002 emissions and Newark Airport meteorology inputs, has the best model performance across all of the 4 monitoring sites, since its boxes are well within "the factor of 2" zone and approximately centered at 1. The contribution of the background concentration to the AERMOD[3] predictions improved model performance for the sites of MDL1 and MDL4. For the other two sites (MDL2 and MDL3), the AERMOD[3] predictions without the contribution of background concentration have the better performance.
- For PERC (see Figure E-34 to Figure E-37), the contribution of the background concentration to the model predictions made the model performance better for all of the modeling options and all of the 4 sites. Generally, the ISCST3 model predictions have a little better model performance than the AERMOD predictions. For the sensitivity comparison of using the different meteorology inputs, a similar pattern was observed as in the case of Benzene, where the model predictions with the inputs of MERI data are higher than those with the inputs of Newark Airport data. However, the model predictions with the Newark Airport data are generally under-estimated. Therefore, it appears that the model predictions with the MERI data have better model performance.
- For TCE (see Figure E-38 to Figure E-41), the contribution of background concentration is essential for improving the model performance for all of the modeling options and all of the 4 sites as seen in the case of PERC above. Generally, both the ISCST3 and AERMOD

model predictions have similar model performance. For the sensitivity comparison of using the two different meteorology inputs, the same pattern was observed as in the case of Benzene, where the model predictions with the Newark Airport data performed better than those with the MERI data. For the sensitivity comparison of using the two different emissions inputs, the model predictions with the NEI-2002 data performed better than those with the NEI-1999 data.

- For As (see Figure E-42 and Figure E-43), all of the model predictions are under-estimated, regardless of which modeling input option was used, as seen in the comparison of the time-series profiles above.
- For Pb (see Figure E-44 and Figure E-45), the model predictions with the emissions inputs of NEI-2002 have better model performance than those with the NEI-1999 emission inputs, as seen in the comparison of the time-series profiles above. Regarding the sensitivity of using different meteorology inputs, the same pattern was observed again, where the model predictions with the MERI data are higher than those with the Newark Airport data.

E.2.2 Results of Q-Q plot

The Q-Q plots are organized in a layout similar to the 4-panel time-series figures but with different arrangements of modeling results in each of the 4 panels. Specifically,

- Panel (a) shows the two Q-Q plots of the ISCST3 predictions with the two different meteorology inputs (Newark Airport data versus MERI data) against measurements, where the emissions inputs are from NEI-1999.
- Panel (b) shows the two Q-Q plots of the ISCST3 predictions with the two different meteorology inputs (Newark Airport data versus MERI data) against measurements, where the emissions inputs are from NEI-2002.
- Panel (c) shows the two Q-Q plots of the AERMOD predictions with the two different meteorology inputs (Newark Airport data versus MERI data) against measurements, where the emissions inputs are from NEI-1999.
- Panel (d) shows the two Q-Q plots of the AERMOD predictions with the two different meteorology inputs (Newark Airport data versus MERI data) against measurements, where the emissions inputs are from NEI-2002.

These 4-panel Q-Q plots are presented in Figure E-46 to Figure E-57 for the 3 VOCs (Benzene, PERC, and TCE) at the 4 monitoring sites and in Figure E-58 to Figure E-61 for the 2 metals (As and Pb) at the 2 monitoring sites.

- For Benzene (see Figure E-46 to Figure E-49), the distribution tails of the model predictions at three sites (MDL1, MDL2, and MDL3) tend to deviate from the straight line and shift downward. The distributions of model predictions at the 4th site (MDL4) fit the straight line along with the measurement data better. For the sensitivity comparison of using the two different emissions data, the distributions of model predictions with the NEI-2002 data tend to fit the straight line better than those with the NEI-1999 data. For the sensitivity comparison of using the two different meteorology data, the distributions of model predictions with the Newark Airport data tend to fit the straight line better than those with the MERI data.
- For PERC (see Figure E-50 to Figure E-53), the distribution tails of the model predictions at three sites (MDL1, MDL2, and MDL3) tend to deviate from the straight line and shift upward. The better model performance at the 4th site (MDL4) was observed again. In general, the distributions of AERMOD model predictions tend to fit the straight line better than ISCST3 predictions.

- For TCE (see Figure E-54 to Figure E-57), the distributions of model predictions with the emissions inputs of NEI-2002 tend to fit the straight line better than those with the NEI-1999 data.
- For As (see Figure E-58 and Figure E-59), the distributions of model predictions across different modeling inputs options fit the straight line well along with the measurement data.
- For Pb (see Figure E-60 and Figure E-61), the distributions of model predictions with the emissions inputs of NEI-2002 tend to fit the straight line better than those with the NEI-1999 data.

Figure E-1. Aerial map showing landfills and sampling sites in the Meadowlands District

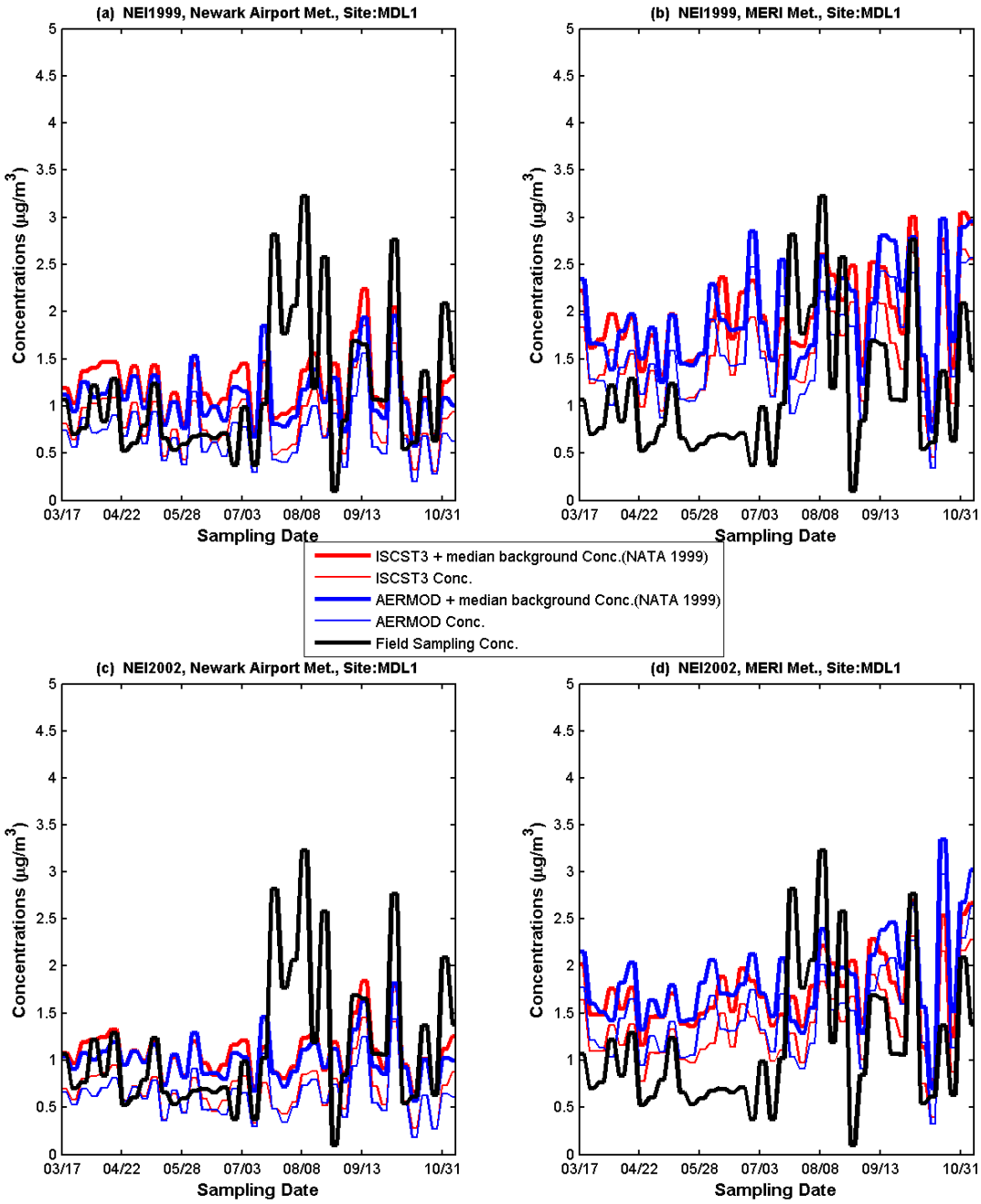


Figure E-2. Comparison of time-series profiles of Benzene ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, and the field measurements at the monitoring site of MDL1 in the Meadowlands District from March 17, 2005 to November 6, 2005.

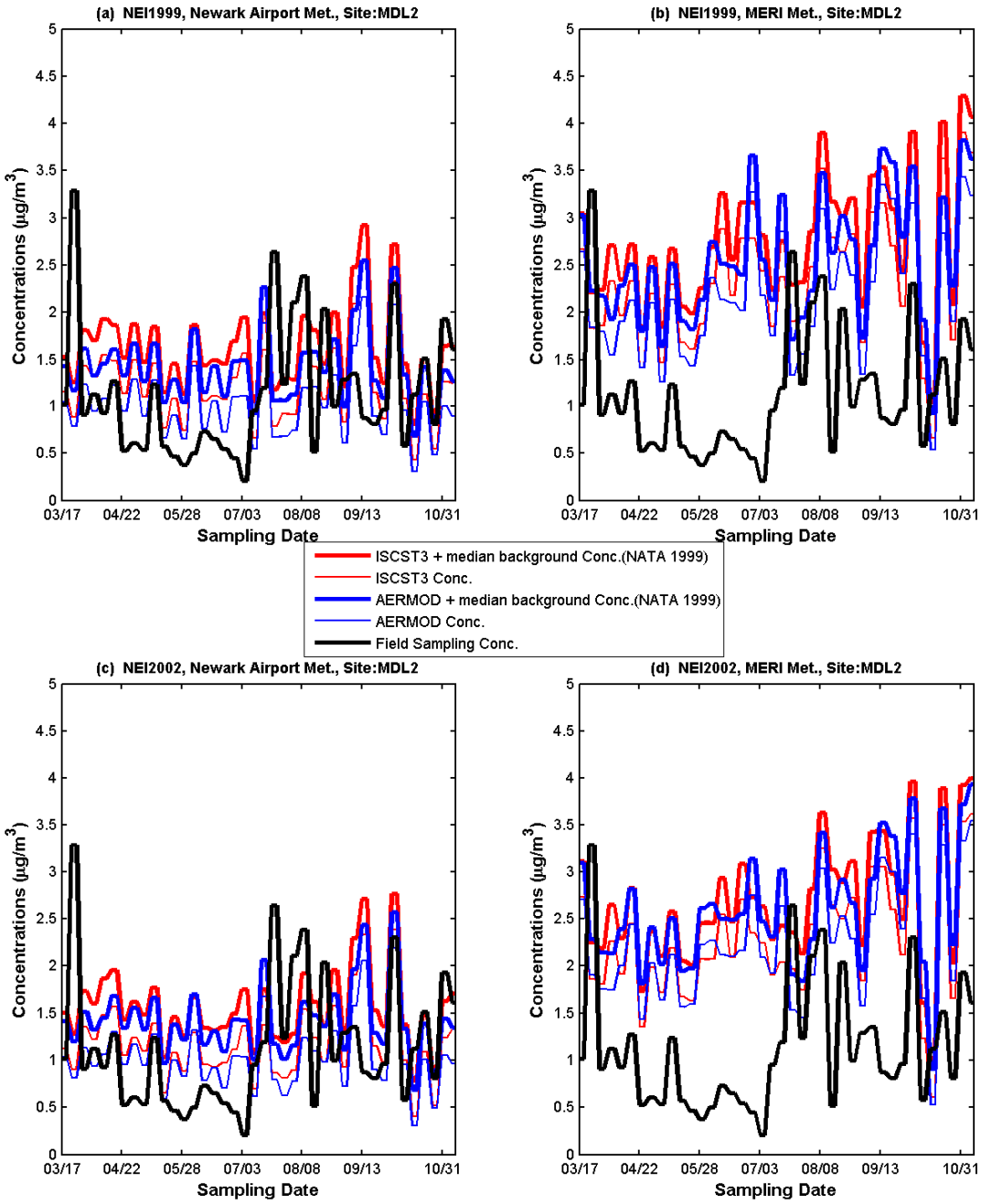


Figure E-3. Comparison of time-series profiles of Benzene ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, and the field measurements at the monitoring site of MDL2 in the Meadowlands District from March 17, 2005 to November 6, 2005.

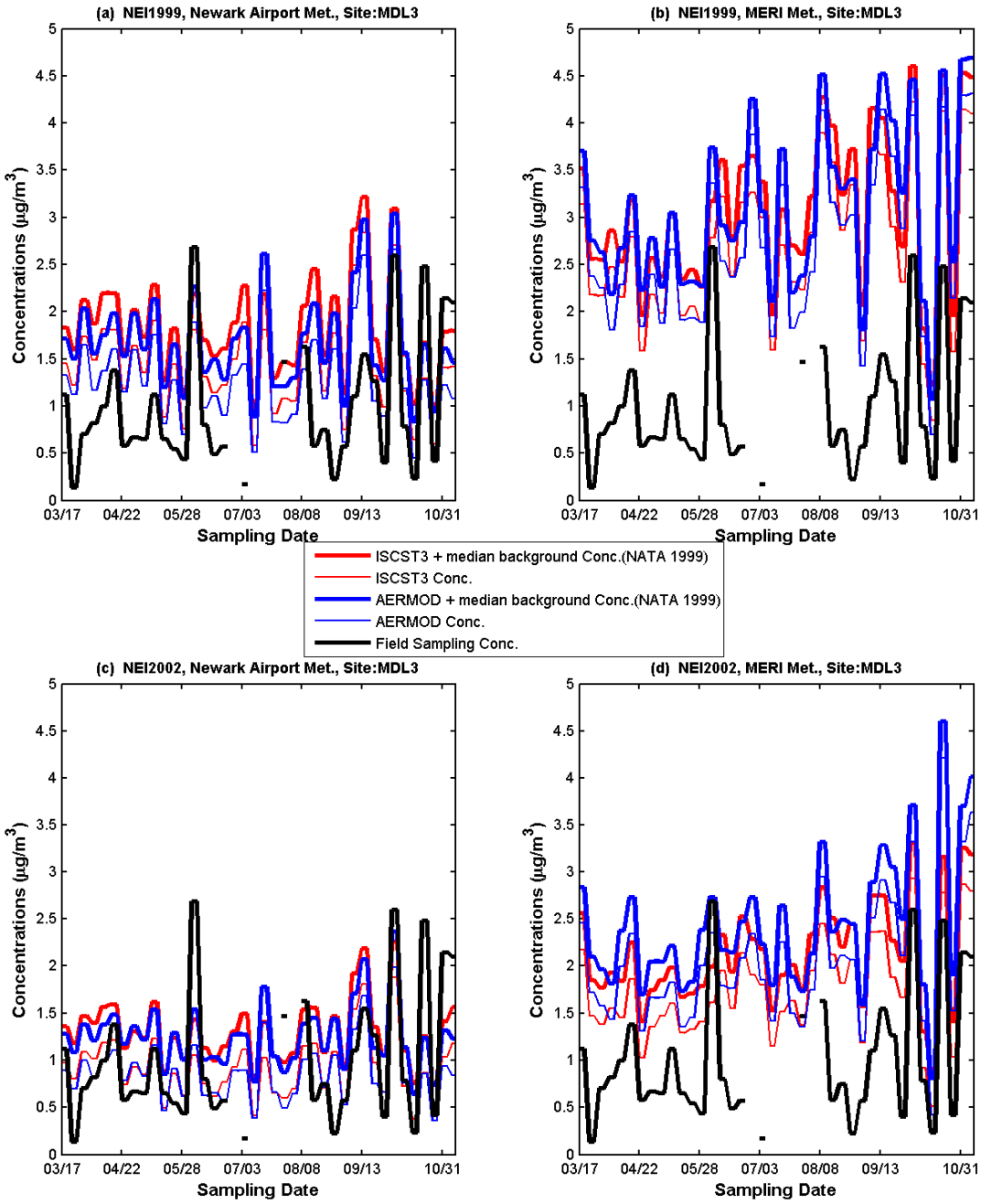


Figure E-4. Comparison of time-series profiles of Benzene ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, and the field measurements at the monitoring site of MDL3 in the Meadowlands District from March 17, 2005 to November 6, 2005.

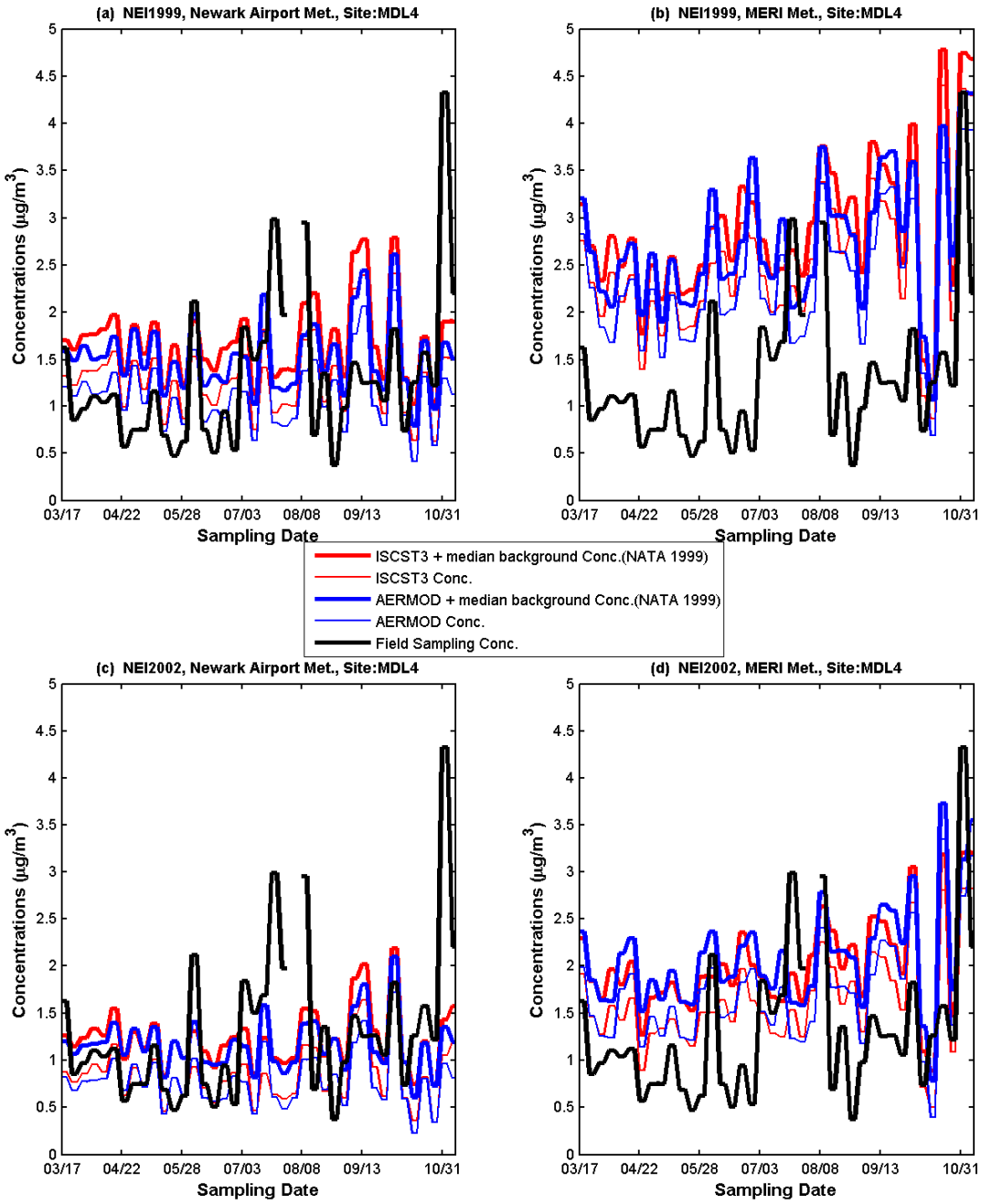


Figure E-5. Comparison of time-series profiles of Benzene ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, and the field measurements at the monitoring site of MDL4 in the Meadowlands District from March 17, 2005 to November 6, 2005.

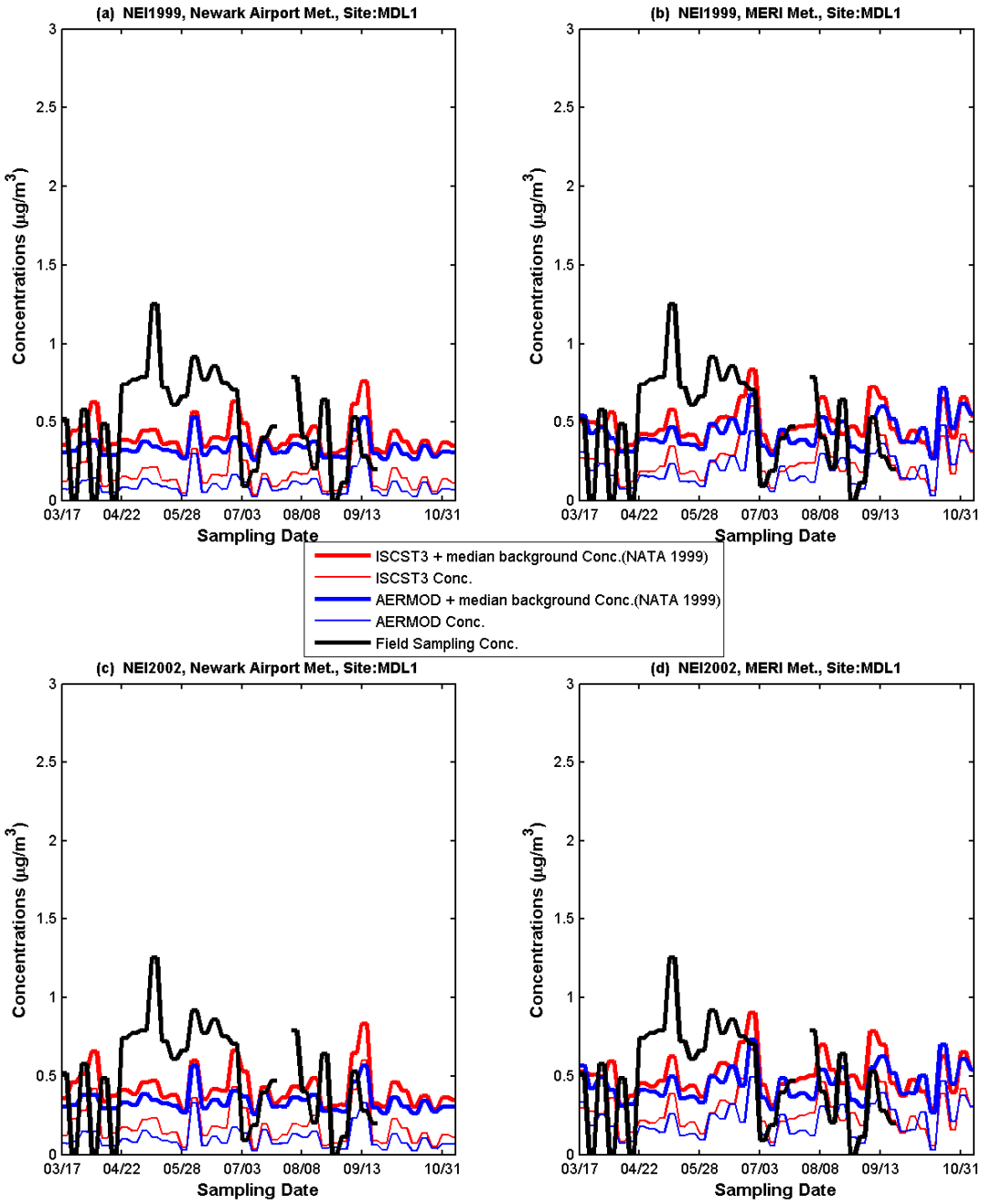


Figure E-6. Comparison of time-series profiles of PERC ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, and the field measurements at the monitoring site of MDL1 in the Meadowlands District from March 17, 2005 to November 6, 2005.

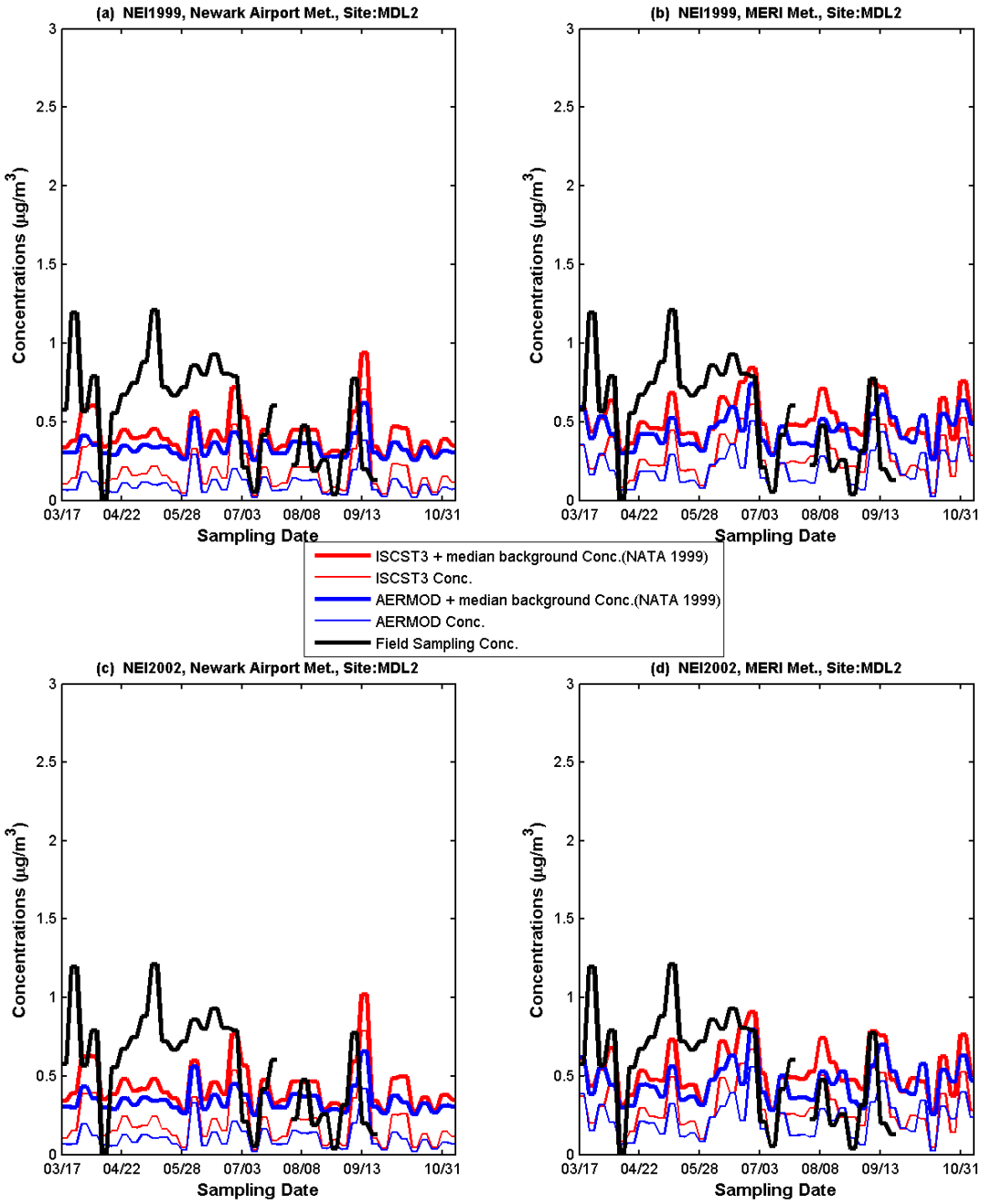


Figure E-7. Comparison of time-series profiles of PERC ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, and the field measurements at the monitoring site of MDL2 in the Meadowlands District from March 17, 2005 to November 6, 2005.

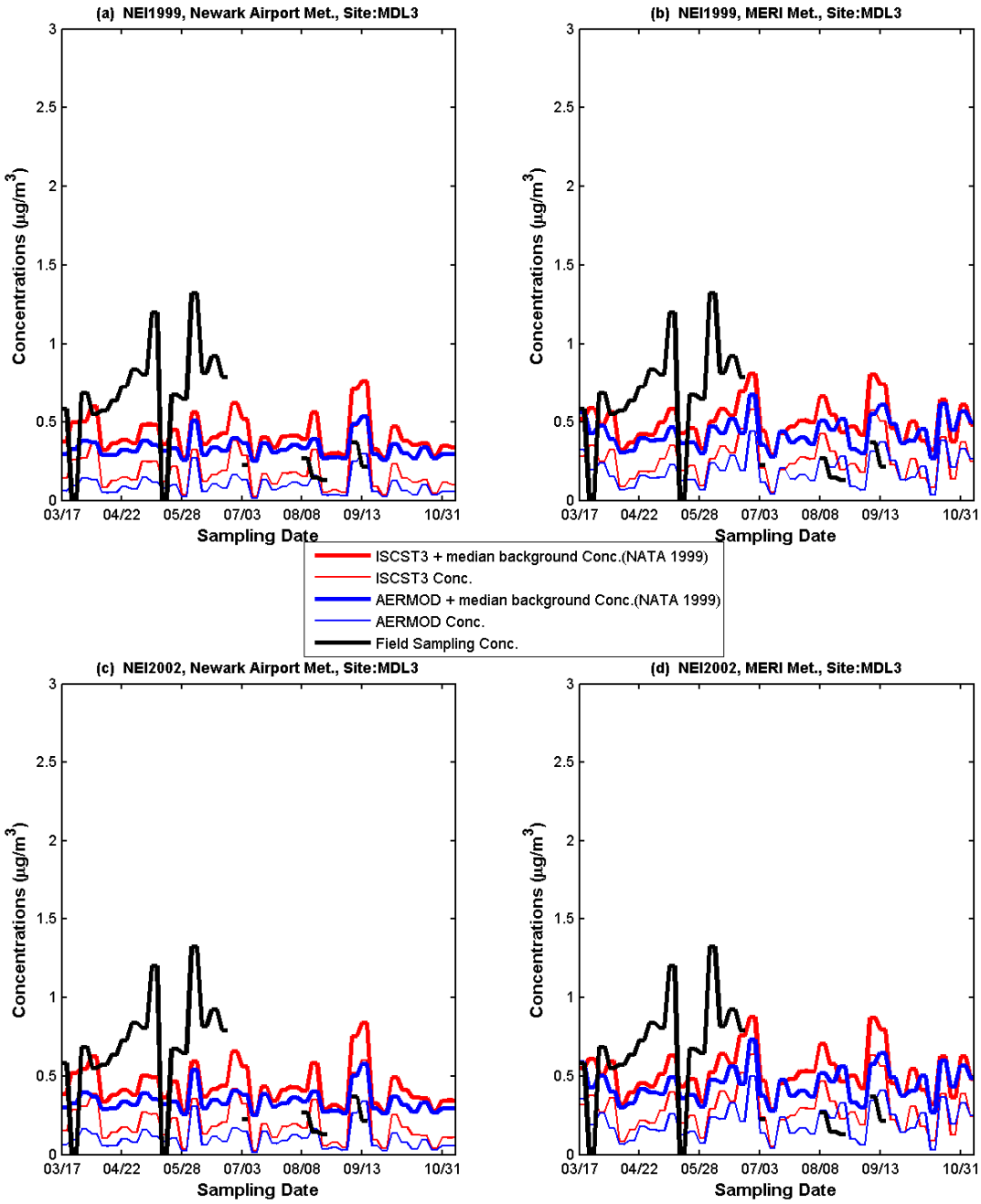


Figure E-8. Comparison of time-series profiles of PERC ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, and the field measurements at the monitoring site of MDL3 in the Meadowlands District from March 17, 2005 to November 6, 2005.

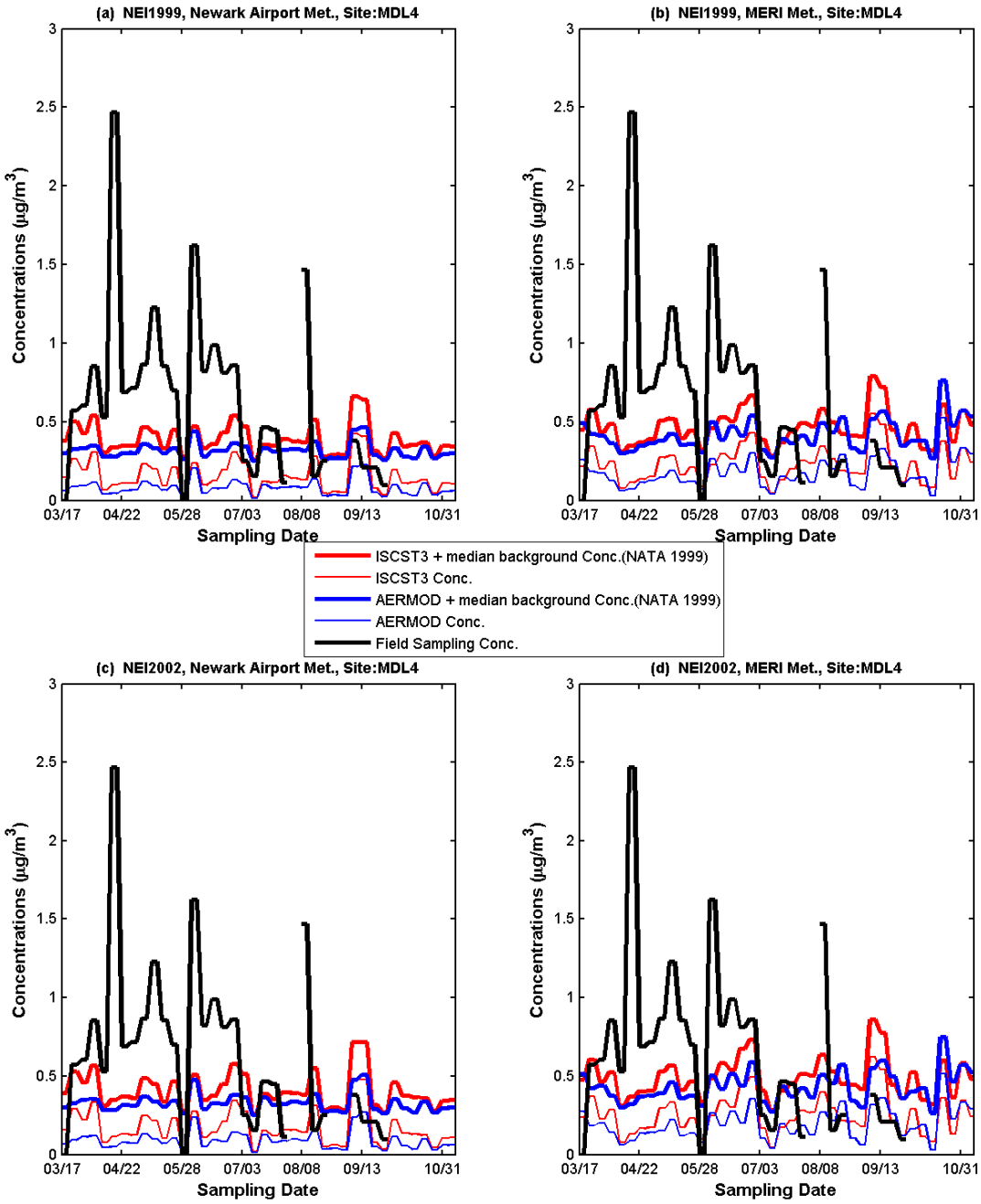


Figure E-9. Comparison of time-series profiles of PERC ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, and the field measurements at the monitoring site of MDL4 in the Meadowlands District from March 17, 2005 to November 6, 2005.

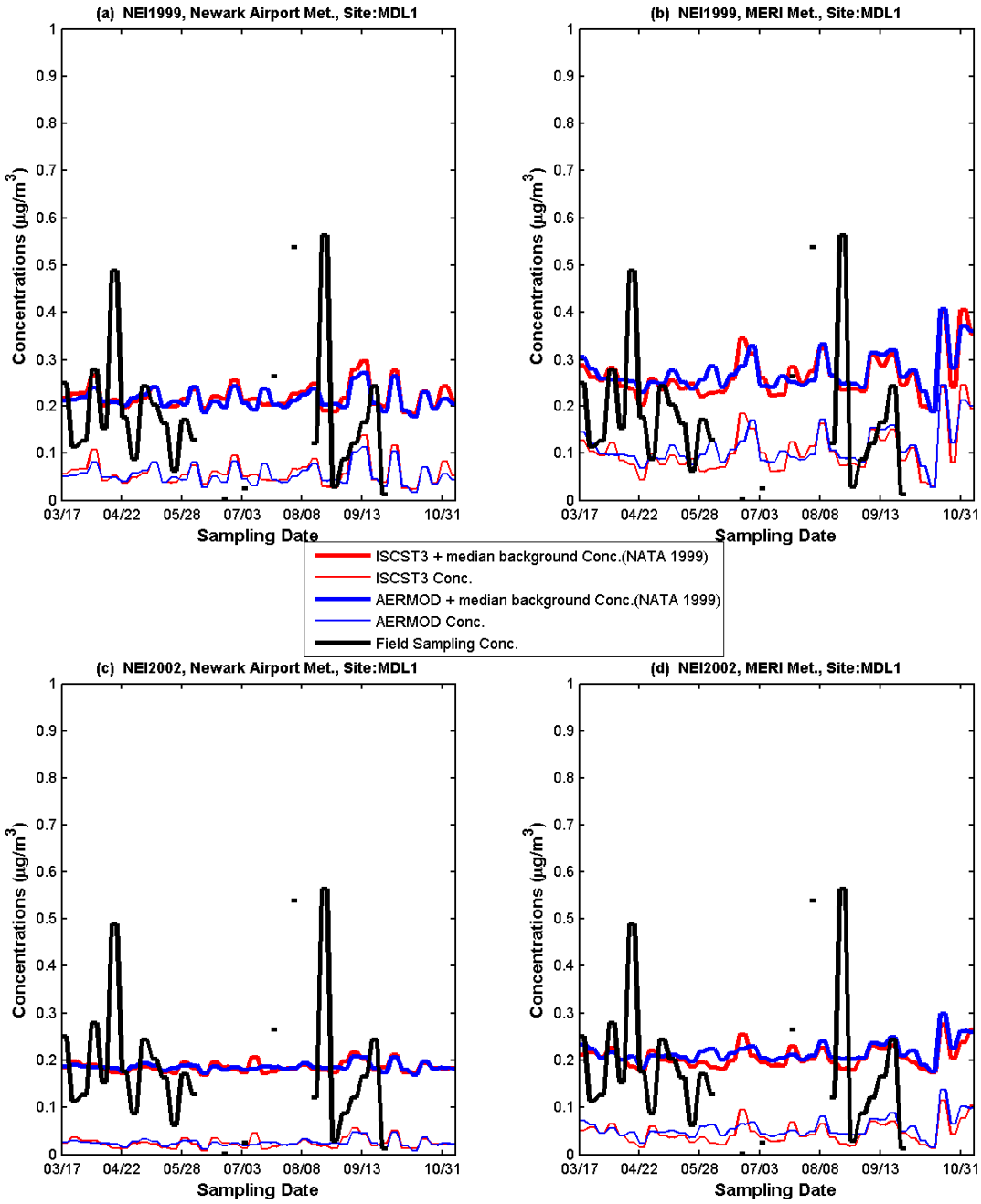


Figure E-10. Comparison of time-series profiles of TCE ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, and the field measurements at the monitoring site of MDL1 in the Meadowlands District from March 17, 2005 to November 6, 2005.

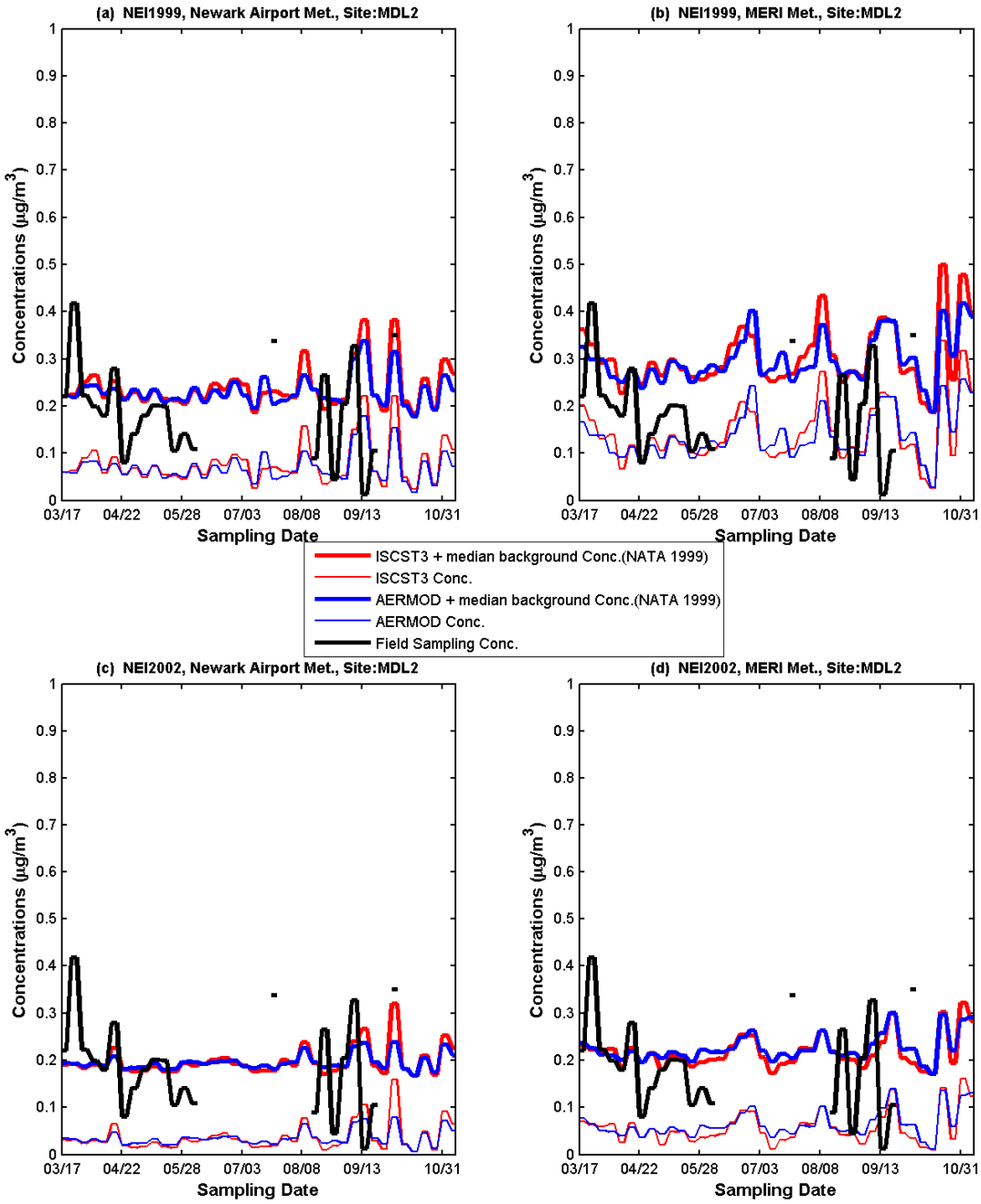


Figure E-11. Comparison of time-series profiles of TCE ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, and the field measurements at the monitoring site of MDL2 in the Meadowlands District from March 17, 2005 to November 6, 2005.

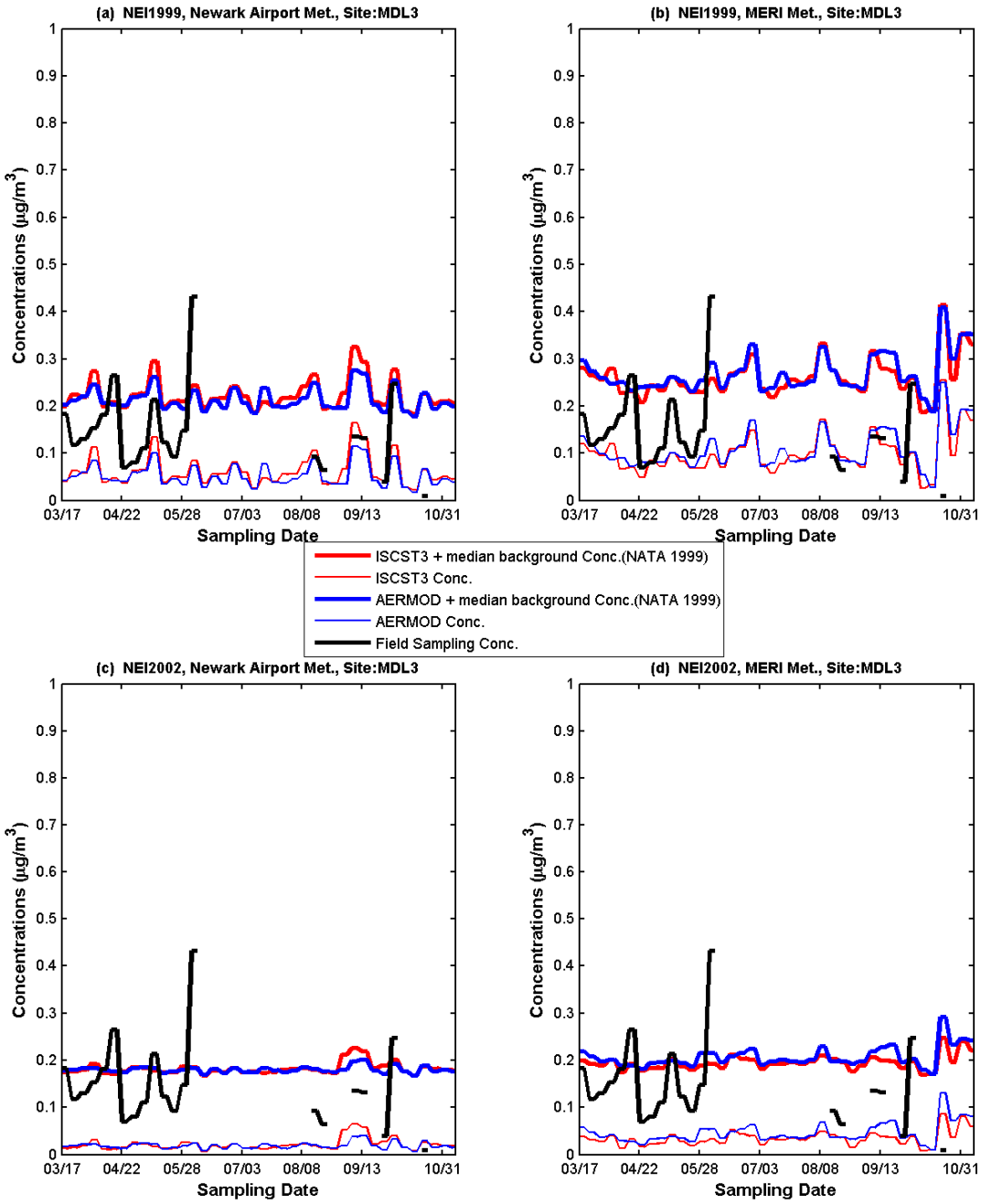


Figure E-12. Comparison of time-series profiles of TCE ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, and the field measurements at the monitoring site of MDL3 in the Meadowlands District from March 17, 2005 to November 6, 2005.

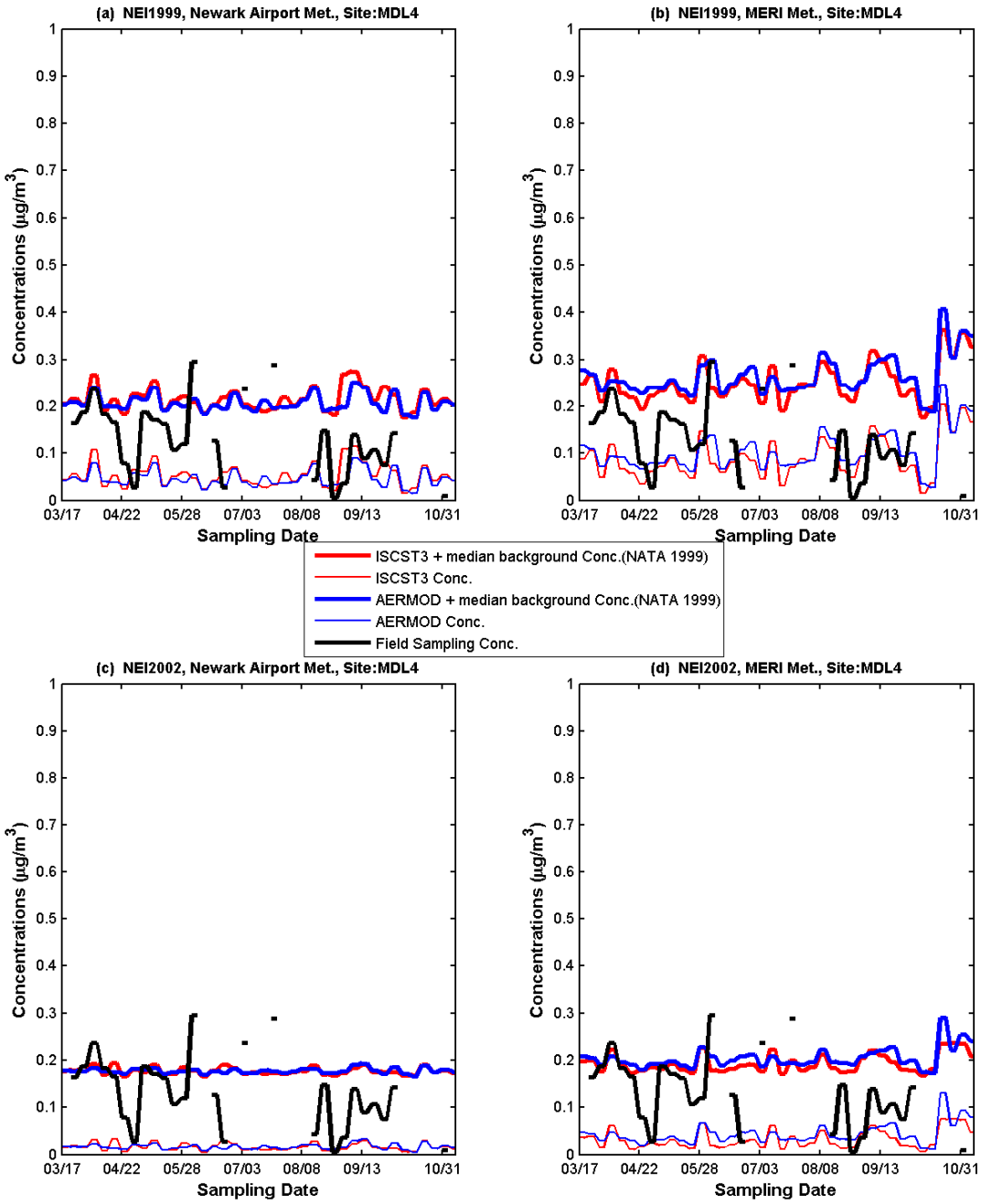


Figure E-13. Comparison of time-series profiles of TCE ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, and the field measurements at the monitoring site of MDL4 in the Meadowlands District from March 17, 2005 to November 6, 2005.

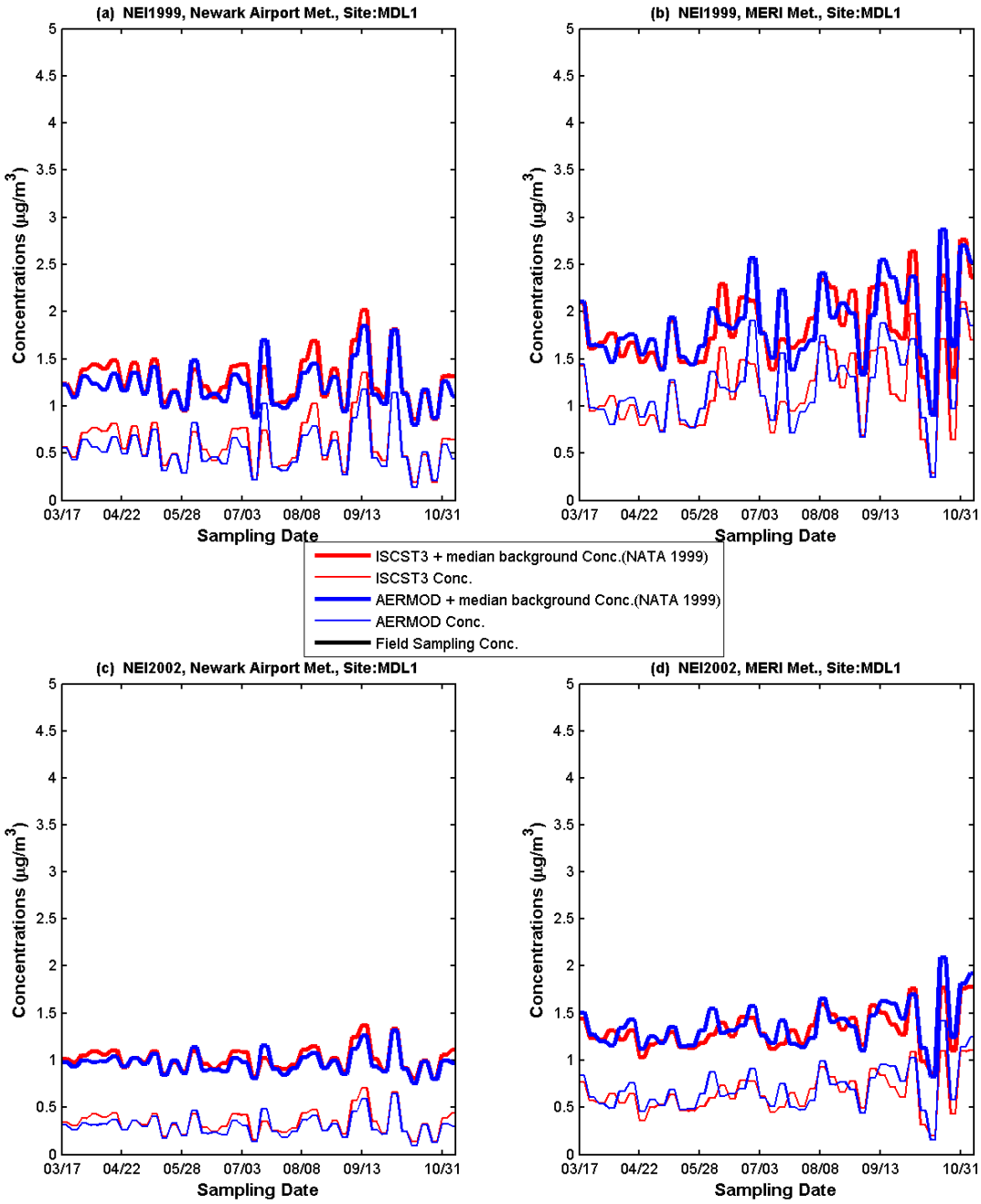


Figure E-14. Comparison of time-series profiles of Formaldehyde ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, at the monitoring site of MDL1 in the Meadowlands District from March 17, 2005 to November 6, 2005.

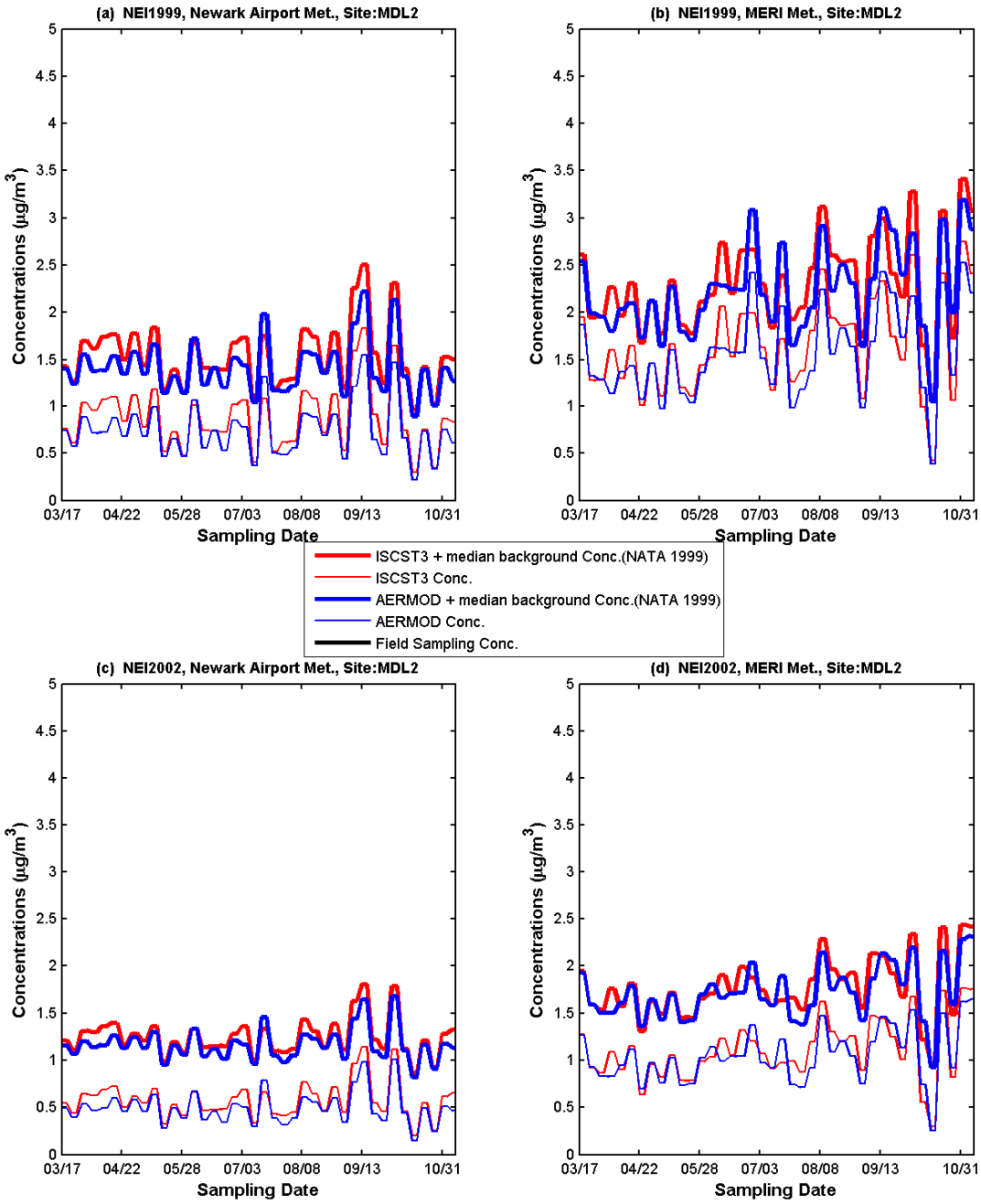


Figure E-15. Comparison of time-series profiles of Formaldehyde ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, at the monitoring site of MDL2 in the Meadowlands District from March 17, 2005 to November 6, 2005.

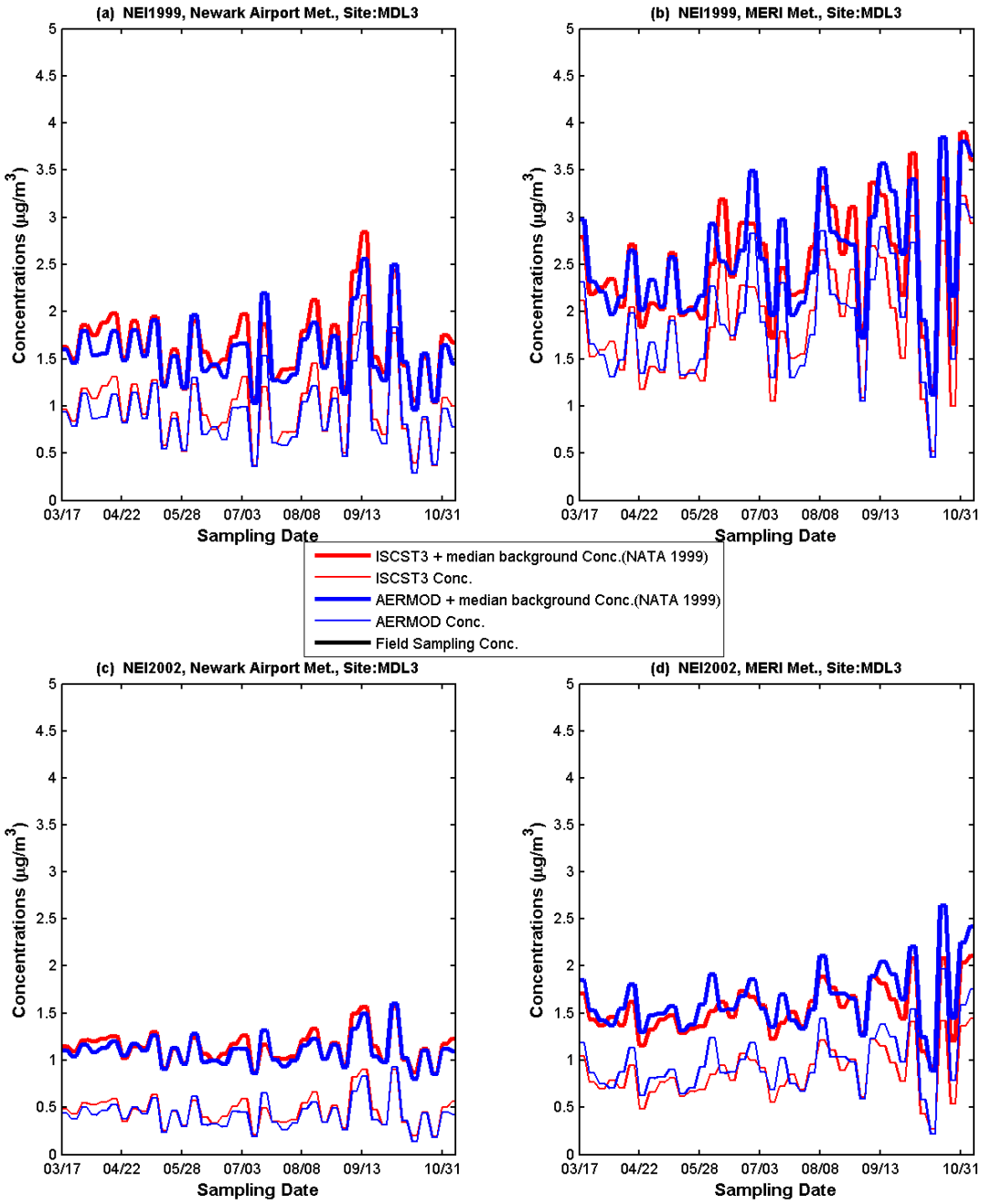


Figure E-16. Comparison of time-series profiles of Formaldehyde ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, at the monitoring site of MDL3 in the Meadowlands District from March 17, 2005 to November 6, 2005.

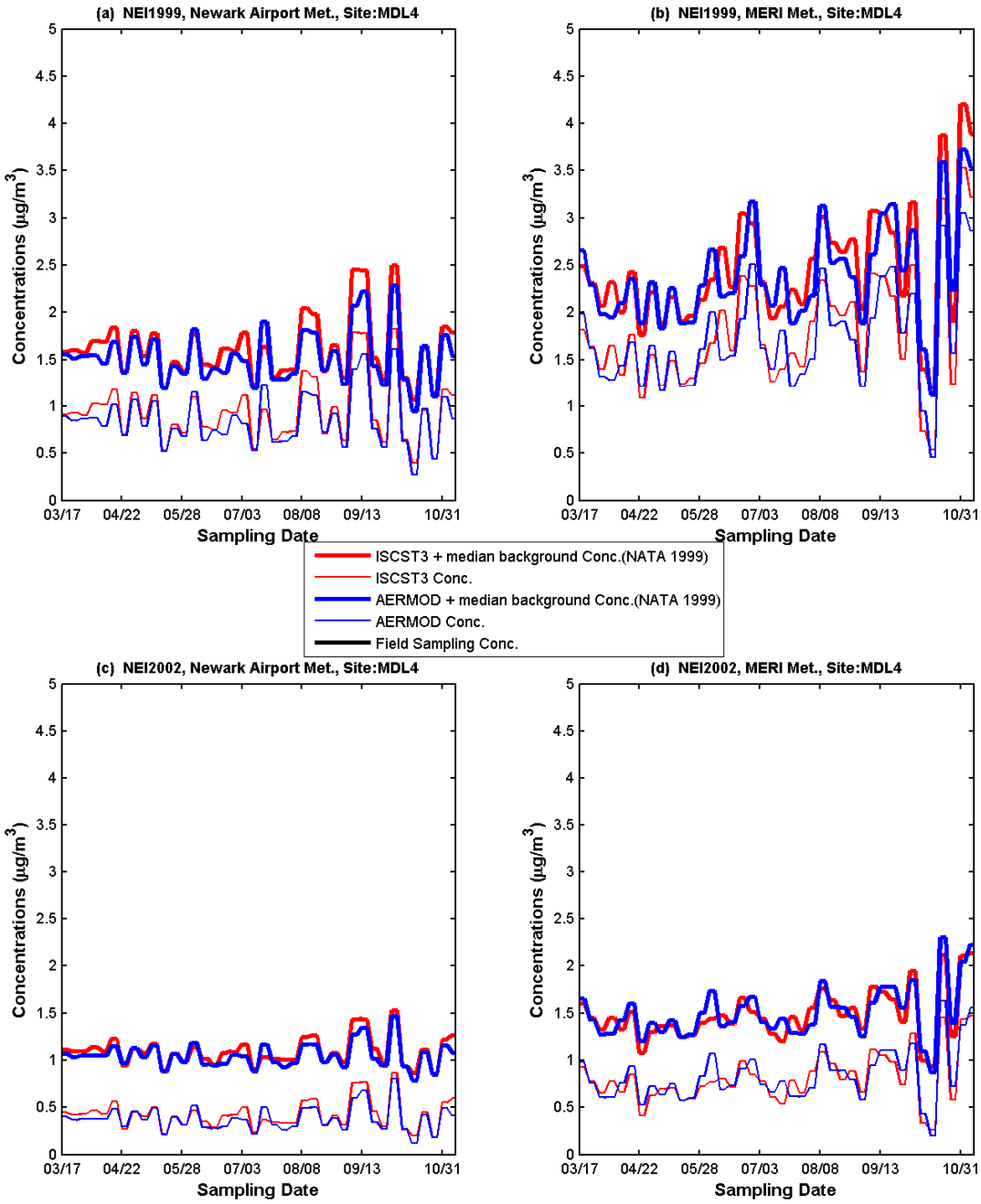


Figure E-17. Comparison of time-series profiles of Formaldehyde ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, at the monitoring site of MDL4 in the Meadowlands District from March 17, 2005 to November 6, 2005.

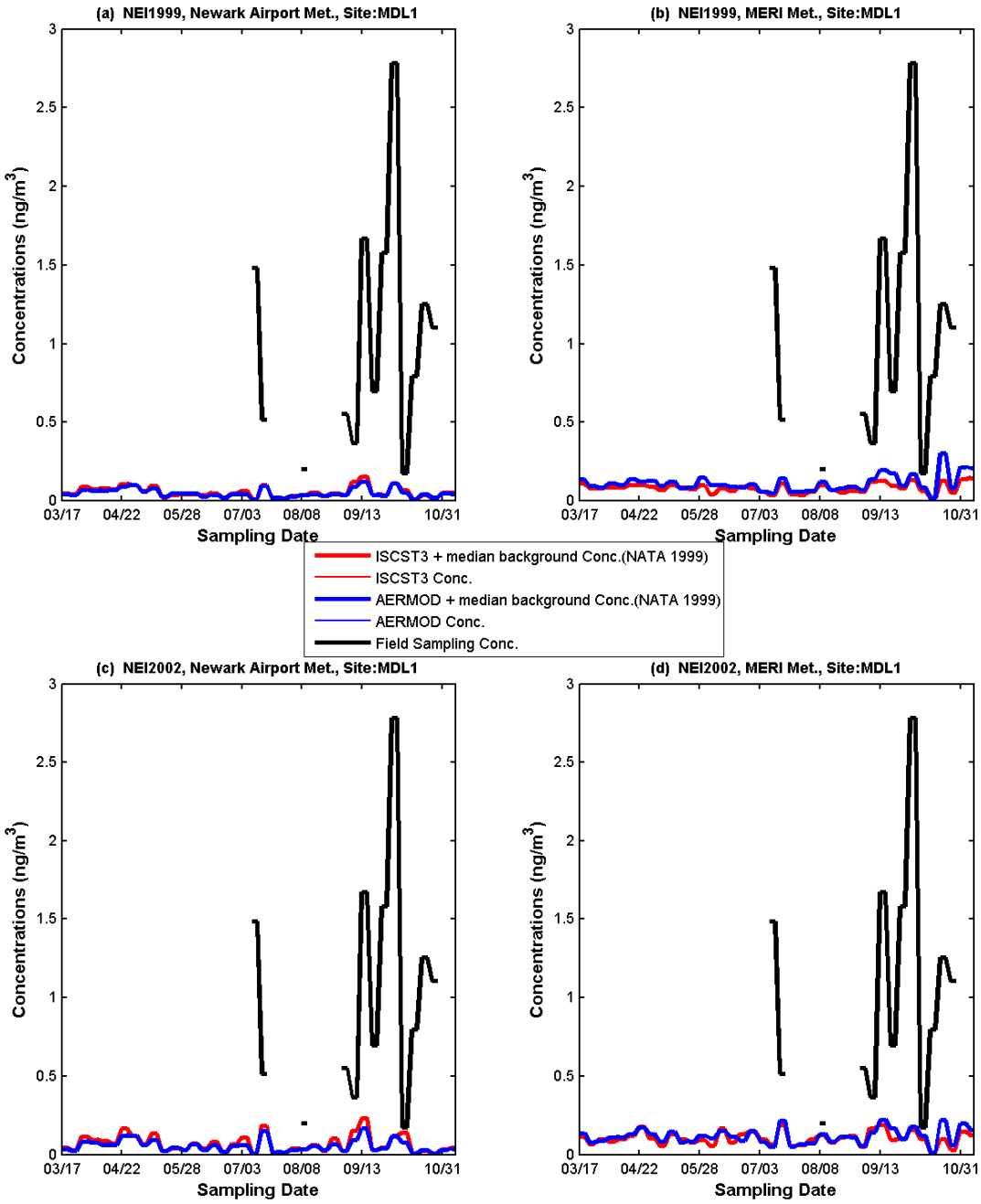


Figure E-18. Comparison of time-series profiles of Arsenic (fine PM) ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, and the field measurements at the monitoring site of MDL1 in the Meadowlands District from March 17, 2005 to November 6, 2005.

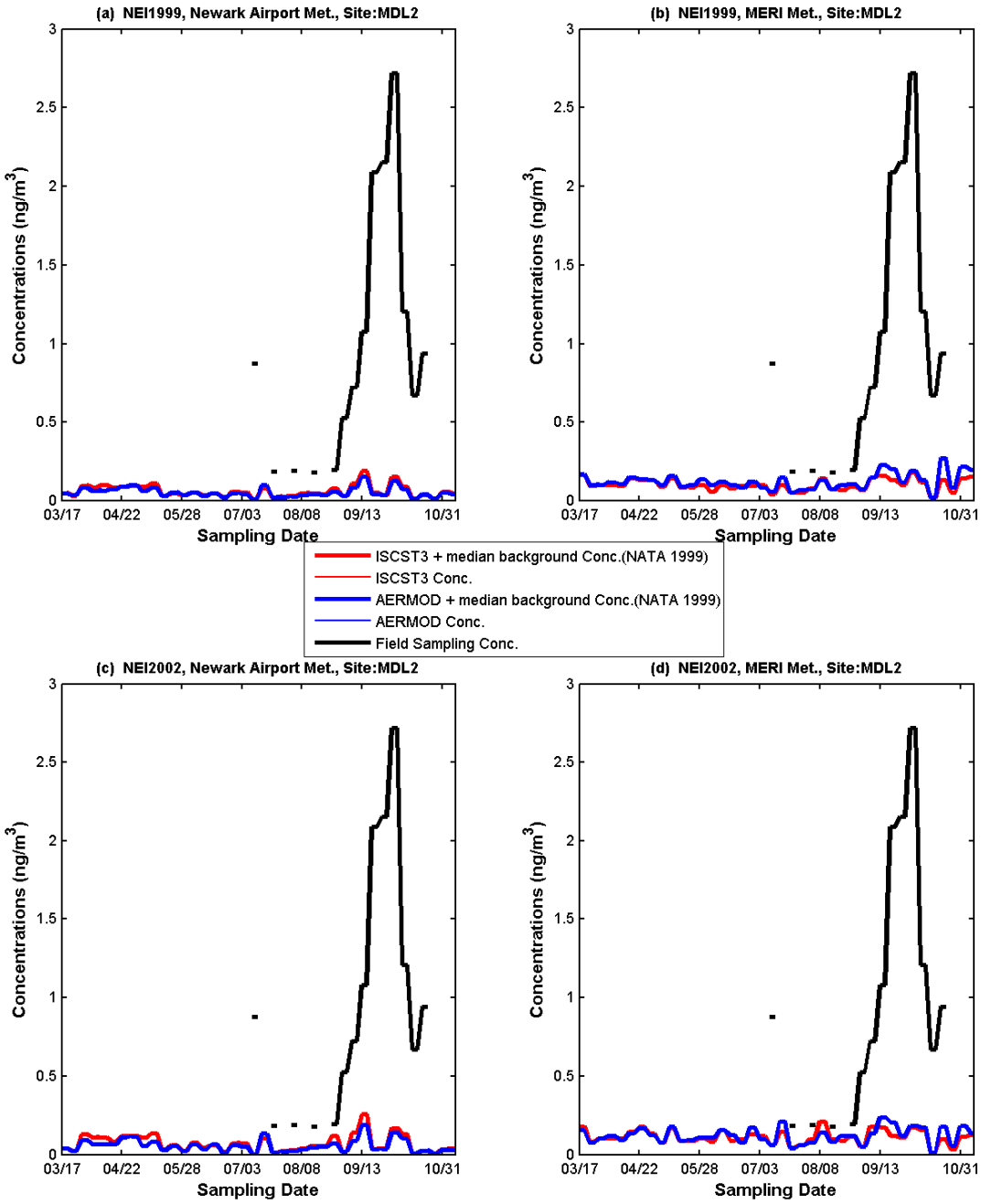


Figure E-19. Comparison of time-series profiles of Arsenic (fine PM) ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, and the field measurements at the monitoring site of MDL2 in the Meadowlands District from March 17, 2005 to November 6, 2005.

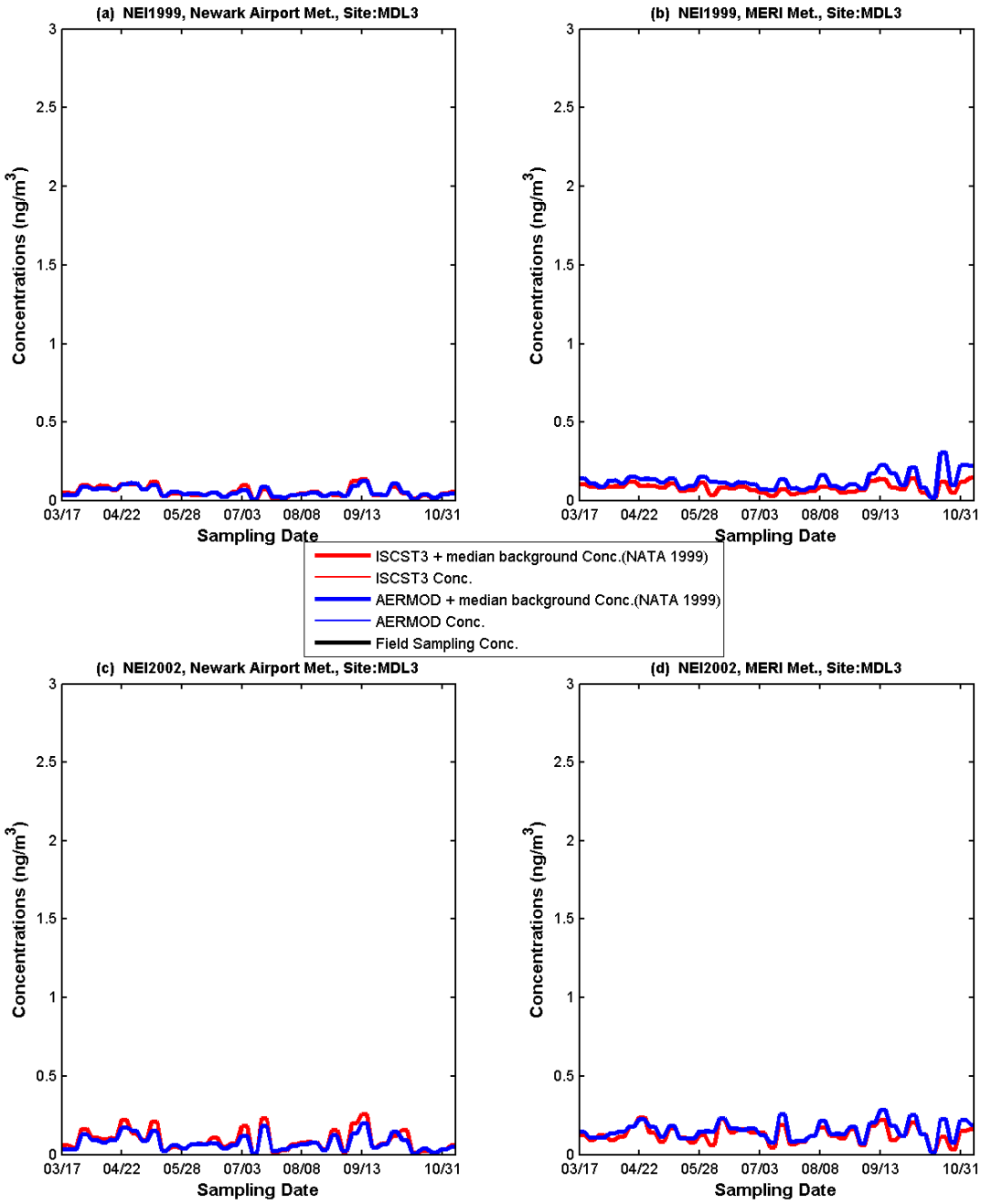


Figure E-20. Comparison of time-series profiles of Arsenic (fine PM) ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, at the monitoring site of MDL3 in the Meadowlands District from March 17, 2005 to November 6, 2005.

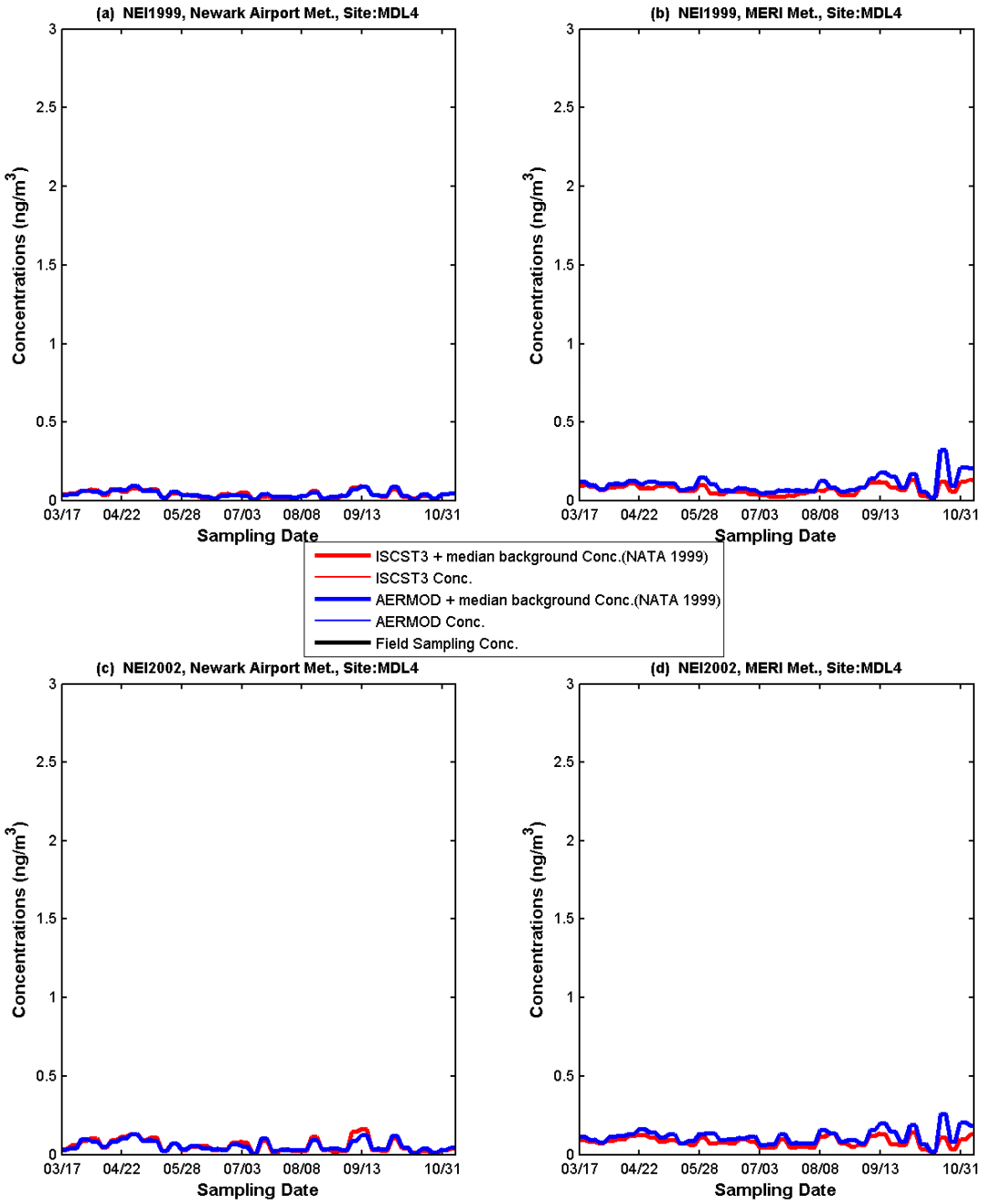


Figure E-21. Comparison of time-series profiles of Arsenic (fine PM) ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, at the monitoring site of MDL4 in the Meadowlands District from March 17, 2005 to November 6, 2005.

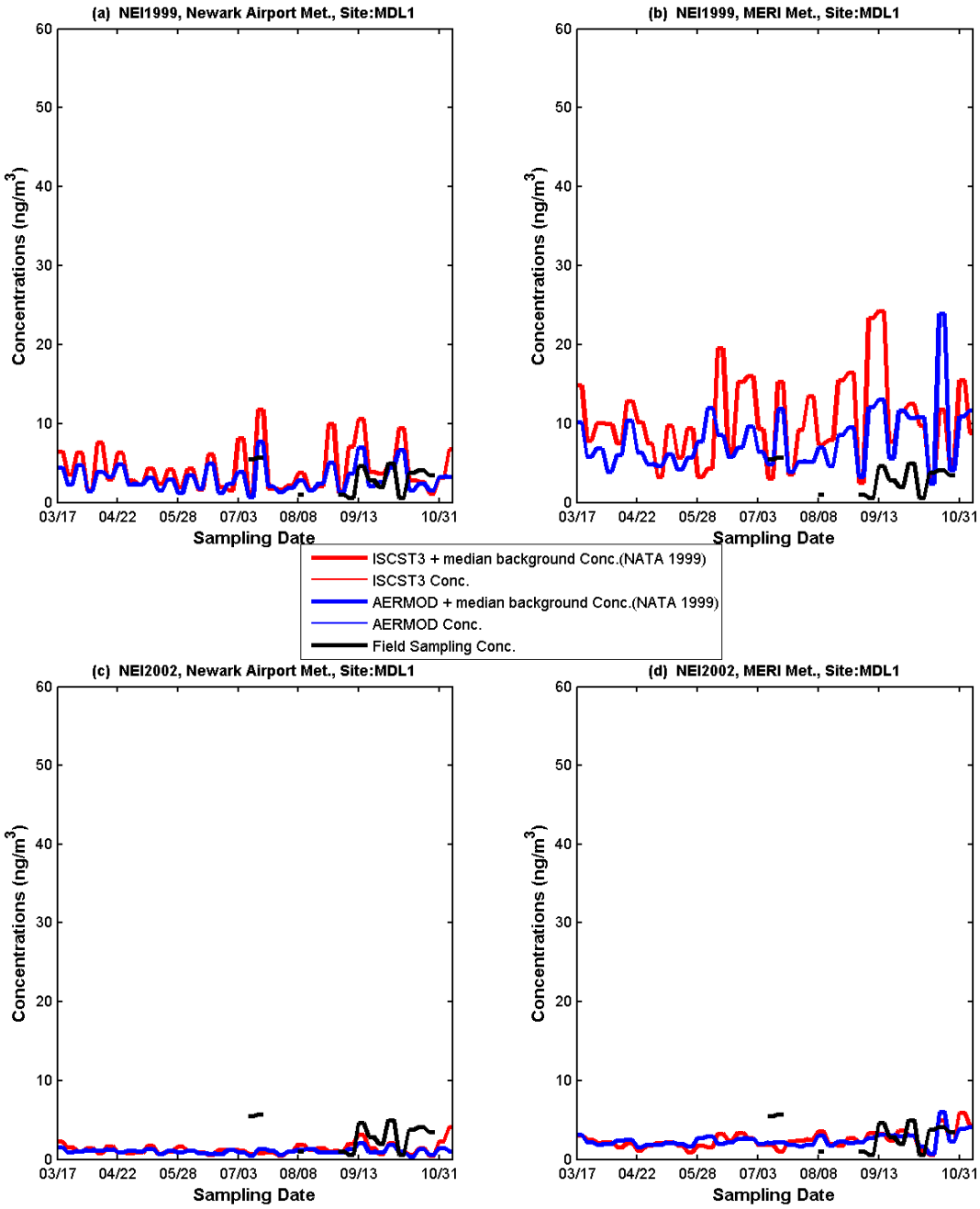


Figure E-22. Comparison of time-series profiles of Lead (fine PM) ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, and the field measurements at the monitoring site of MDL1 in the Meadowlands District from March 17, 2005 to November 6, 2005.

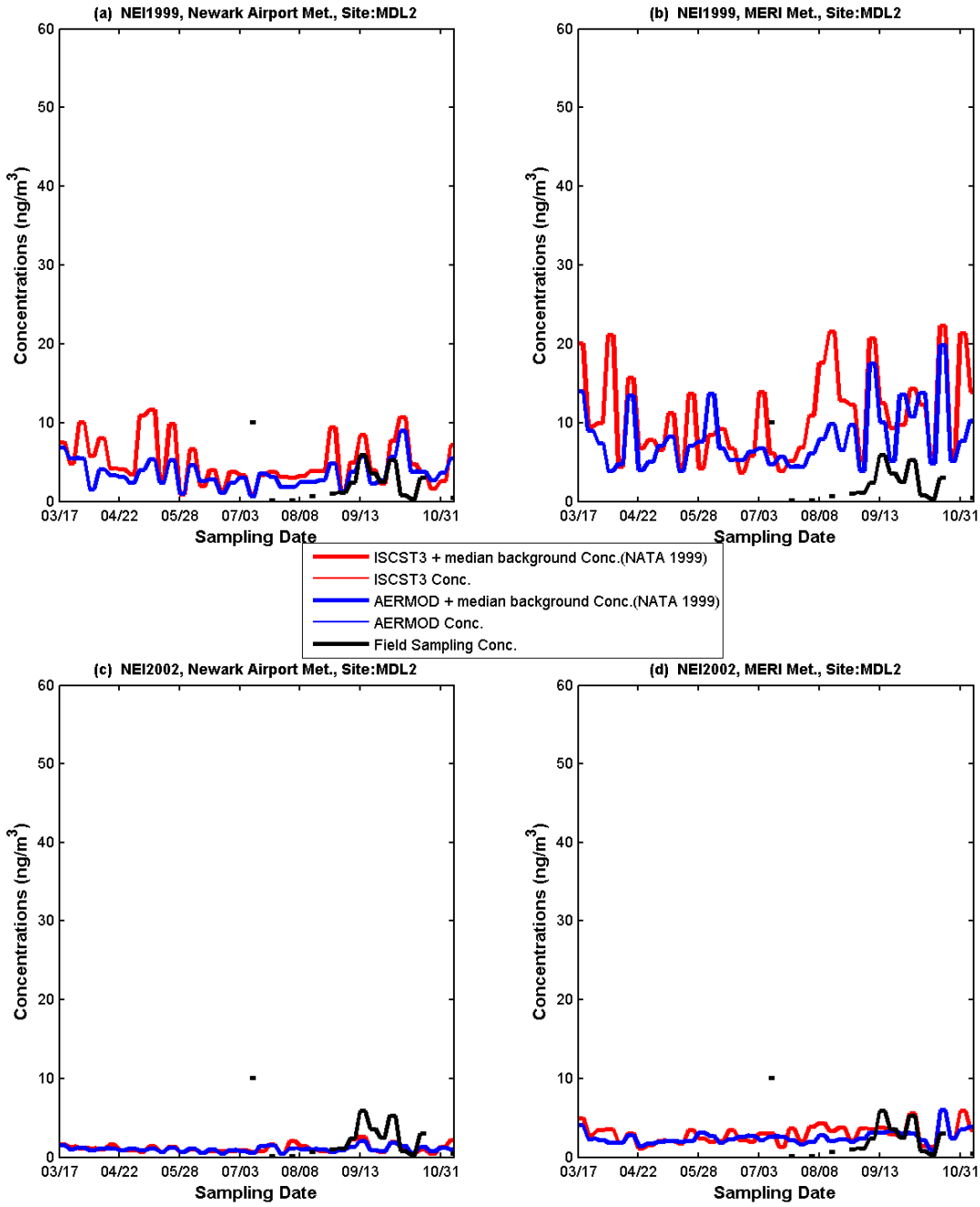


Figure E-23. Comparison of time-series profiles of Lead (fine PM) ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, and the field measurements at the monitoring site of MDL2 in the Meadowlands District from March 17, 2005 to November 6, 2005.

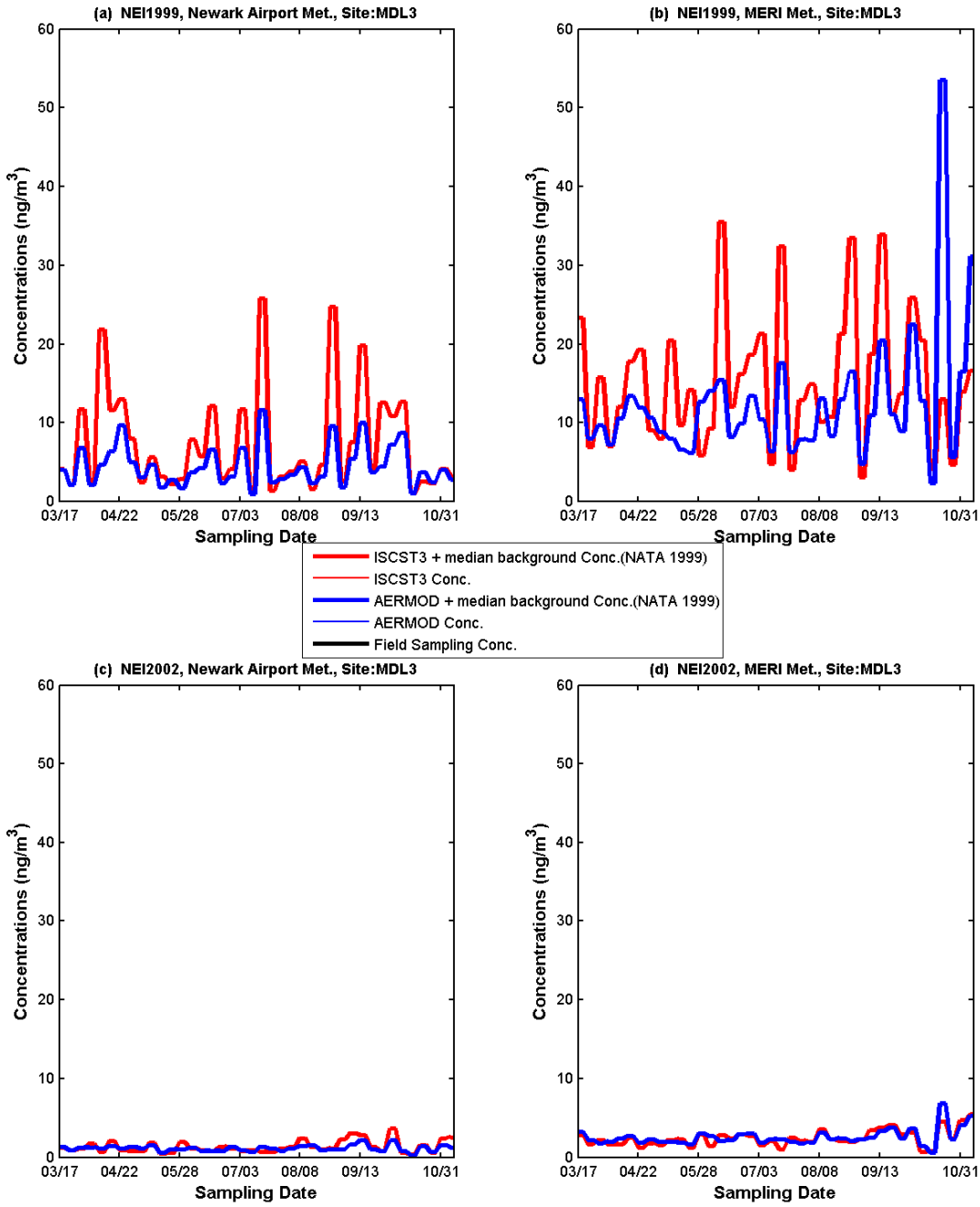


Figure E-24. Comparison of time-series profiles of Lead (fine PM) ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, at the monitoring site of MDL3 in the Meadowlands District from March 17, 2005 to November 6, 2005.

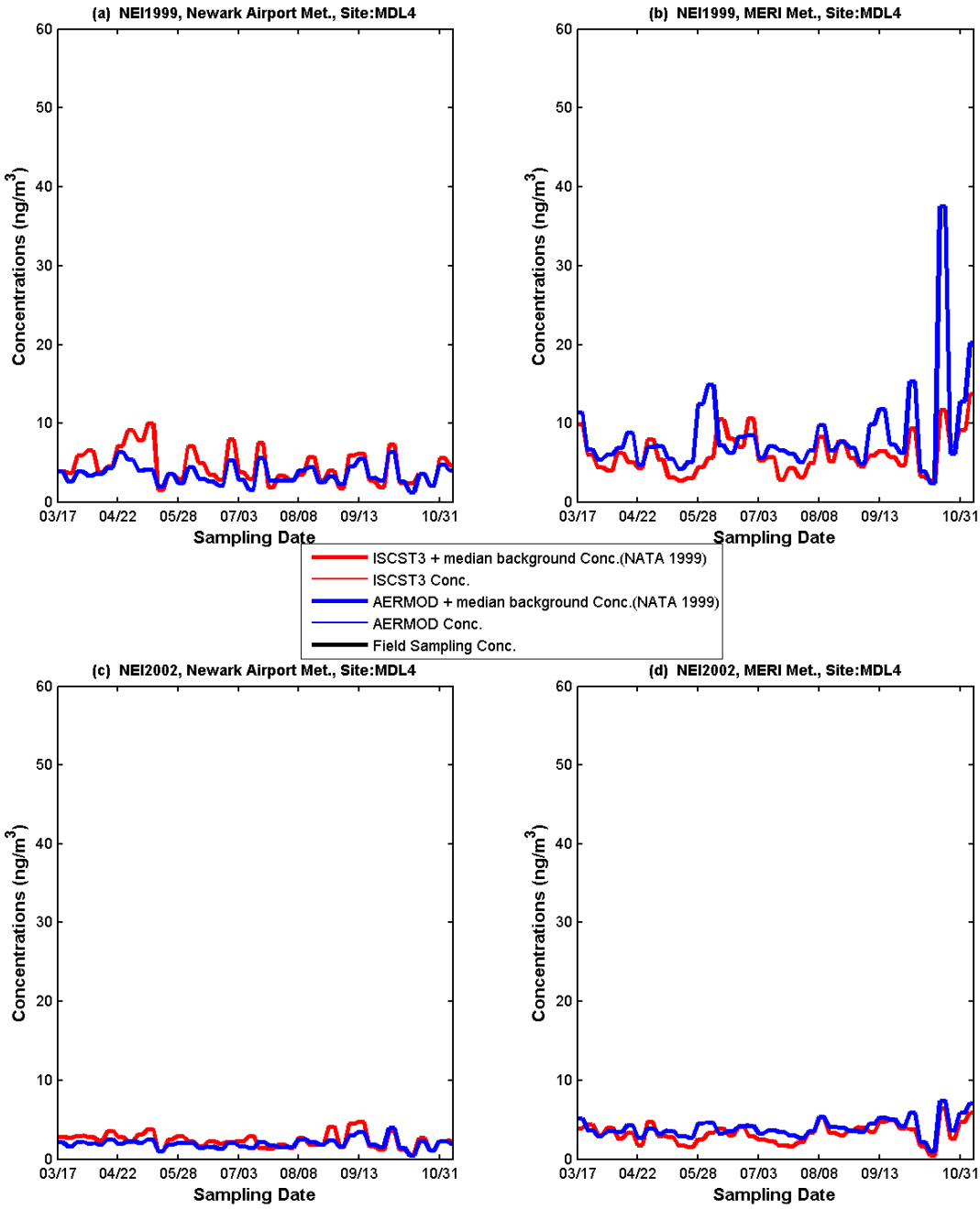


Figure E-25. Comparison of time-series profiles of Lead (fine PM) ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, at the monitoring site of MDL4 in the Meadowlands District from March 17, 2005 to November 6, 2005.

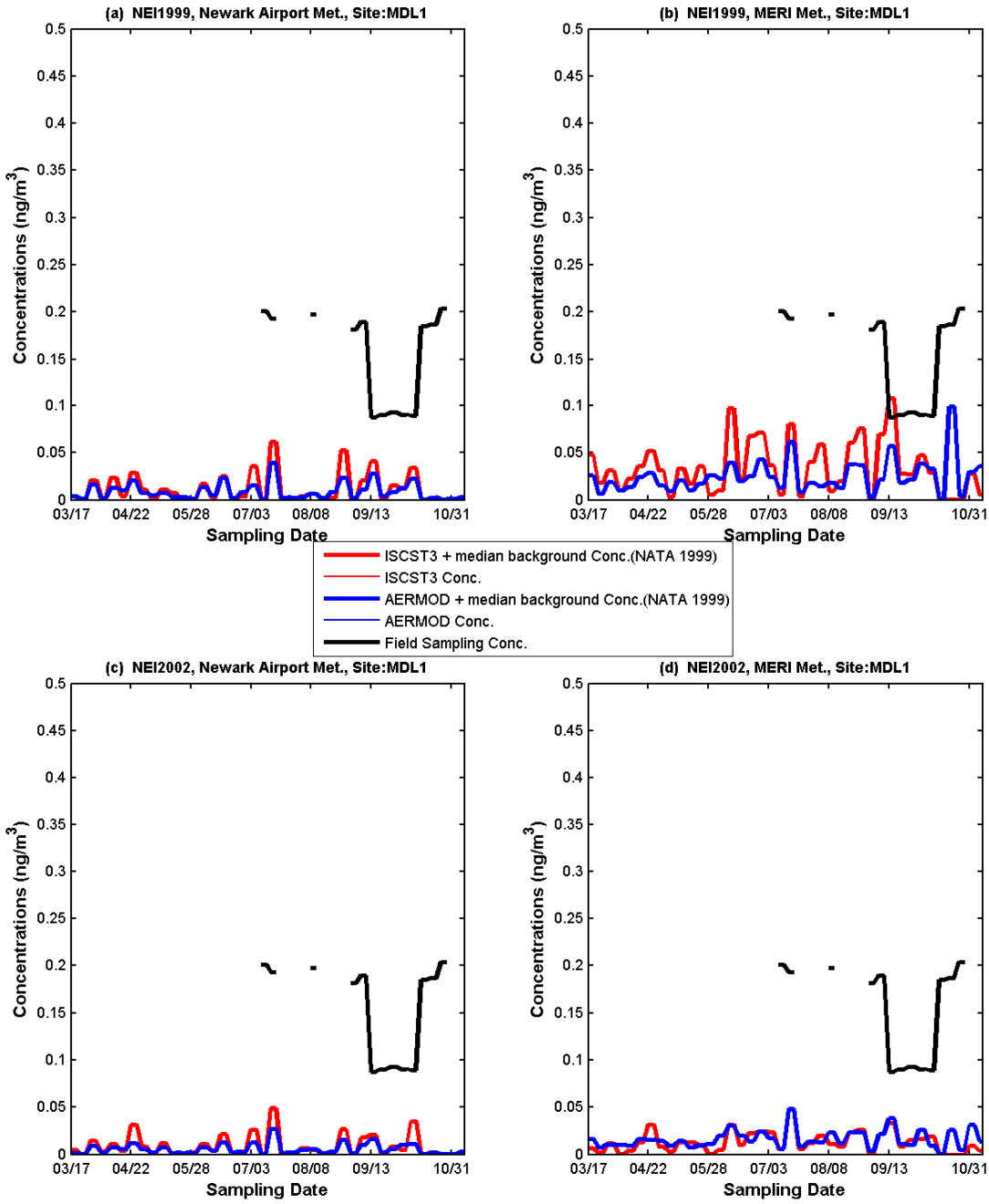


Figure E-26. Comparison of time-series profiles of Mercury (fine PM) ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, and the field measurements at the monitoring site of MDL1 in the Meadowlands District from March 17, 2005 to November 6, 2005.

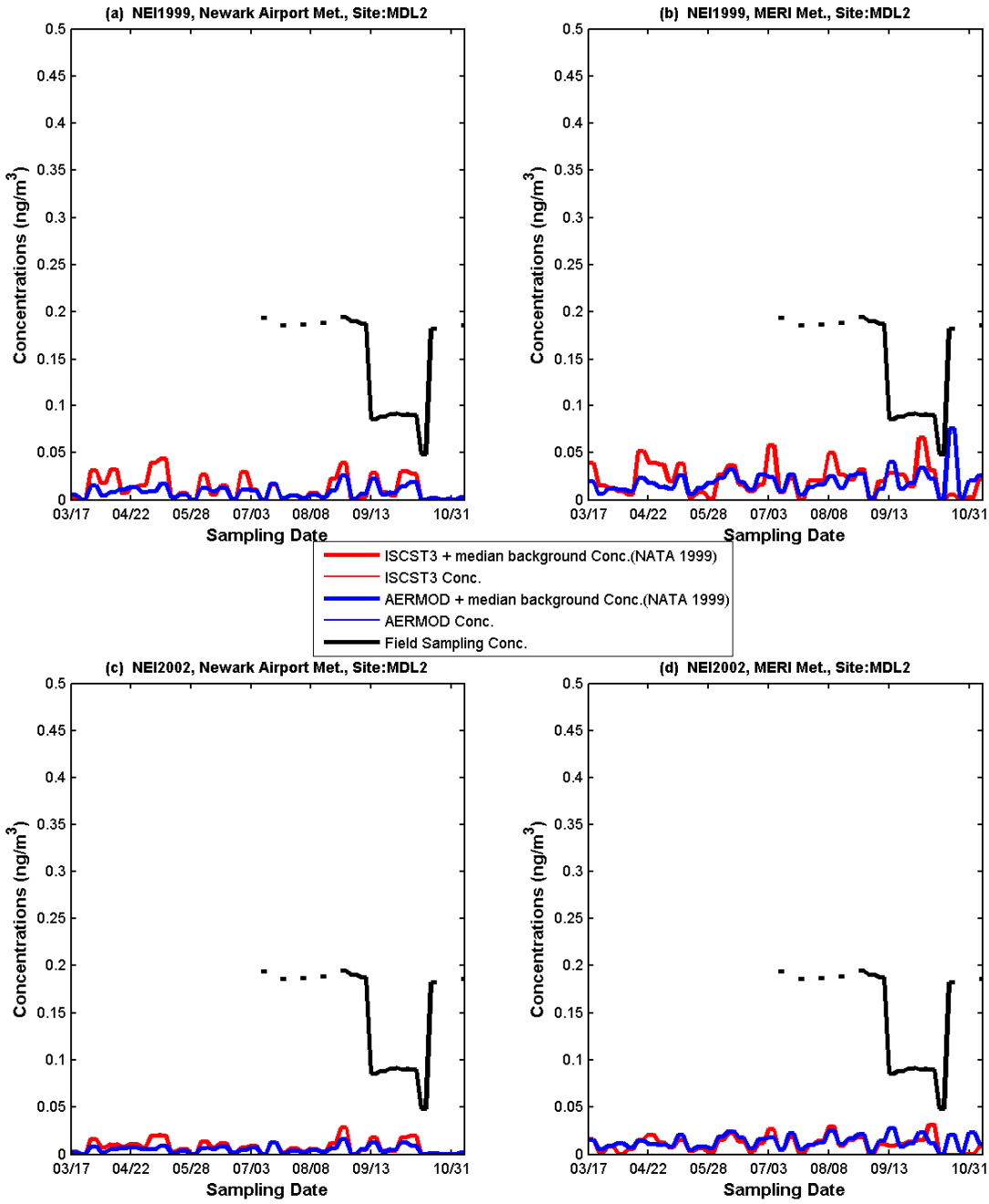


Figure E-27. Comparison of time-series profiles of Mercury (fine PM) ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, and the field measurements at the monitoring site of MDL2 in the Meadowlands District from March 17, 2005 to November 6, 2005.

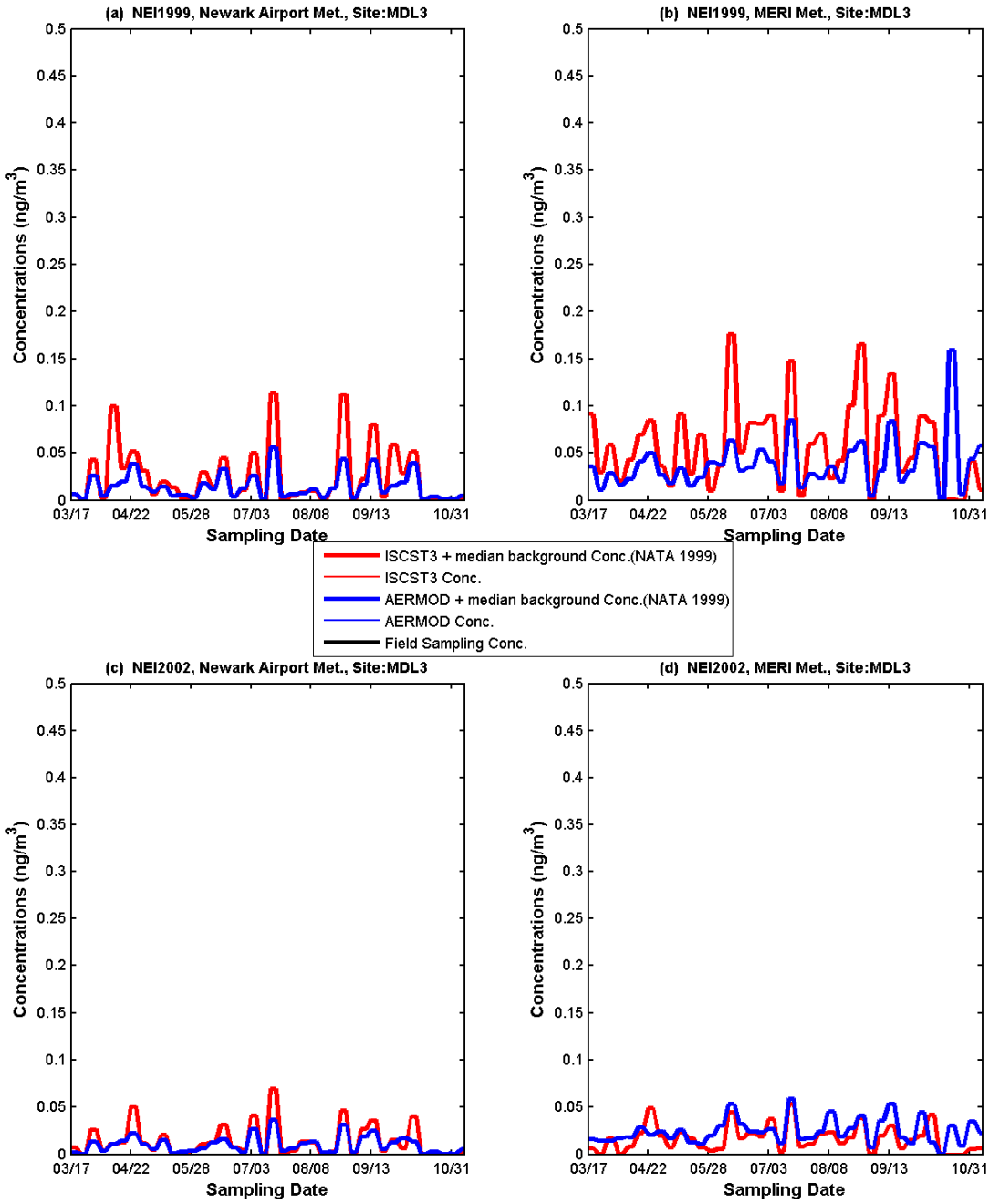


Figure E-28. Comparison of time-series profiles of Mercury (fine PM) ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, at the monitoring site of MDL3 in the Meadowlands District from March 17, 2005 to November 6, 2005.

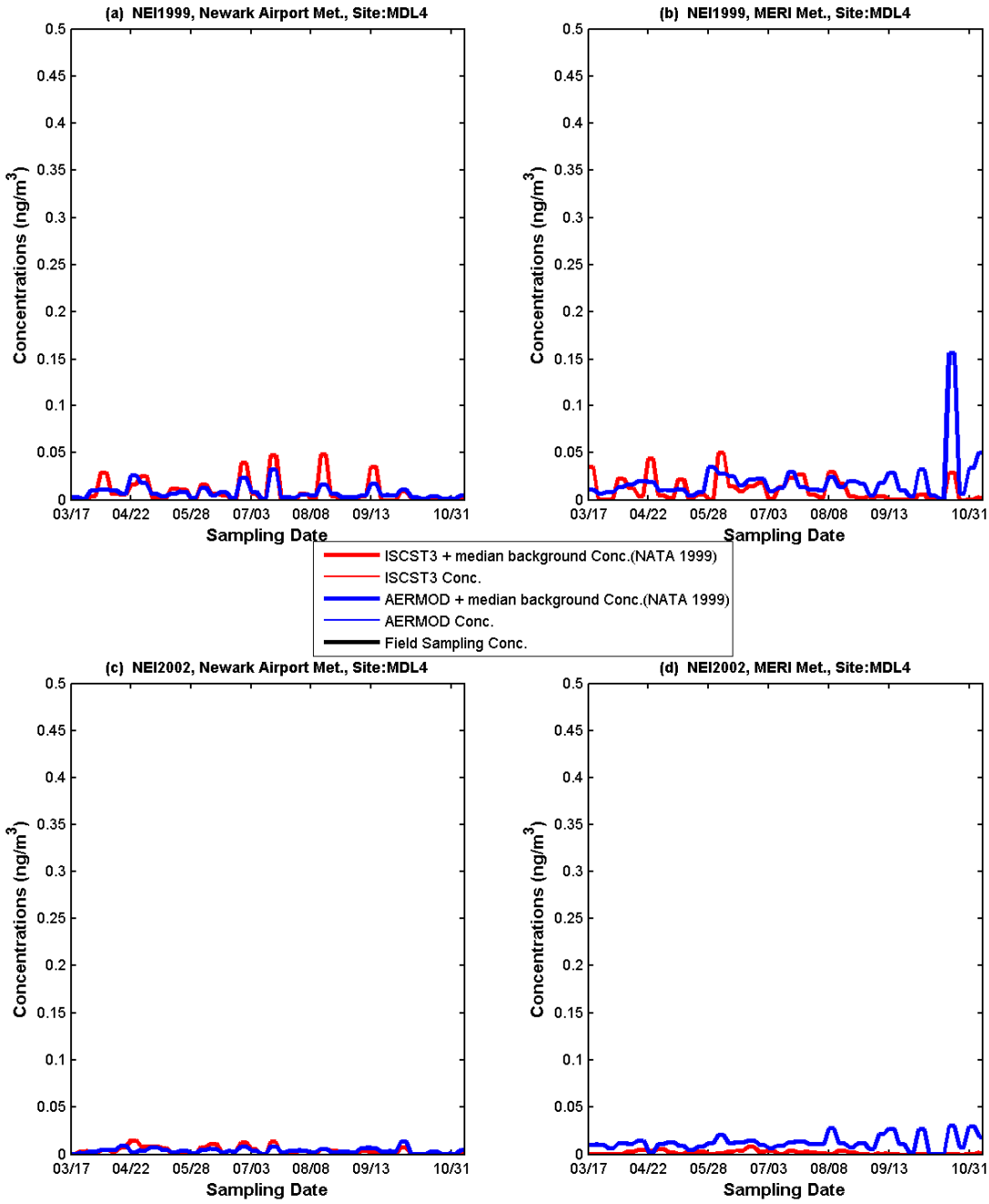


Figure E-29. Comparison of time-series profiles of Mercury (fine PM) ambient concentrations estimated by both the ISCST3 and AERMOD simulations using 4 different combinations of modeling inputs options, (a) NEI-1999 emissions and Newark Airport meteorology (b) NEI-1999 emissions and MERI meteorology (c) NEI-2002 and Newark Airport meteorology (d) NEI-2002 and MERI meteorology, at the monitoring site of MDL4 in the Meadowlands District from March 17, 2005 to November 6, 2005.

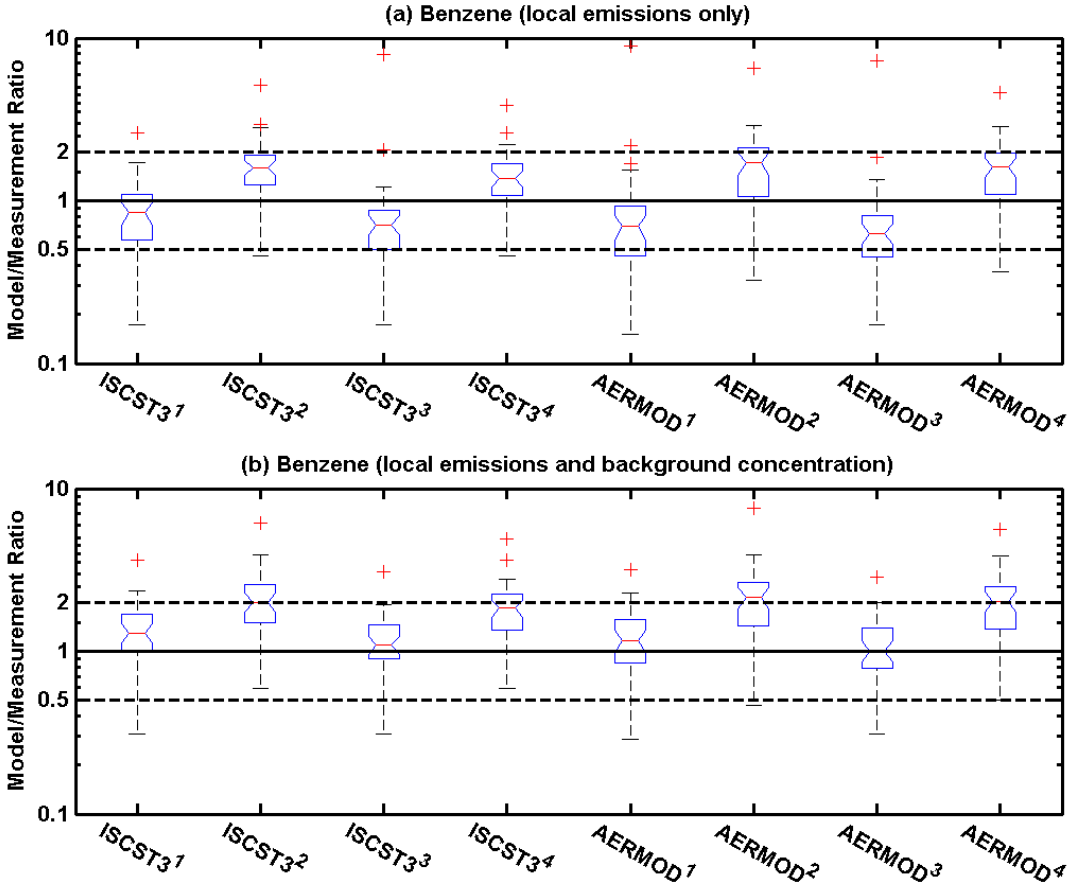


Figure E-30. Comparison of box-plots for the model-to-measurement ratios of Benzene ambient concentrations, where the model predictions based on (a) only the local emissions and (b) local emissions and background concentration of the 8 sensitivity runs (see Table 1 for the details of emissions and meteorology inputs for each run) were compared with measurements at the monitoring site of MDL1 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

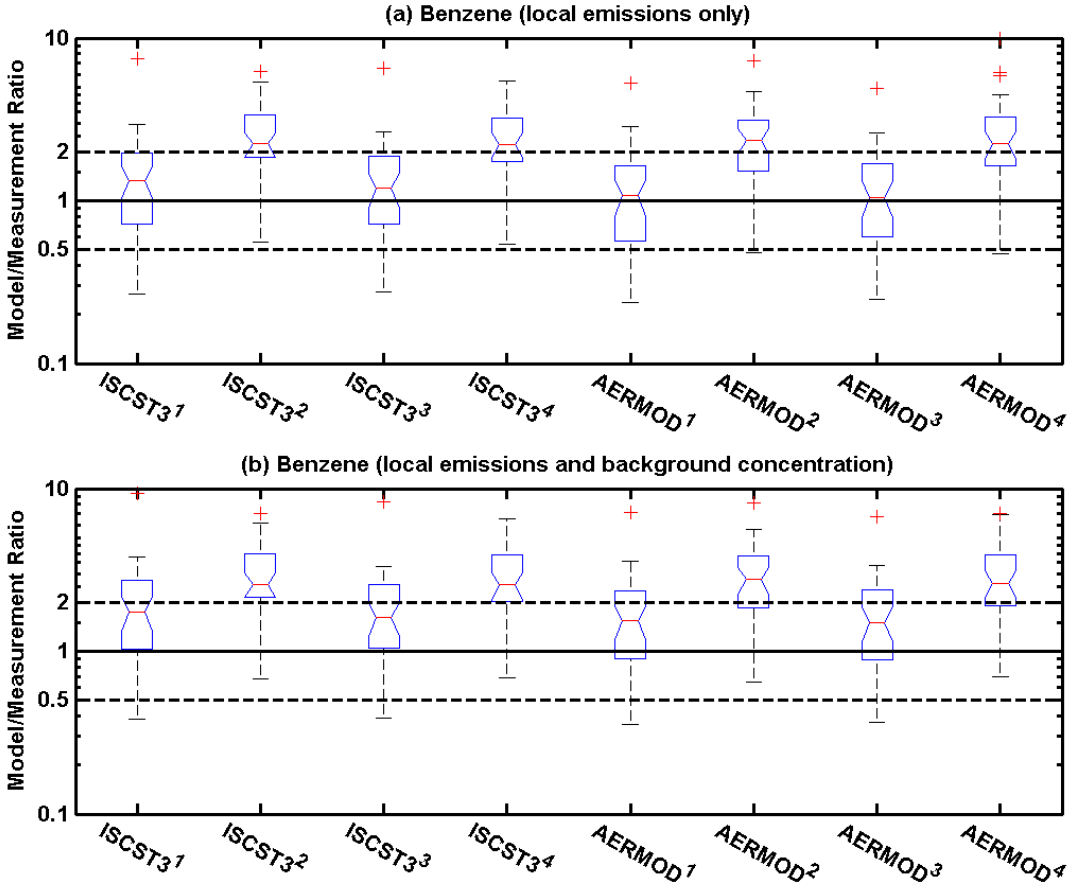


Figure E-31. Comparison of box-plots for the model-to-measurement ratios of Benzene ambient concentrations, where the model predictions based on (a) only the local emissions and (b) local emissions and background concentration of the 8 sensitivity runs (see Table 1 for the details of emissions and meteorology inputs for each run) were compared with measurements at the monitoring site of MDL2 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

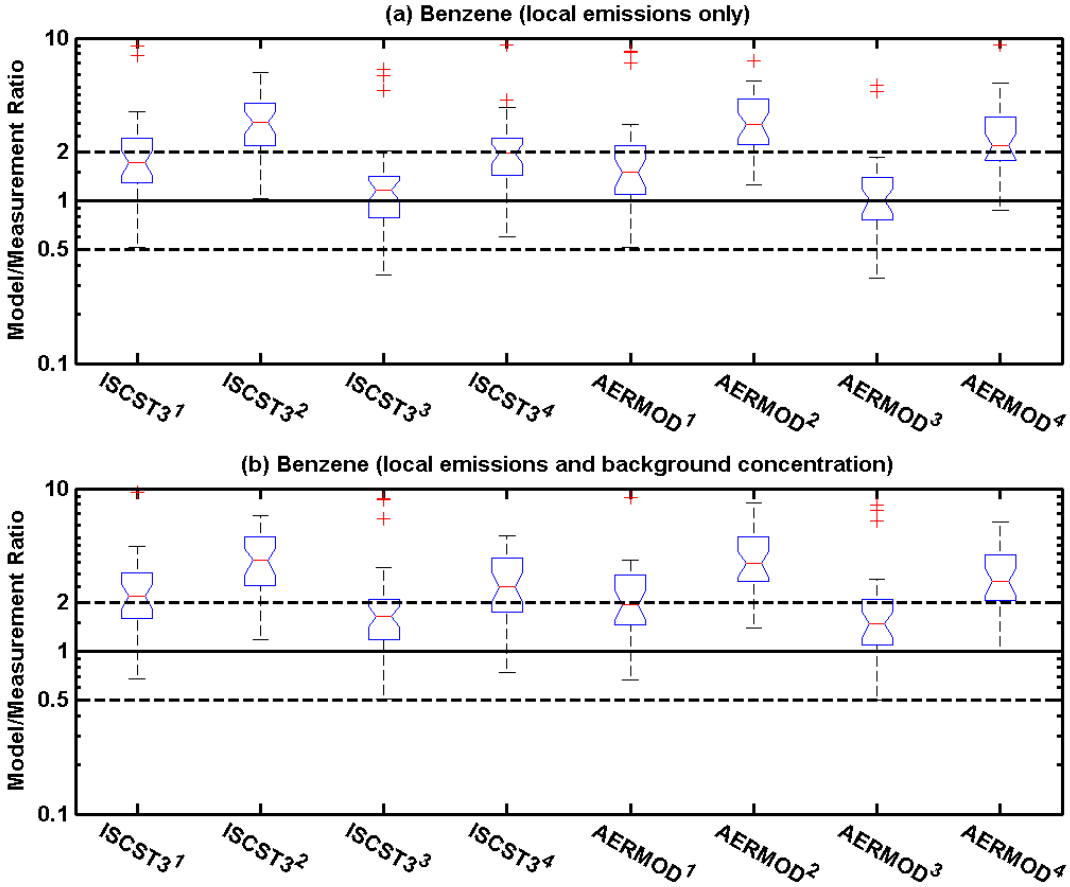


Figure E-32. Comparison of box-plots for the model-to-measurement ratios of Benzene ambient concentrations, where the model predictions based on (a) only the local emissions and (b) local emissions and background concentration of the 8 sensitivity runs (see Table 1 for the details of emissions and meteorology inputs for each run) were compared with measurements at the monitoring site of MDL3 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

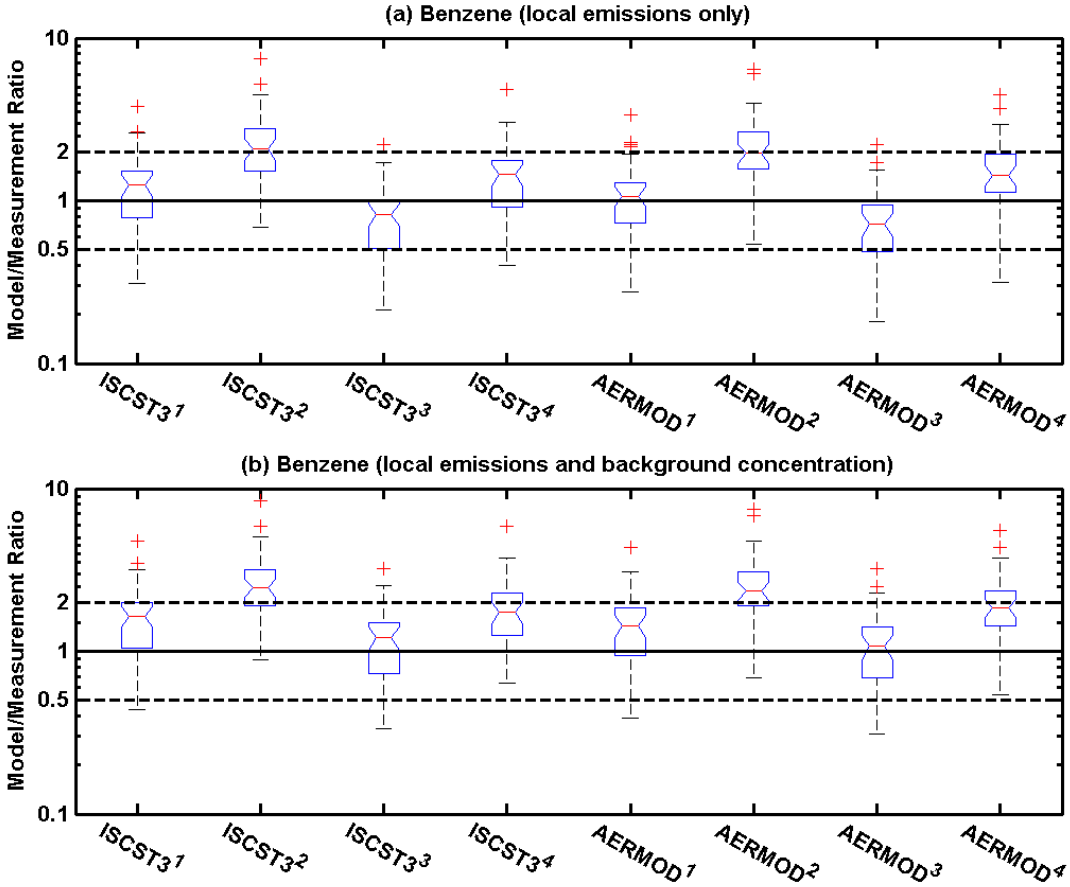


Figure E-33. Comparison of box-plots for the model-to-measurement ratios of Benzene ambient concentrations, where the model predictions based on (a) only the local emissions and (b) local emissions and background concentration of the 8 sensitivity runs (see Table 1 for the details of emissions and meteorology inputs for each run) were compared with measurements at the monitoring site of MDL4 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

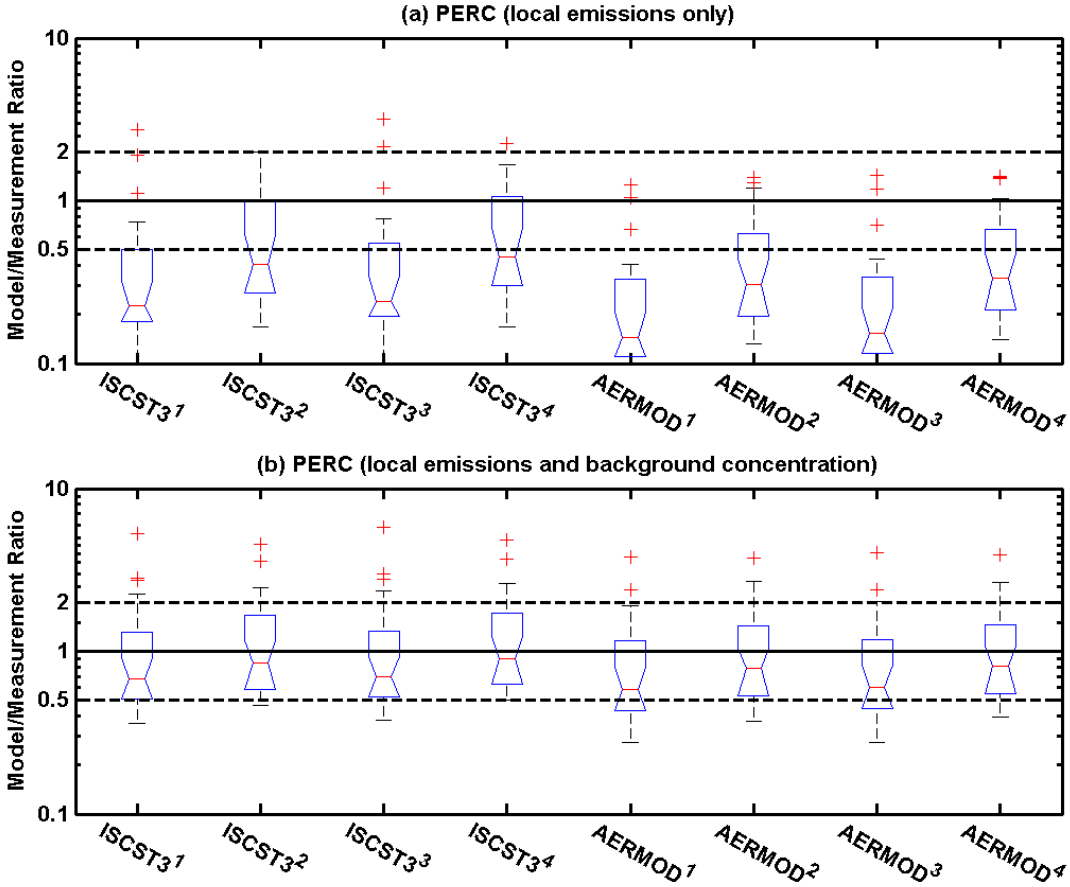


Figure E-34. Comparison of box-plots for the model-to-measurement ratios of PERC ambient concentrations, where the model predictions based on (a) only the local emissions and (b) local emissions and background concentration of the 8 sensitivity runs (see Table 1 for the details of emissions and meteorology inputs for each run) were compared with measurements at the monitoring site of MDL1 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

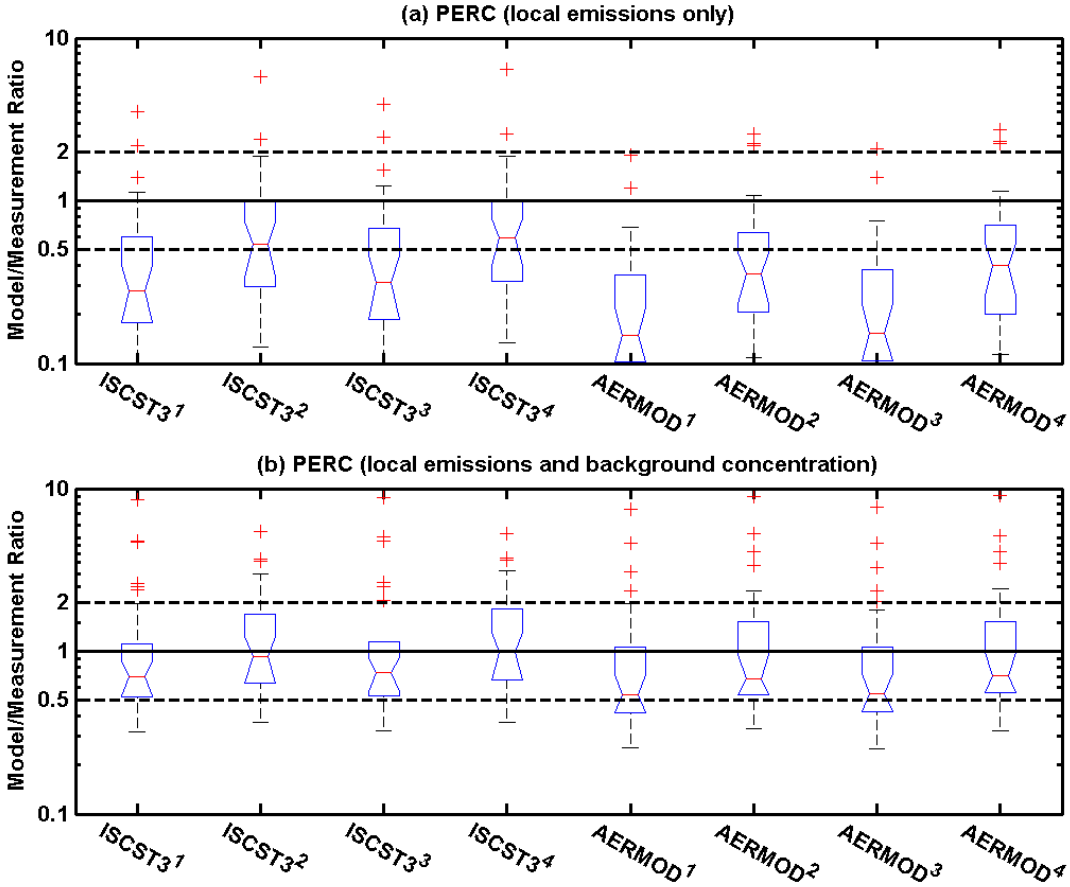


Figure E-35. Comparison of box-plots for the model-to-measurement ratios of PERC ambient concentrations, where the model predictions based on (a) only the local emissions and (b) local emissions and background concentration of the 8 sensitivity runs (see Table 1 for the details of emissions and meteorology inputs for each run) were compared with measurements at the monitoring site of MDL2 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

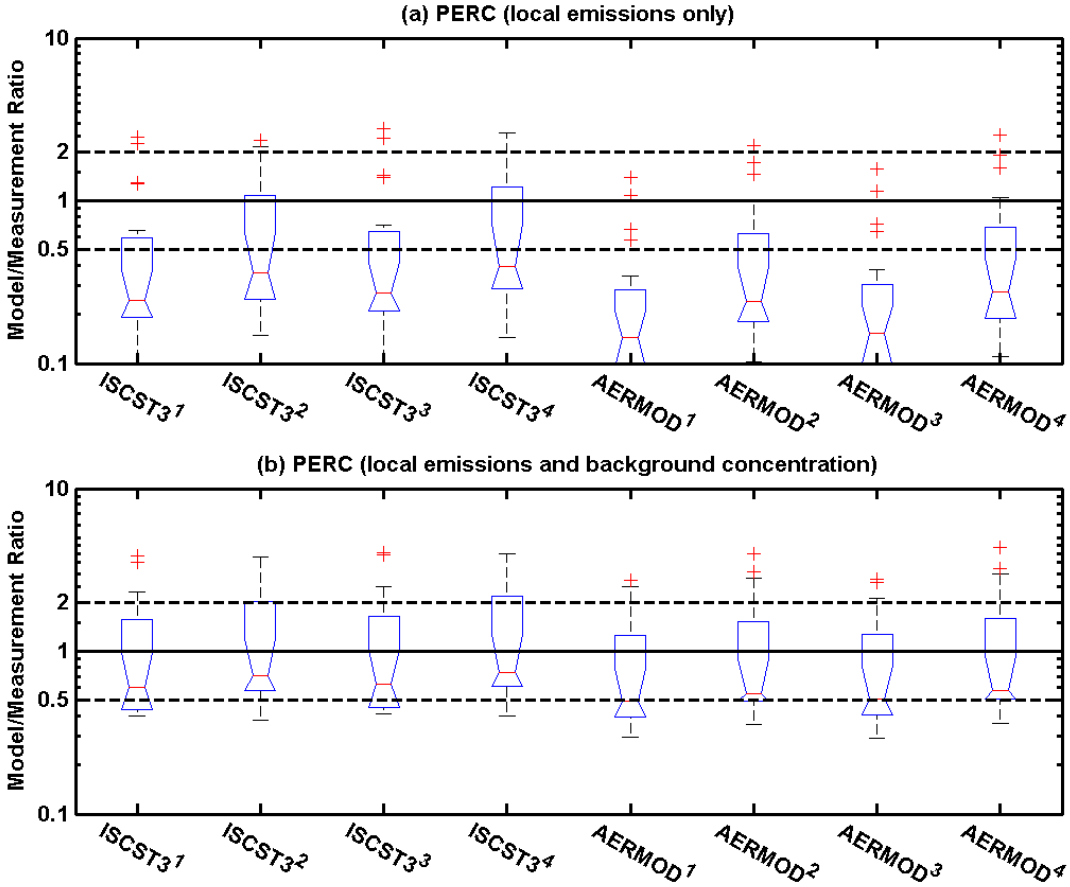


Figure E-36. Comparison of box-plots for the model-to-measurement ratios of PERC ambient concentrations, where the model predictions based on (a) only the local emissions and (b) local emissions and background concentration of the 8 sensitivity runs (see Table 1 for the details of emissions and meteorology inputs for each run) were compared with measurements at the monitoring site of MDL3 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

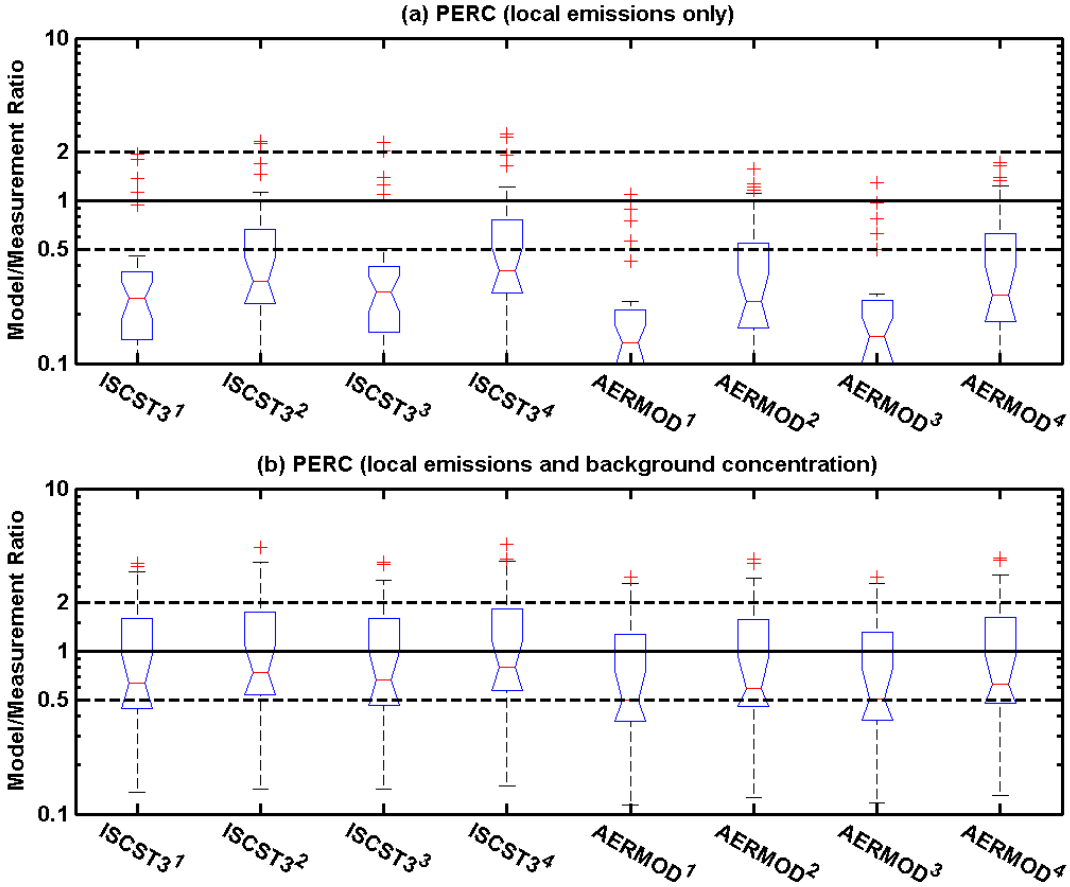


Figure E-37. Comparison of box-plots for the model-to-measurement ratios of PERC ambient concentrations, where the model predictions based on (a) only the local emissions and (b) local emissions and background concentration of the 8 sensitivity runs (see Table 1 for the details of emissions and meteorology inputs for each run) were compared with measurements at the monitoring site of MDL4 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

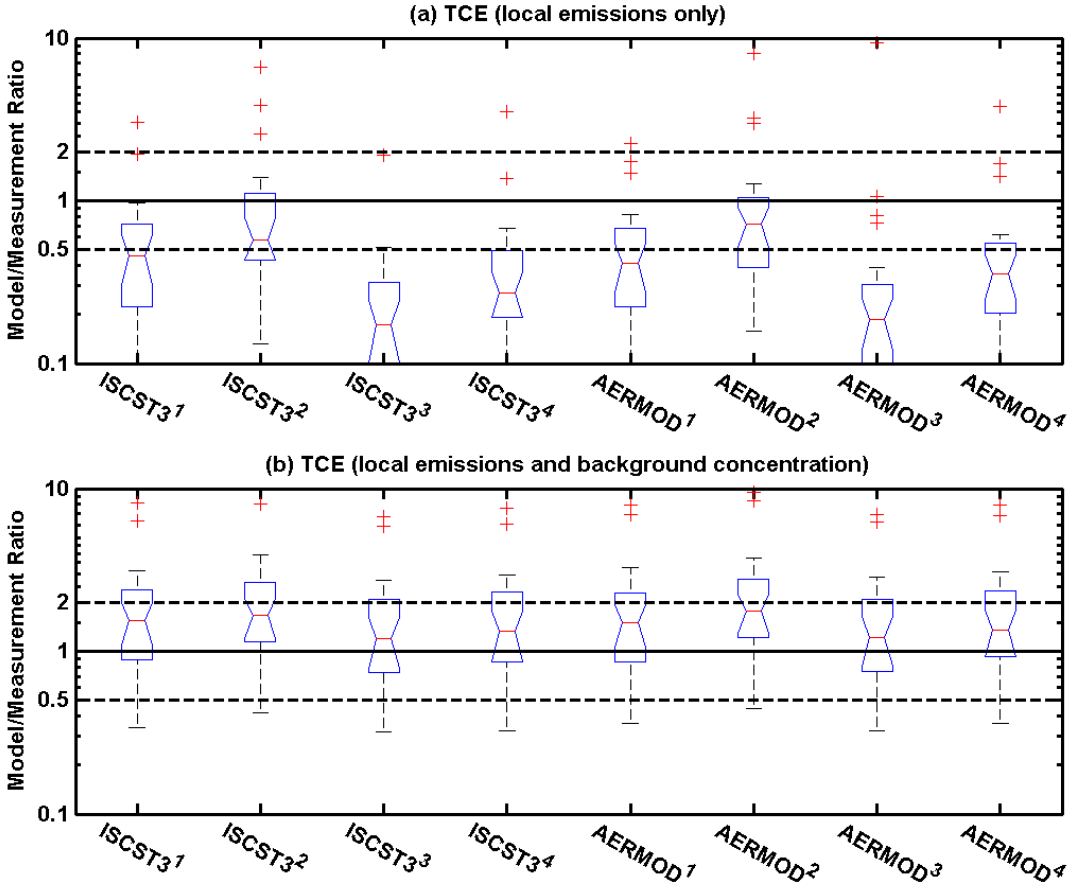


Figure E-38. Comparison of box-plots for the model-to-measurement ratios of TCE ambient concentrations, where the model predictions based on (a) only the local emissions and (b) local emissions and background concentration of the 8 sensitivity runs (see Table 1 for the details of emissions and meteorology inputs for each run) were compared with measurements at the monitoring site of MDL1 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

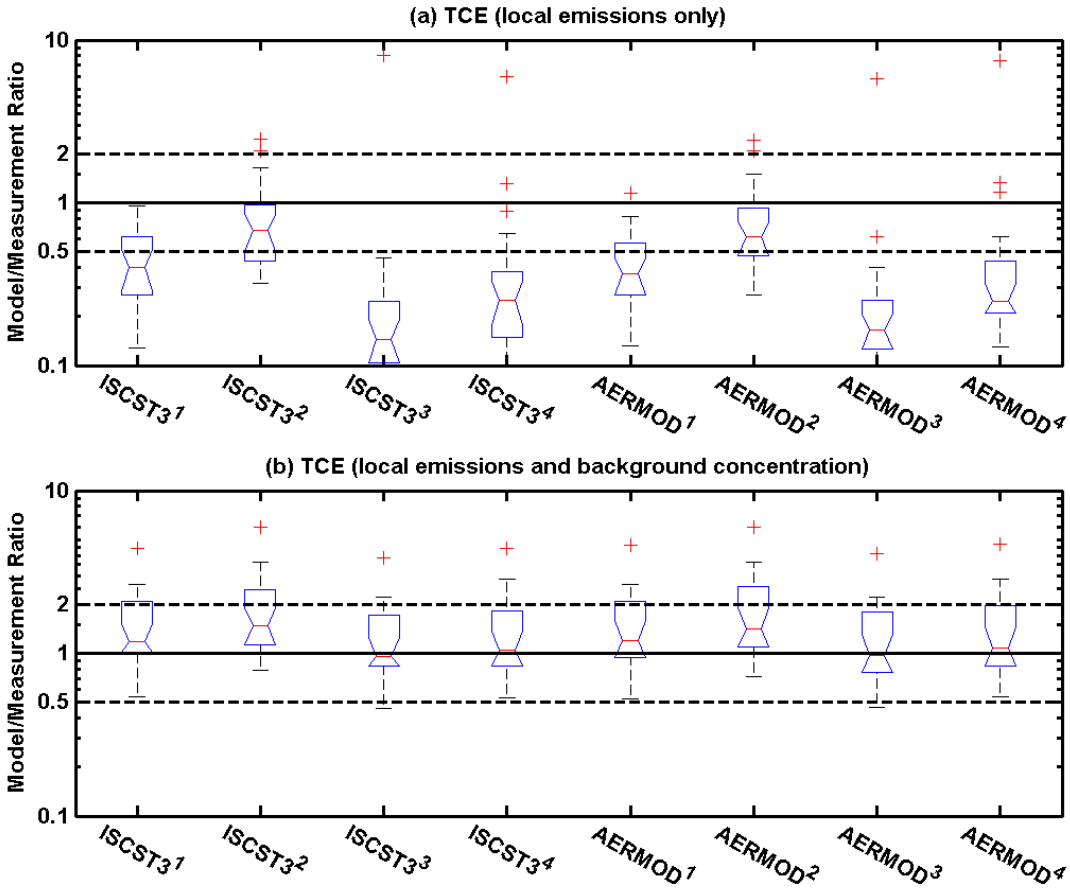


Figure E-39. Comparison of box-plots for the model-to-measurement ratios of TCE ambient concentrations, where the model predictions based on (a) only the local emissions and (b) local emissions and background concentration of the 8 sensitivity runs (see Table 1 for the details of emissions and meteorology inputs for each run) were compared with measurements at the monitoring site of MDL2 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

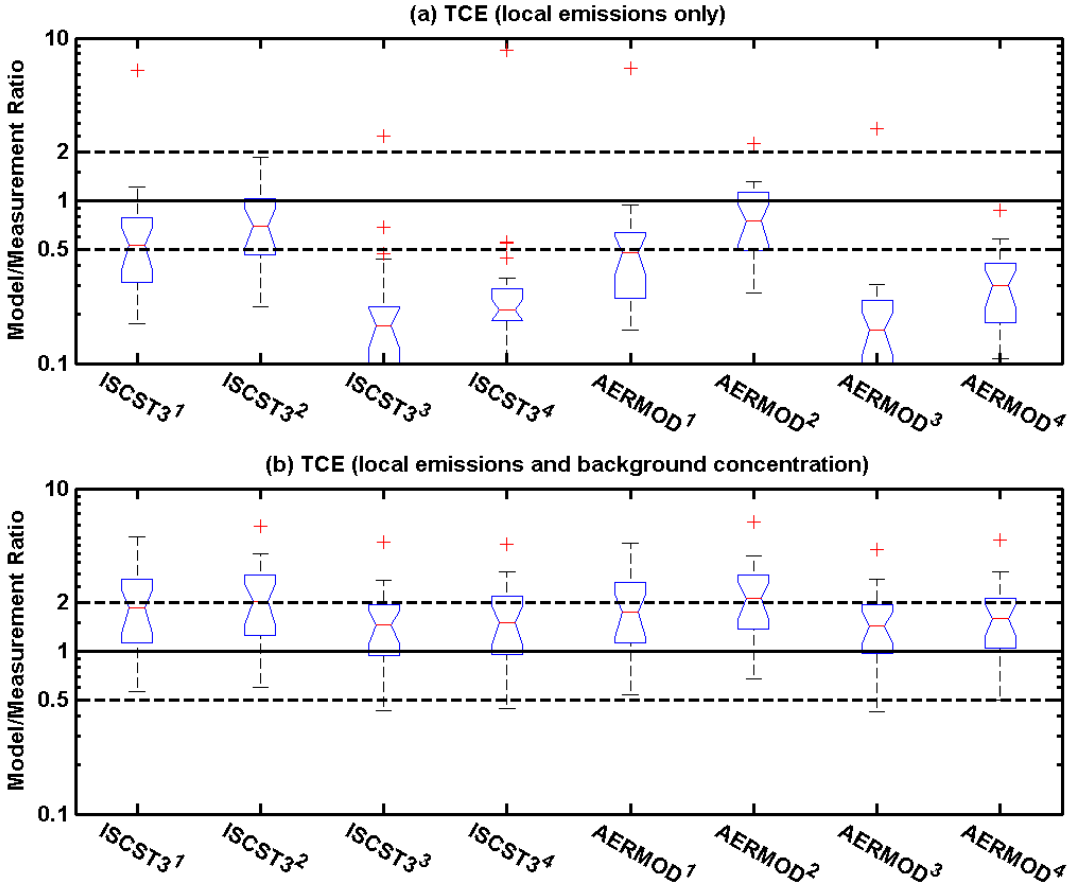


Figure E-40. Comparison of box-plots for the model-to-measurement ratios of TCE ambient concentrations, where the model predictions based on (a) only the local emissions and (b) local emissions and background concentration of the 8 sensitivity runs (see Table 1 for the details of emissions and meteorology inputs for each run) were compared with measurements at the monitoring site of MDL3 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

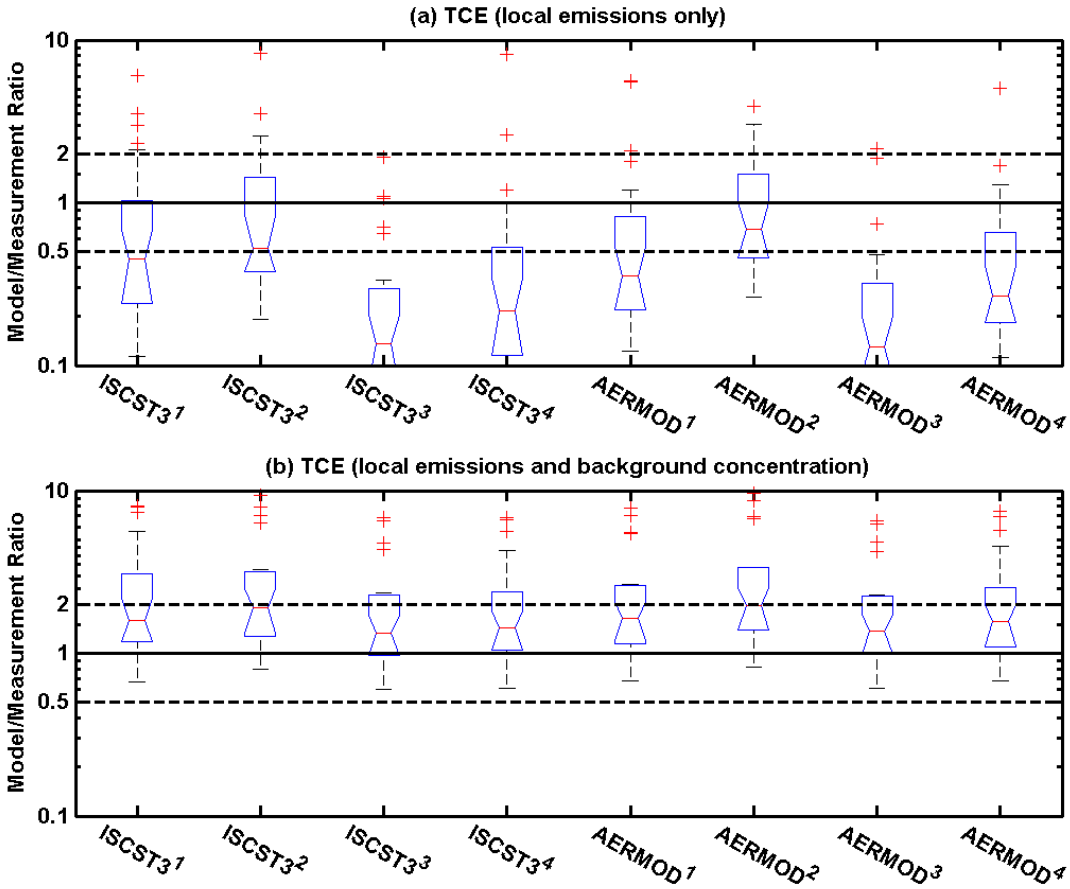


Figure E-41. Comparison of box-plots for the model-to-measurement ratios of TCE ambient concentrations, where the model predictions based on (a) only the local emissions and (b) local emissions and background concentration of the 8 sensitivity runs (see Table 1 for the details of emissions and meteorology inputs for each run) were compared with measurements at the monitoring site of MDL4 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

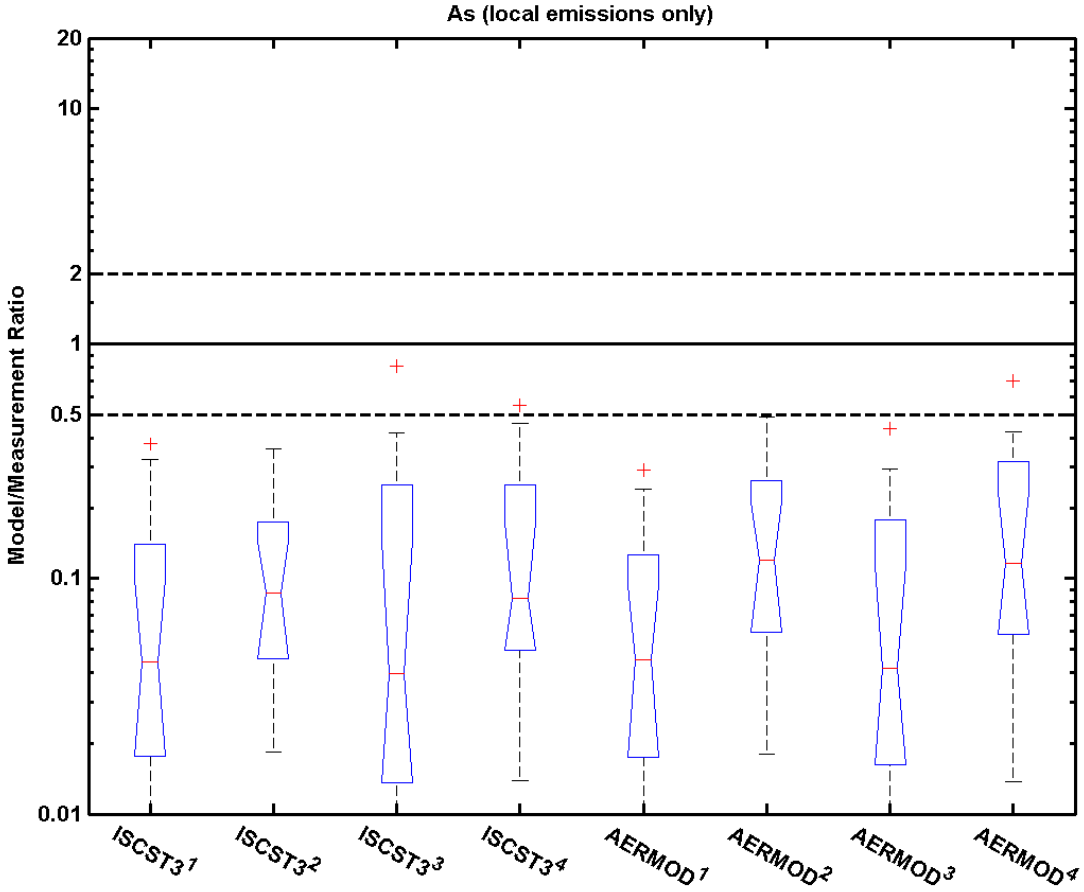


Figure E-42. Comparison of box-plots for the model-to-measurement ratios of Arsenic (fine PM) ambient concentrations, where the model predictions based on only the local emissions of the 8 sensitivity runs (see Table 1 for the details of emissions and meteorology inputs for each run) were compared with measurements at the monitoring site of MDL1 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

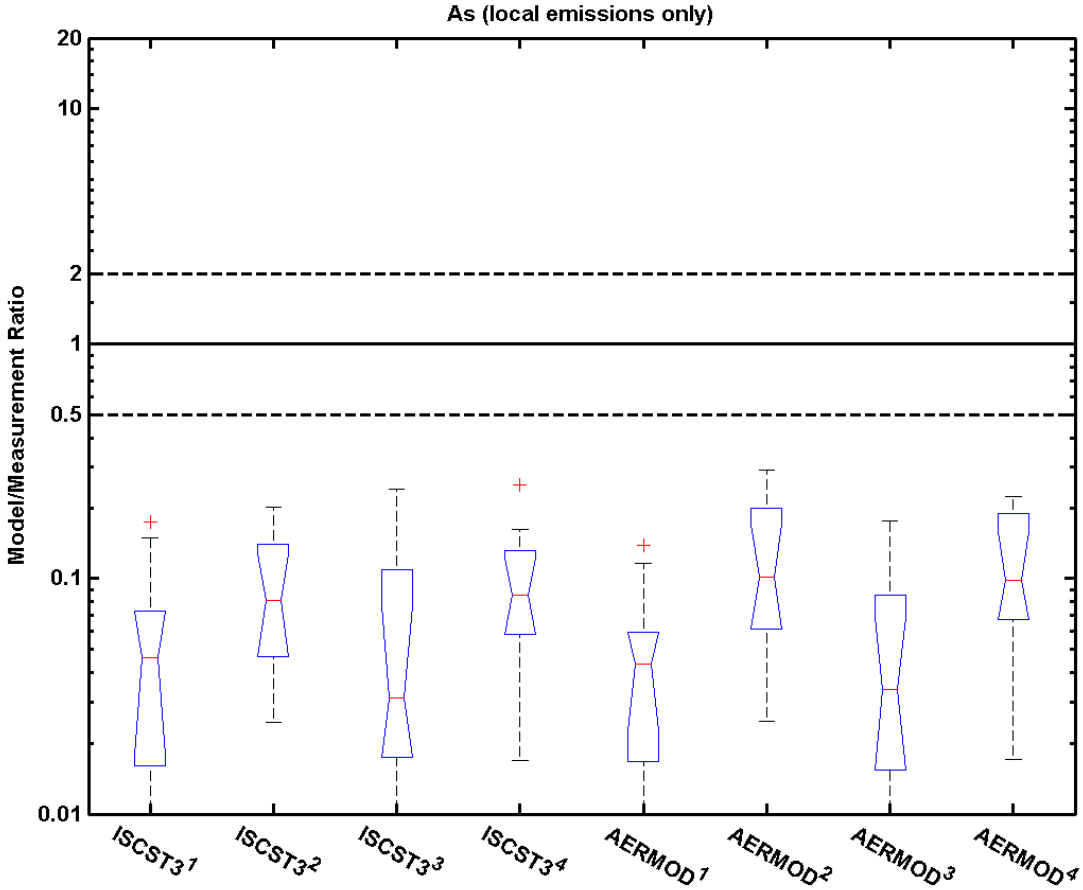


Figure E-43. Comparison of box-plots for the model-to-measurement ratios of Arsenic (fine PM) ambient concentrations, where the model predictions based on only the local emissions of the 8 sensitivity runs (see Table 1 for the details of emissions and meteorology inputs for each run) were compared with measurements at the monitoring site of MDL2 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

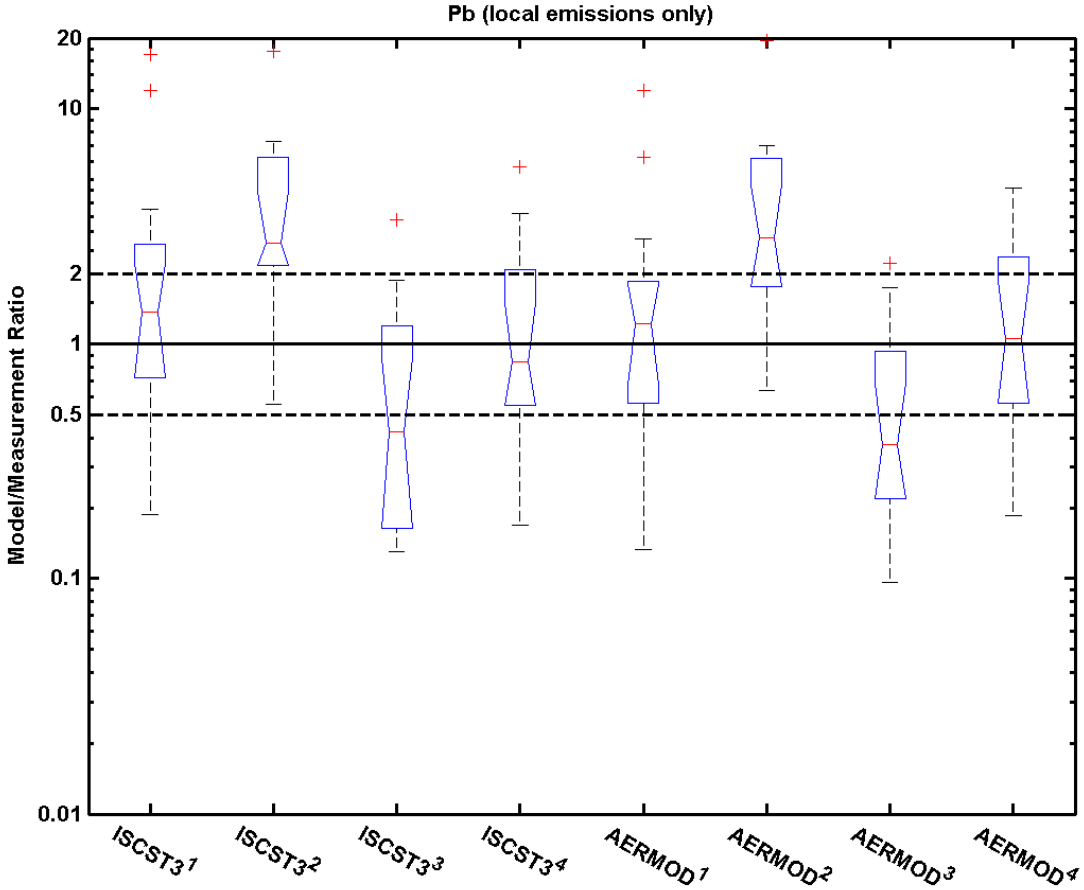


Figure E-44. Comparison of box-plots for the model-to-measurement ratios of Lead (fine PM) ambient concentrations, where the model predictions based on only the local emissions of the 8 sensitivity runs (see Table 1 for the details of emissions and meteorology inputs for each run) were compared with measurements at the monitoring site of MDL1 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

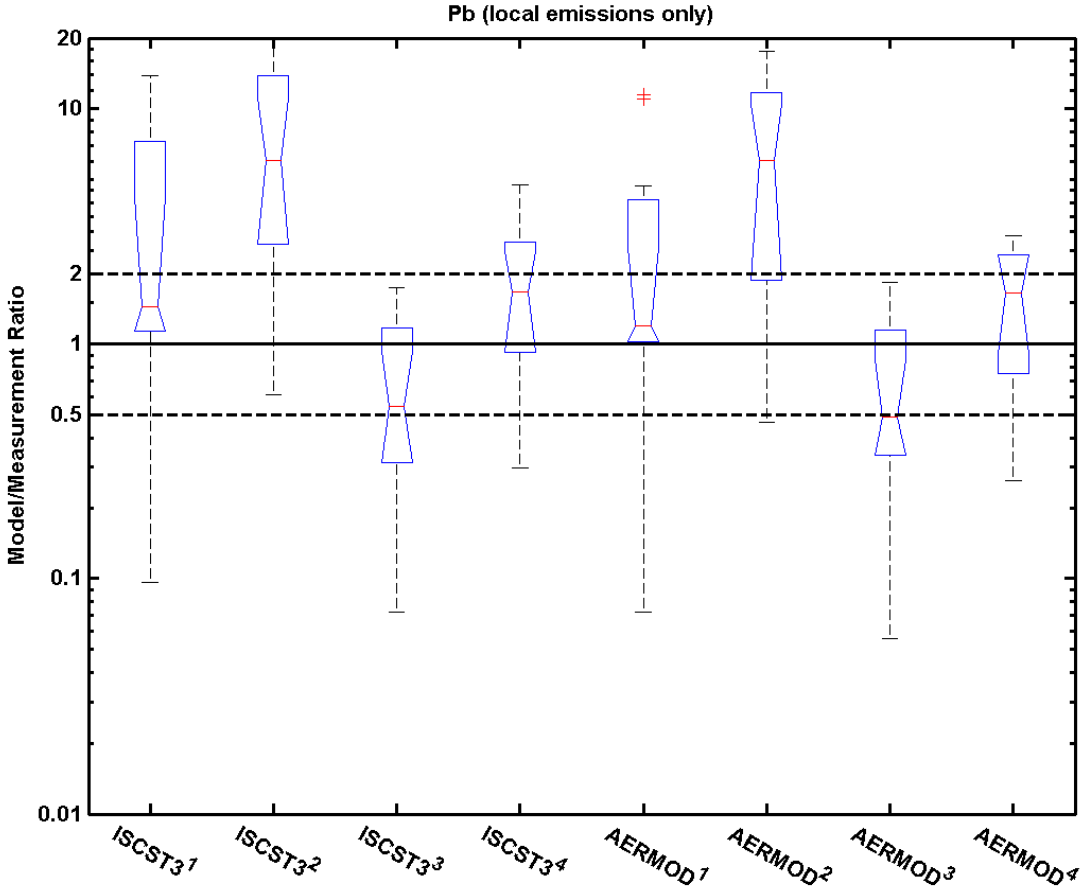


Figure E-45. Comparison of box-plots for the model-to-measurement ratios of Lead (fine PM) ambient concentrations, where the model predictions based on only the local emissions of the 8 sensitivity runs (see Table 1 for the details of emissions and meteorology inputs for each run) were compared with measurements at the monitoring site of MDL2 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

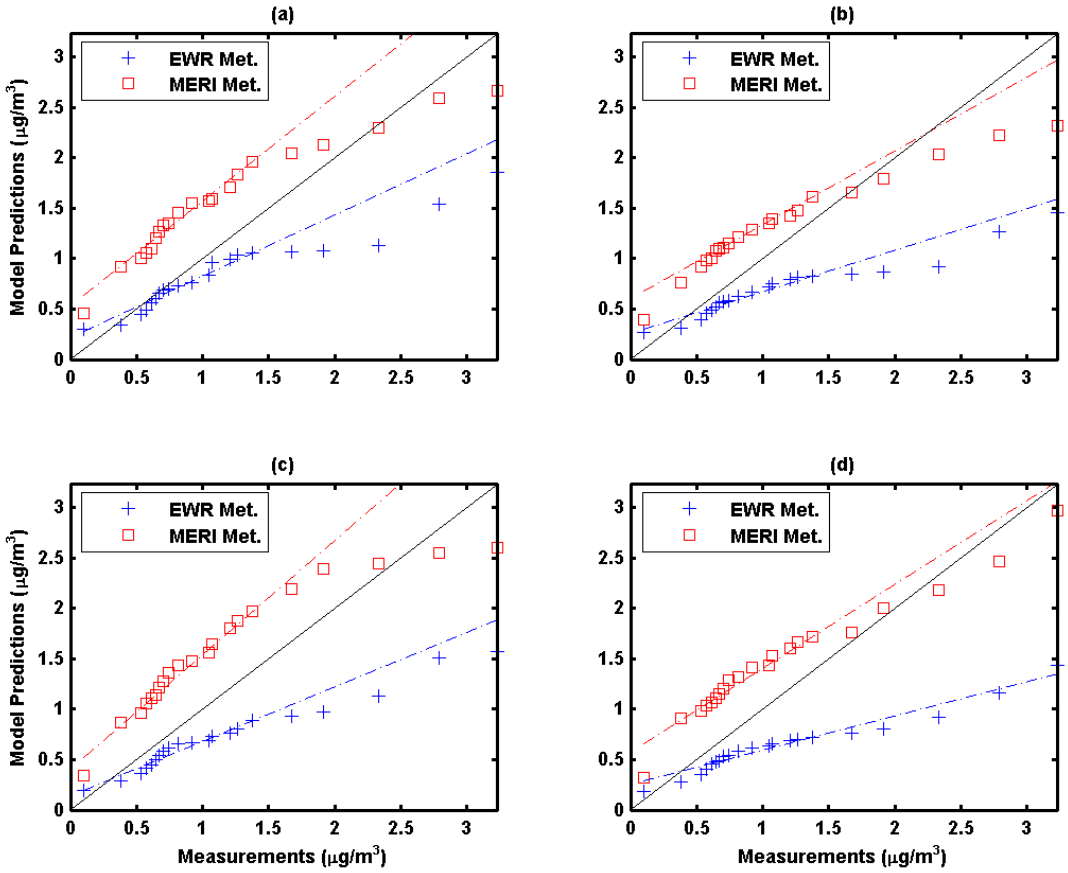


Figure E-46. Comparison of Q-Q plots of model predictions of Benzene ambient concentrations with two different meteorology inputs (Newark Airport (EWR) data versus MERI data), while the other modeling options were based on (a) ISCST3 and NEI-1999 emissions, (b) ISCST3 and NEI-2002 emissions, (c) AERMOD and NEI-1999 emissions, and (d) AERMOD and NEI-2002 emissions, against measurements at the monitoring site of MDL1 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

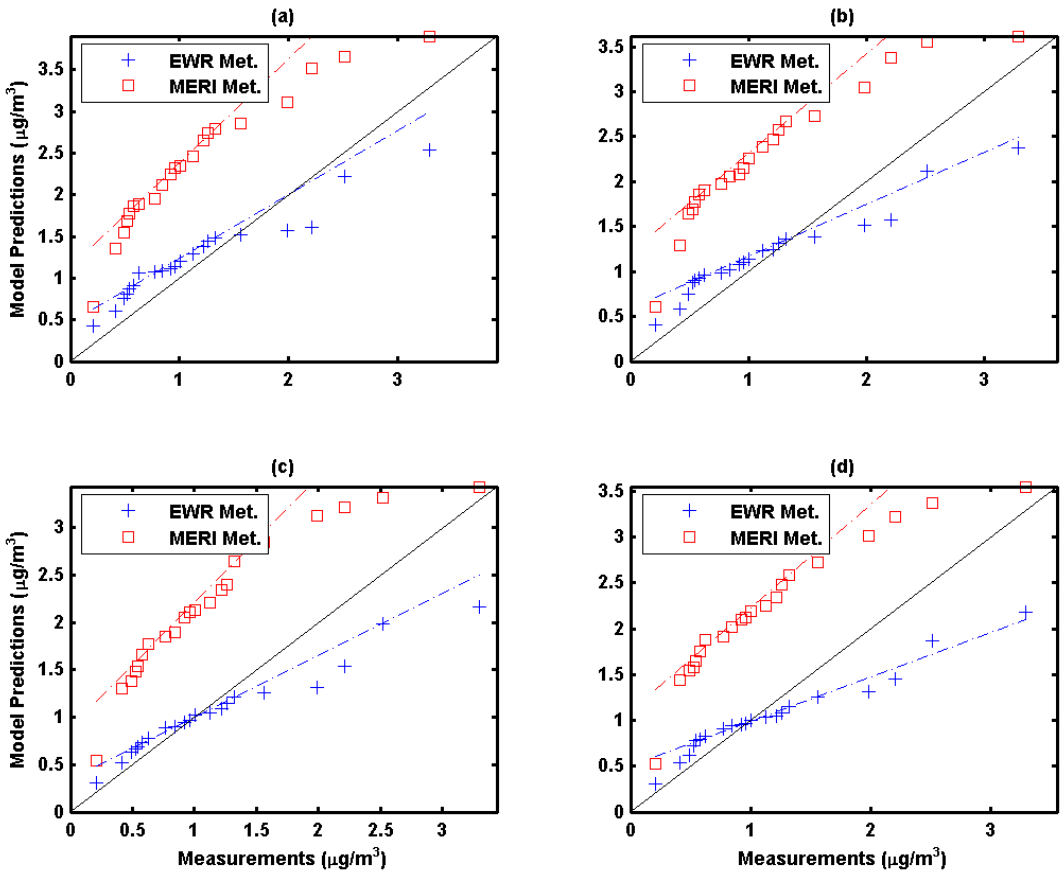


Figure E-47. Comparison of Q-Q plots of model predictions of Benzene ambient concentrations with two different meteorology inputs (Newark Airport (EWR) data versus MERI data), while the other modeling options were based on (a) ISCST3 and NEI-1999 emissions, (b) ISCST3 and NEI-2002 emissions, (c) AERMOD and NEI-1999 emissions, and (d) AERMOD and NEI-2002 emissions, against measurements at the monitoring site of MDL2 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

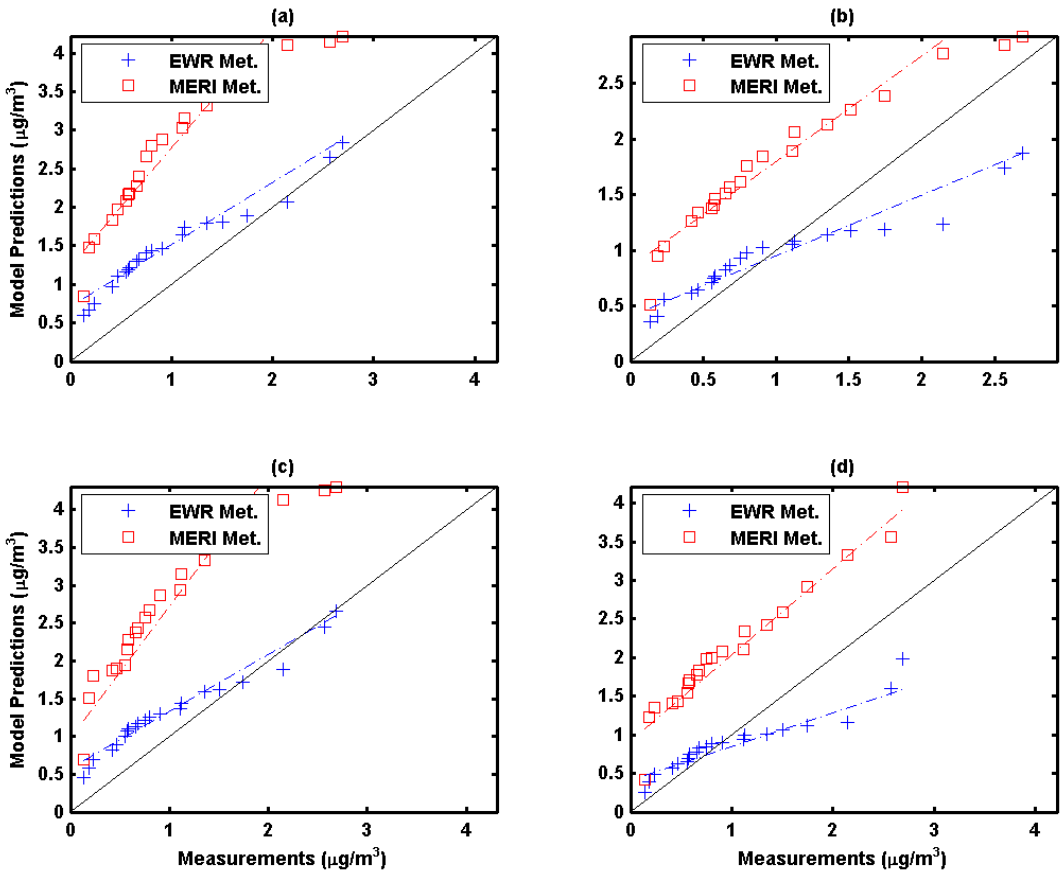


Figure E-48. Comparison of Q-Q plots of model predictions of Benzene ambient concentrations with two different meteorology inputs (Newark Airport (EWR) data versus MERI data), while the other modeling options were based on (a) ISCST3 and NEI-1999 emissions, (b) ISCST3 and NEI-2002 emissions, (c) AERMOD and NEI-1999 emissions, and (d) AERMOD and NEI-2002 emissions, against measurements at the monitoring site of MDL3 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

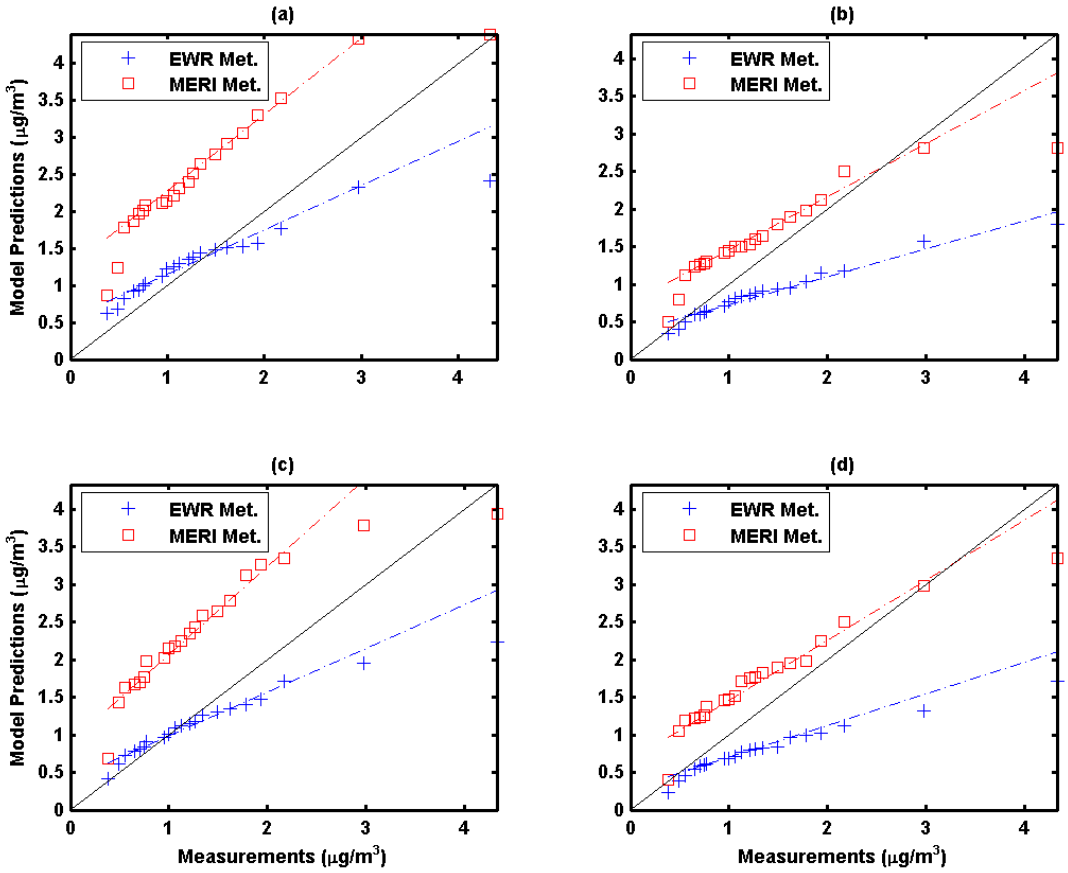


Figure E-49. Comparison of Q-Q plots of model predictions of Benzene ambient concentrations with two different meteorology inputs (Newark Airport (EWR) data versus MERI data), while the other modeling options were based on (a) ISCST3 and NEI-1999 emissions, (b) ISCST3 and NEI-2002 emissions, (c) AERMOD and NEI-1999 emissions, and (d) AERMOD and NEI-2002 emissions, against measurements at the monitoring site of MDL4 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

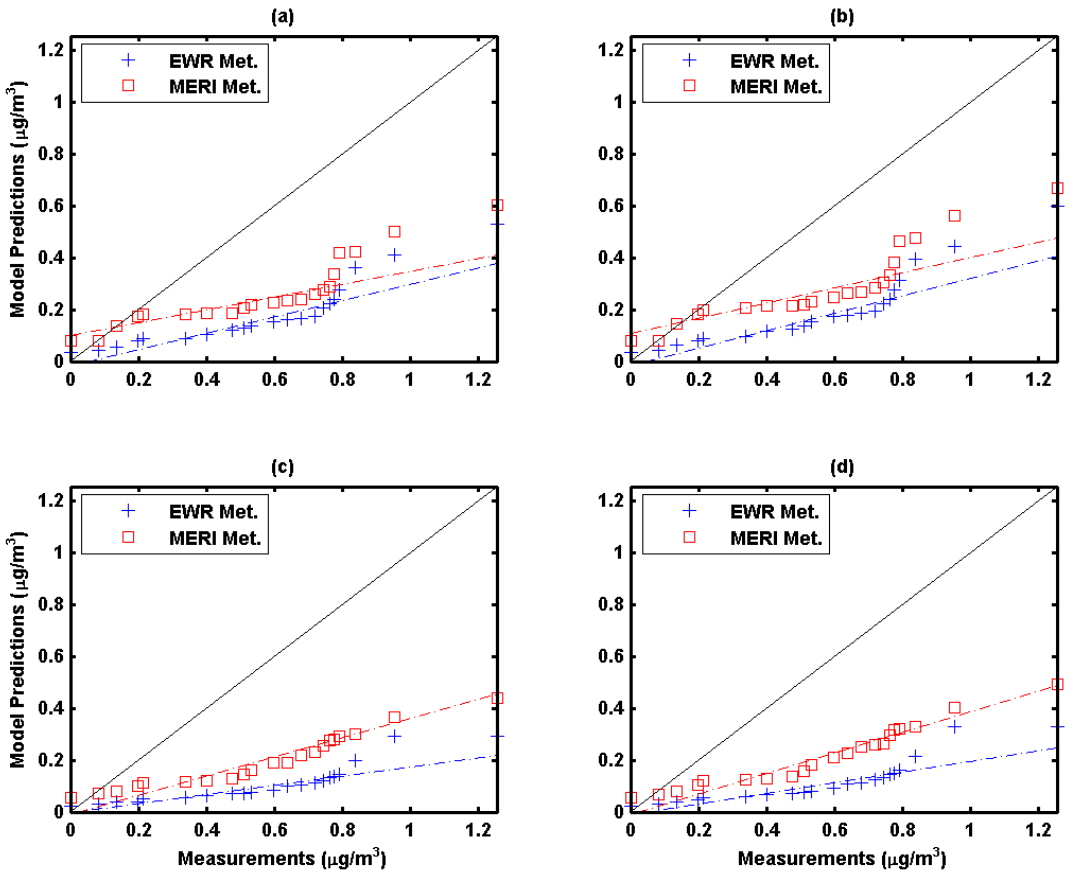


Figure E-50. Comparison of Q-Q plots of model predictions of PERC ambient concentrations with two different meteorology inputs (Newark Airport (EWR) data versus MERI data), while the other modeling options were based on (a) ISCST3 and NEI-1999 emissions, (b) ISCST3 and NEI-2002 emissions, (c) AERMOD and NEI-1999 emissions, and (d) AERMOD and NEI-2002 emissions, against measurements at the monitoring site of MDL1 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

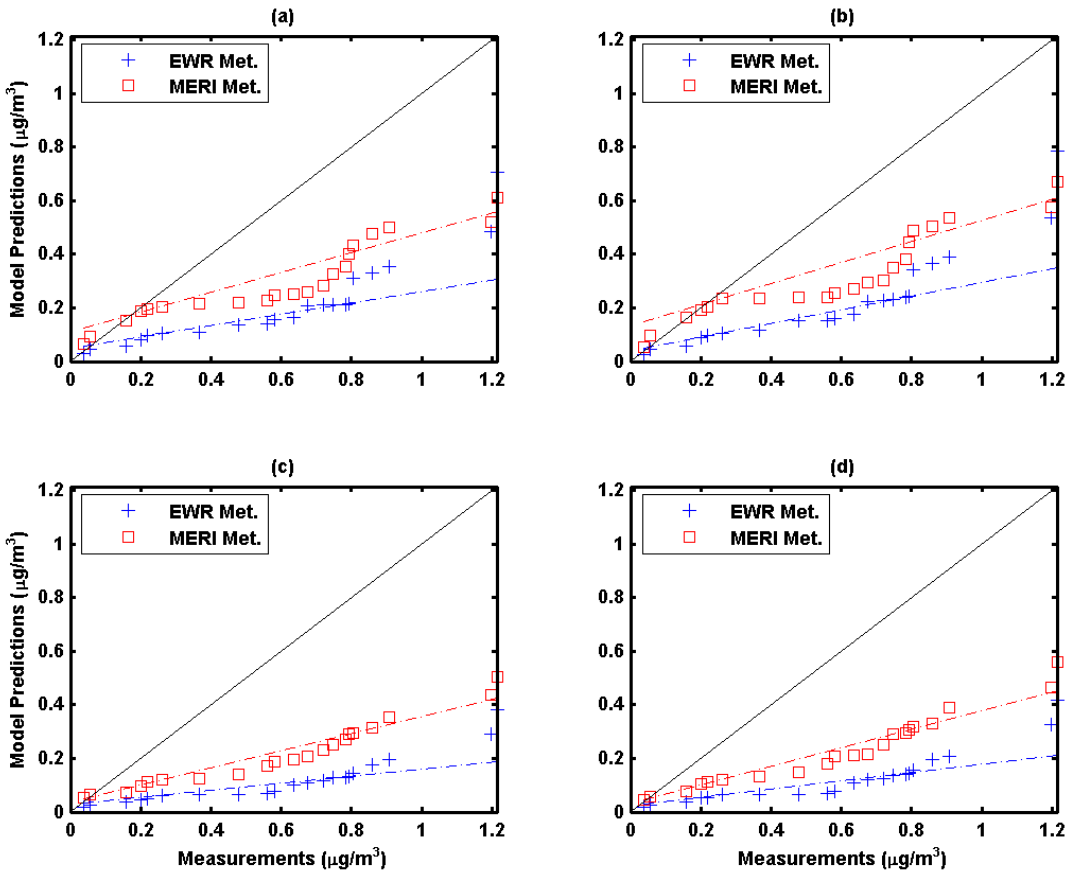


Figure E-51. Comparison of Q-Q plots of model predictions of PERC ambient concentrations with two different meteorology inputs (Newark Airport (EWR) data versus MERI data), while the other modeling options were based on (a) ISCST3 and NEI-1999 emissions, (b) ISCST3 and NEI-2002 emissions, (c) AERMOD and NEI-1999 emissions, and (d) AERMOD and NEI-2002 emissions, against measurements at the monitoring site of MDL2 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

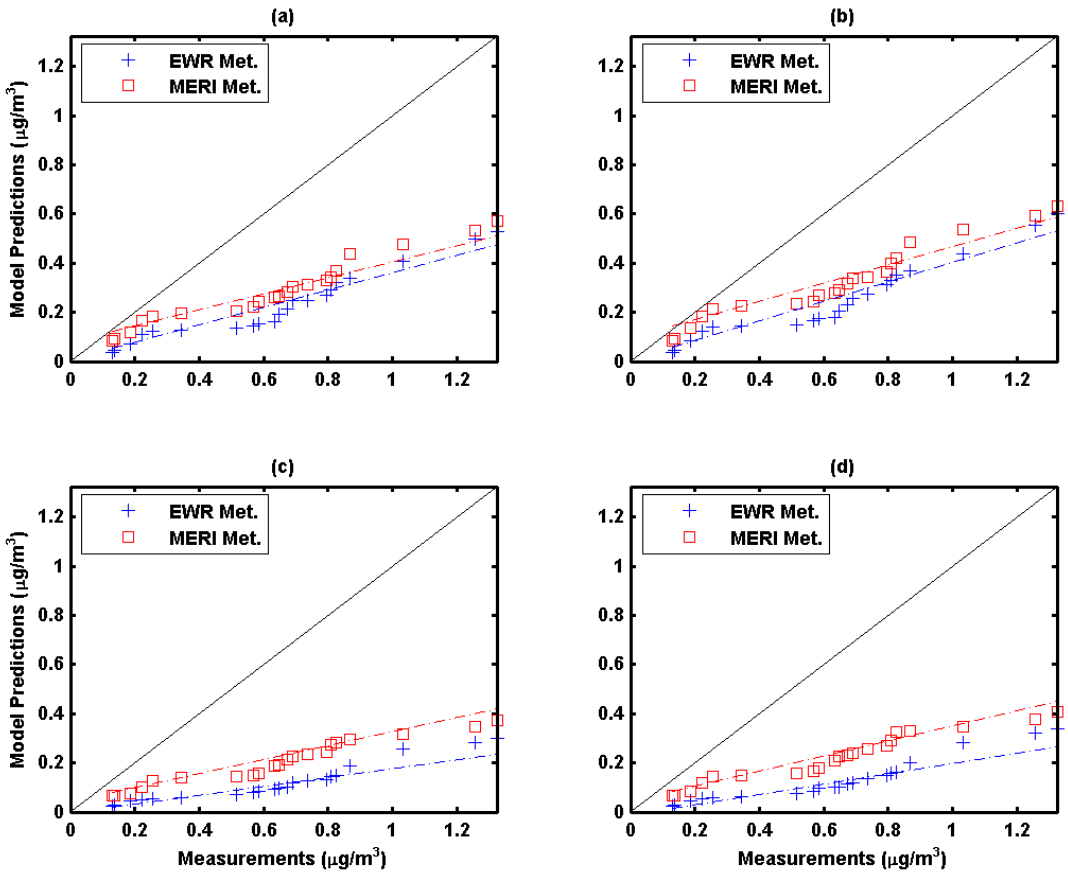


Figure E-52. Comparison of Q-Q plots of model predictions of PERC ambient concentrations with two different meteorology inputs (Newark Airport (EWR) data versus MERI data), while the other modeling options were based on (a) ISCST3 and NEI-1999 emissions, (b) ISCST3 and NEI-2002 emissions, (c) AERMOD and NEI-1999 emissions, and (d) AERMOD and NEI-2002 emissions, against measurements at the monitoring site of MDL3 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

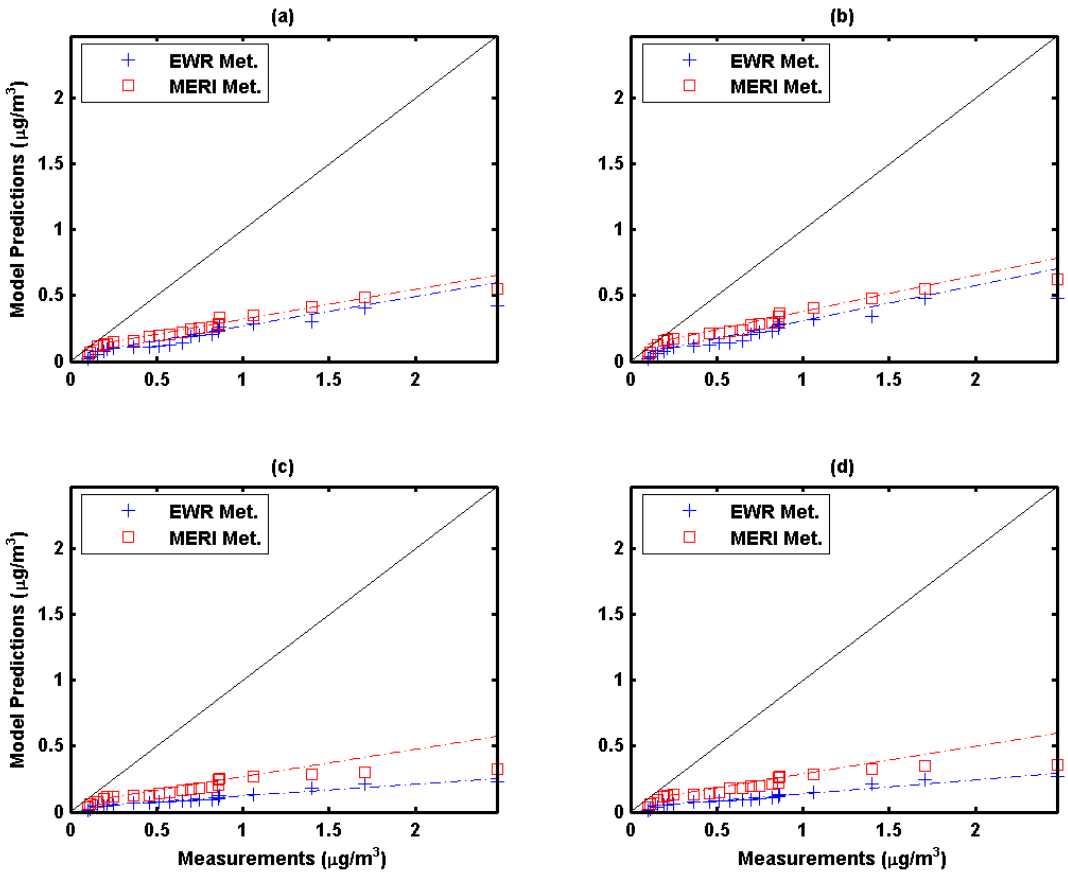


Figure E-53. Comparison of Q-Q plots of model predictions of PERC ambient concentrations with two different meteorology inputs (Newark Airport (EWR) data versus MERI data), while the other modeling options were based on (a) ISCST3 and NEI-1999 emissions, (b) ISCST3 and NEI-2002 emissions, (c) AERMOD and NEI-1999 emissions, and (d) AERMOD and NEI-2002 emissions, against measurements at the monitoring site of MDL4 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

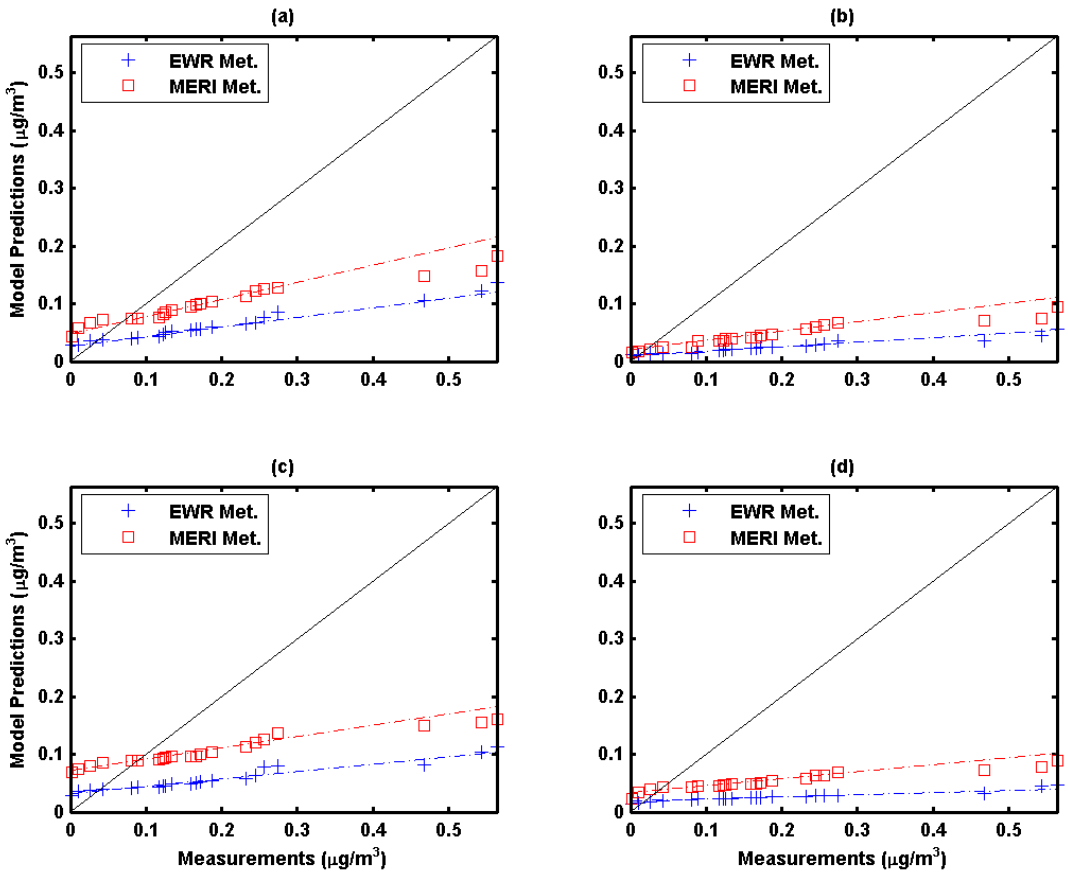


Figure E-54. Comparison of Q-Q plots of model predictions of TCE ambient concentrations with two different meteorology inputs (Newark Airport (EWR) data versus MERI data), while the other modeling options were based on (a) ISCST3 and NEI-1999 emissions, (b) ISCST3 and NEI-2002 emissions, (c) AERMOD and NEI-1999 emissions, and (d) AERMOD and NEI-2002 emissions, against measurements at the monitoring site of MDL1 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

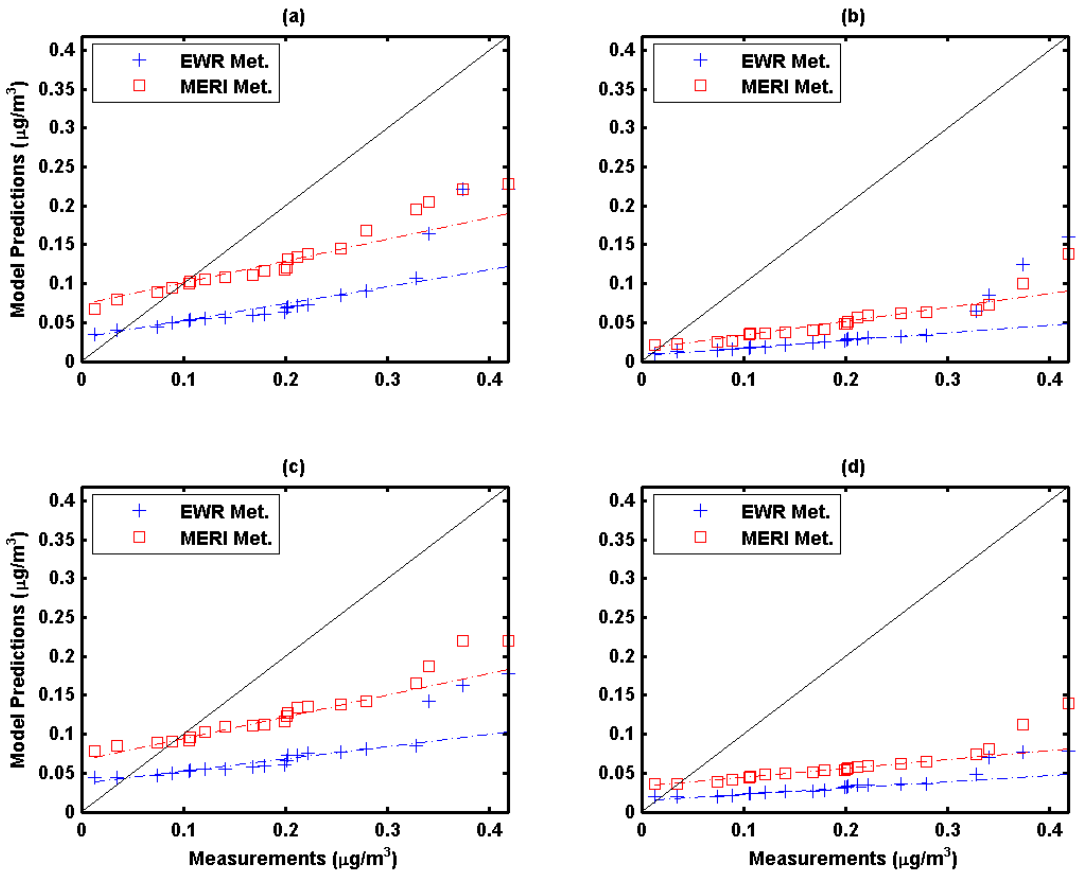


Figure E-55. Comparison of Q-Q plots of model predictions of TCE ambient concentrations with two different meteorology inputs (Newark Airport (EWR) data versus MERI data), while the other modeling options were based on (a) ISCST3 and NEI-1999 emissions, (b) ISCST3 and NEI-2002 emissions, (c) AERMOD and NEI-1999 emissions, and (d) AERMOD and NEI-2002 emissions, against measurements at the monitoring site of MDL2 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

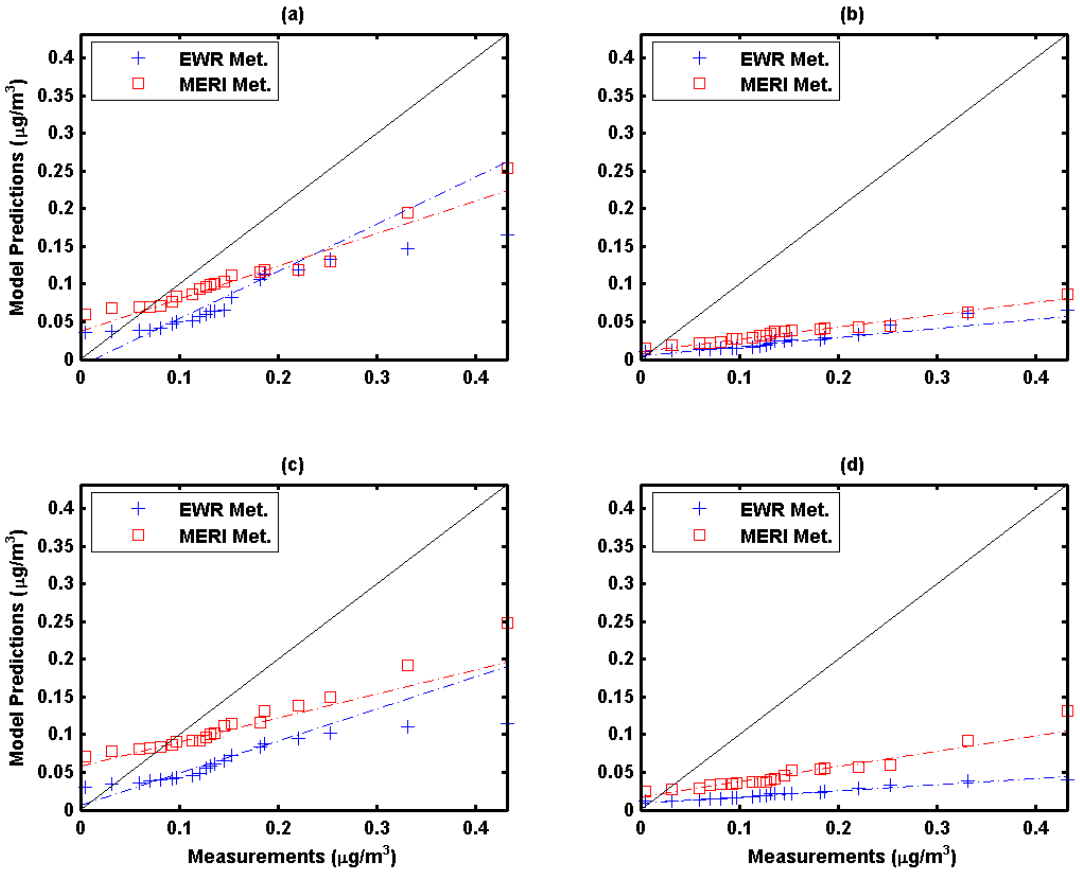


Figure E-56. Comparison of Q-Q plots of model predictions of TCE ambient concentrations with two different meteorology inputs (Newark Airport (EWR) data versus MERI data), while the other modeling options were based on (a) ISCST3 and NEI-1999 emissions, (b) ISCST3 and NEI-2002 emissions, (c) AERMOD and NEI-1999 emissions, and (d) AERMOD and NEI-2002 emissions, against measurements at the monitoring site of MDL3 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

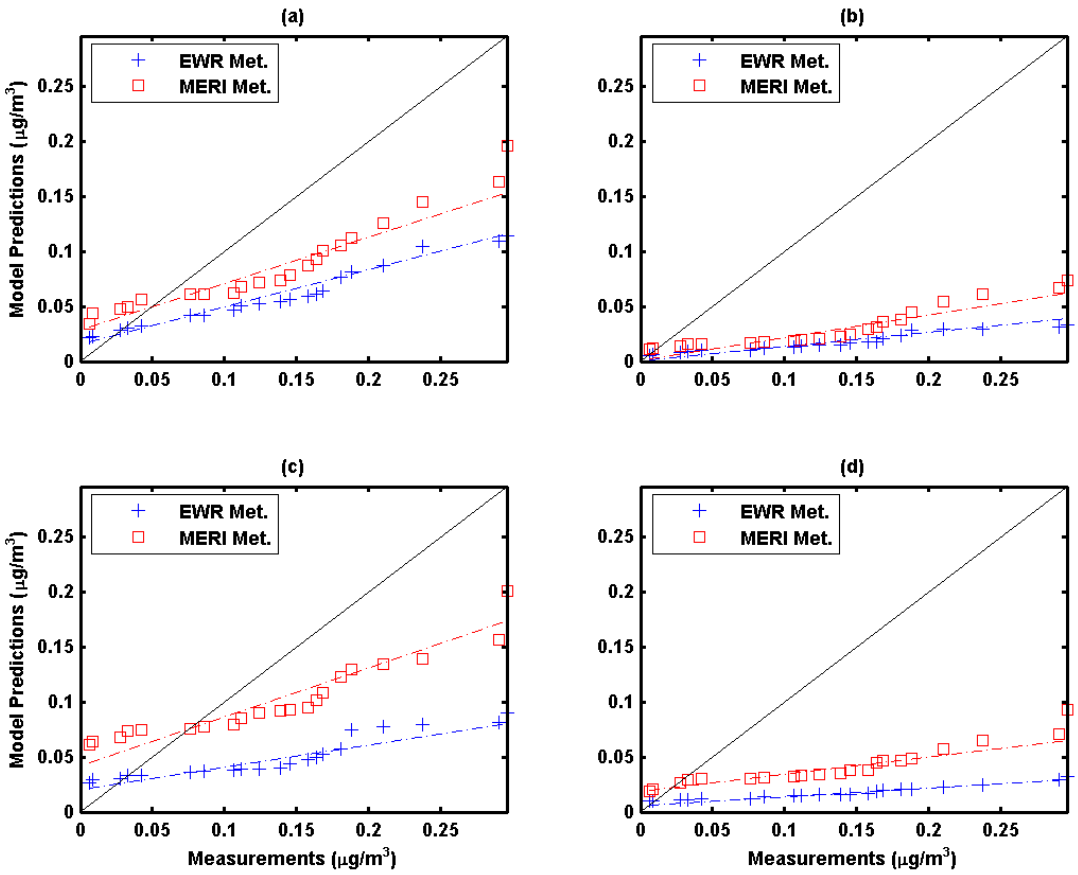


Figure E-57. Comparison of Q-Q plots of model predictions of TCE ambient concentrations with two different meteorology inputs (Newark Airport (EWR) data versus MERI data), while the other modeling options were based on (a) ISCST3 and NEI-1999 emissions, (b) ISCST3 and NEI-2002 emissions, (c) AERMOD and NEI-1999 emissions, and (d) AERMOD and NEI-2002 emissions, against measurements at the monitoring site of MDL4 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

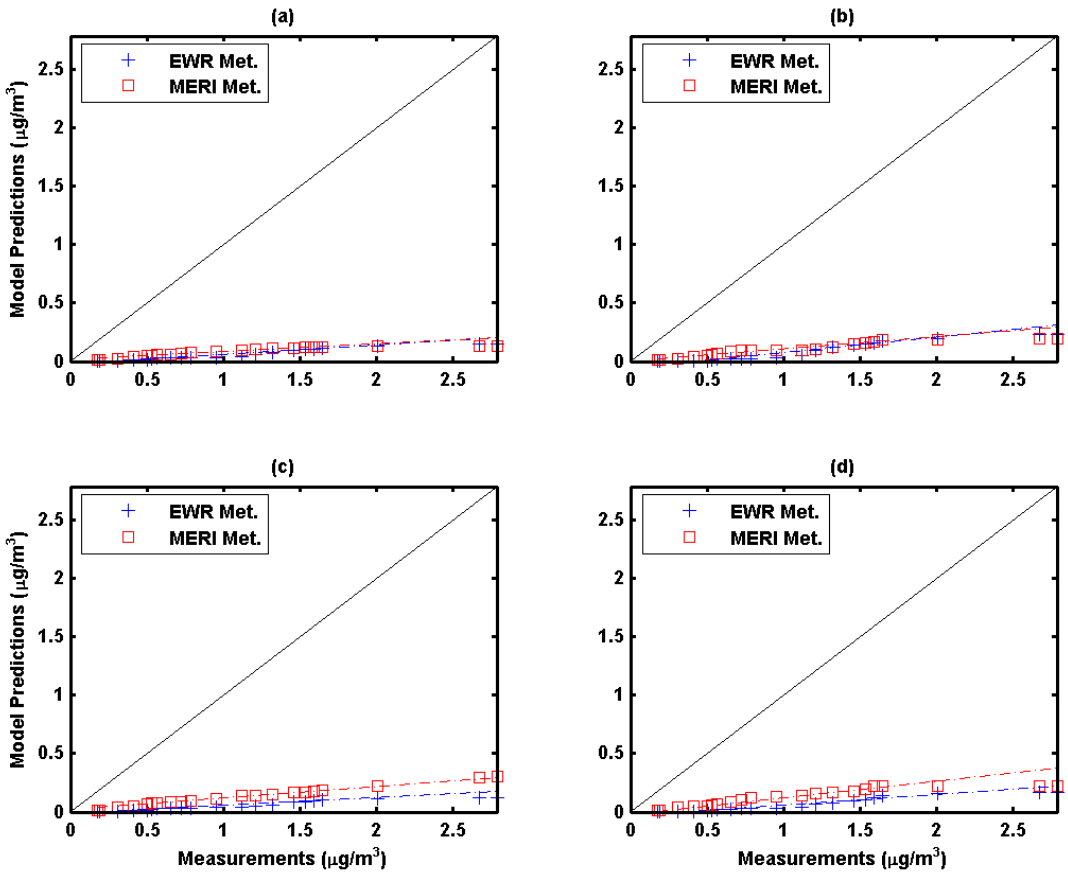


Figure E-58. Comparison of Q-Q plots of model predictions of Arsenic (fine PM) ambient concentrations with two different meteorology inputs (Newark Airport (EWR) data versus MERI data), while the other modeling options were based on (a) ISCST3 and NEI-1999 emissions, (b) ISCST3 and NEI-2002 emissions, (c) AERMOD and NEI-1999 emissions, and (d) AERMOD and NEI-2002 emissions, against measurements at the monitoring site of MDL1 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

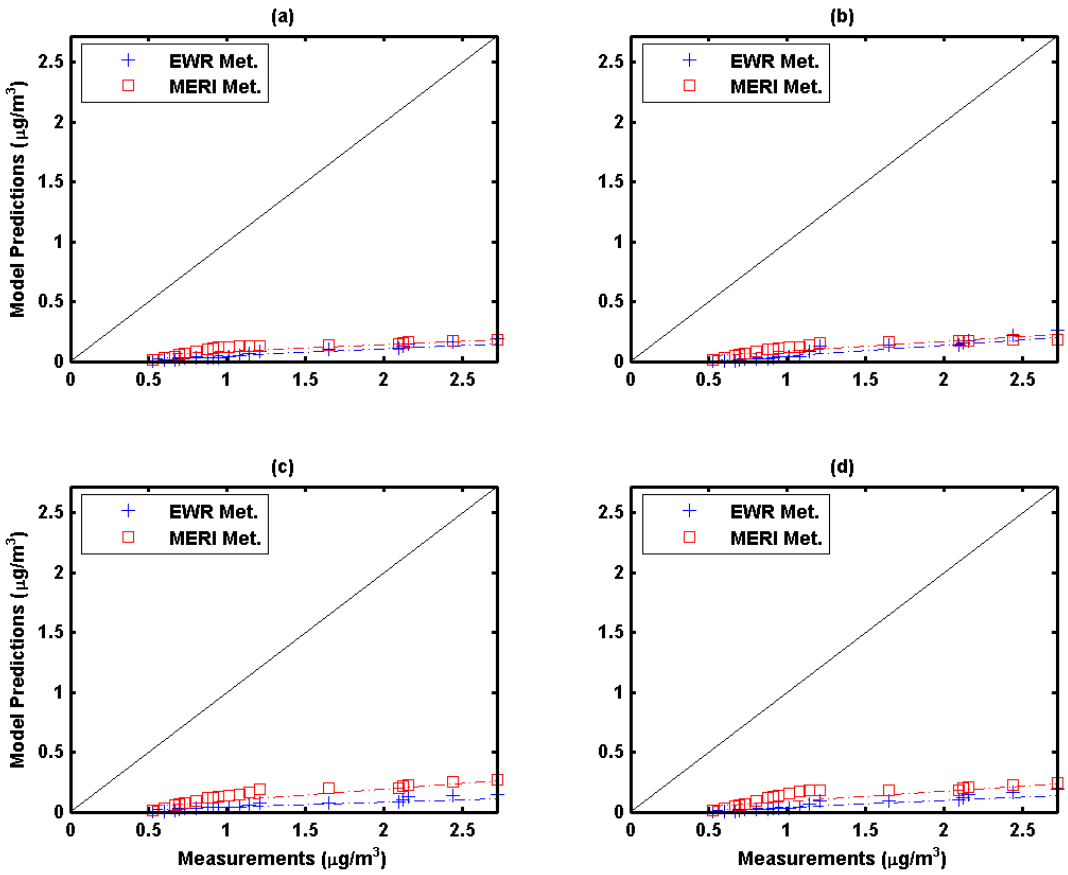


Figure E-59. Comparison of Q-Q plots of model predictions of Arsenic (fine PM) ambient concentrations with two different meteorology inputs (Newark Airport (EWR) data versus MERI data), while the other modeling options were based on (a) ISCST3 and NEI-1999 emissions, (b) ISCST3 and NEI-2002 emissions, (c) AERMOD and NEI-1999 emissions, and (d) AERMOD and NEI-2002 emissions, against measurements at the monitoring site of MDL2 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

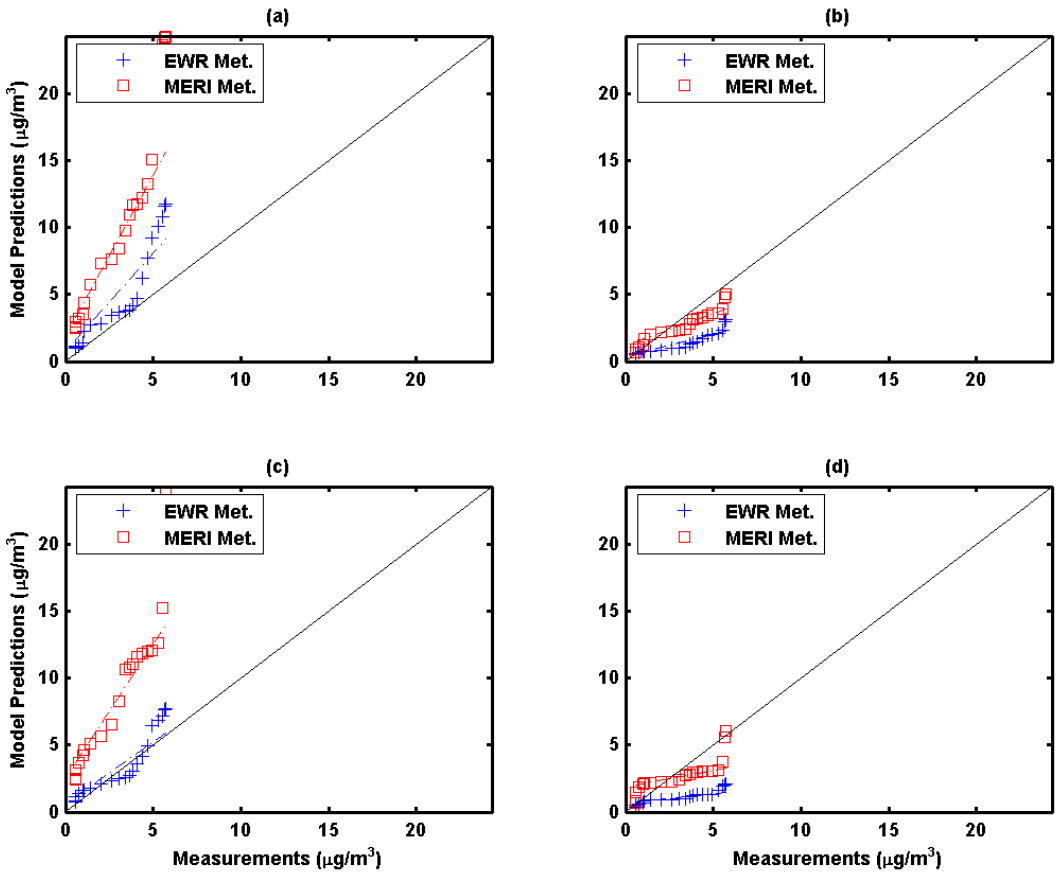


Figure E-60. Comparison of Q-Q plots of model predictions of Lead (fine PM) ambient concentrations with two different meteorology inputs (Newark Airport (EWR) data versus MERI data), while the other modeling options were based on (a) ISCST3 and NEI-1999 emissions, (b) ISCST3 and NEI-2002 emissions, (c) AERMOD and NEI-1999 emissions, and (d) AERMOD and NEI-2002 emissions, against measurements at the monitoring site of MDL1 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

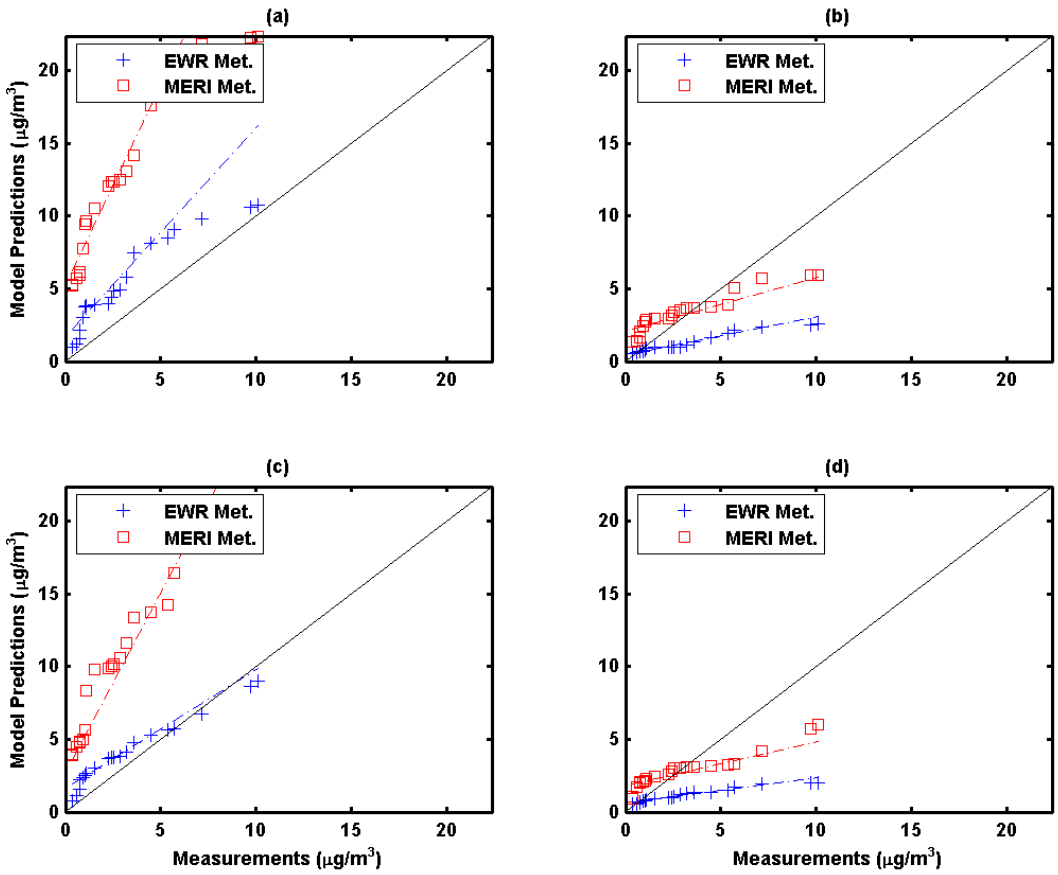


Figure E-61. Comparison of Q-Q plots of model predictions of Lead (fine PM) ambient concentrations with two different meteorology inputs (Newark Airport (EWR) data versus MERI data), while the other modeling options were based on (a) ISCST3 and NEI-1999 emissions, (b) ISCST3 and NEI-2002 emissions, (c) AERMOD and NEI-1999 emissions, and (d) AERMOD and NEI-2002 emissions, against measurements at the monitoring site of MDL2 in the Meadowlands District for the time period of March 17, 2005 to November 6, 2005.

Appendix F Comparison of time-series profiles of the model predictions with field measurements for the ten selected air toxics

Figures E-1 to E-10 present the time-series comparisons of the ISCST3 and AERMOD predictions with the field measurements of the ten air toxics (Benzene, Toluene, Ethylbenzene, Xylenes, PERC, TCE, PDB, As, Pb, and Hg) from March 17, 2005 to March 13, 2007. The best modeling input options (NEI-2002 emissions and Newark Airport meteorology) were used for these simulations.

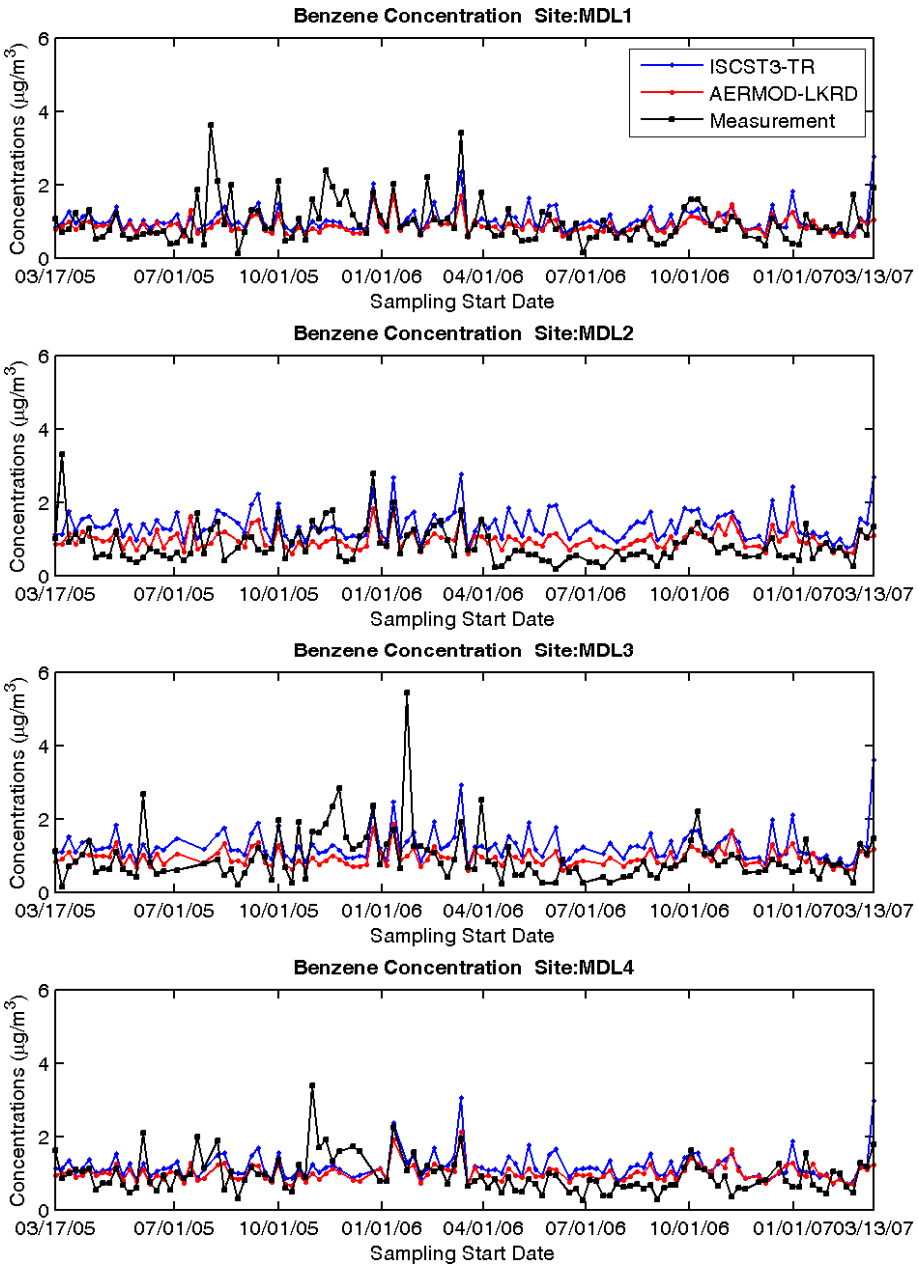


Figure F-1. Time-series profiles of Benzene ambient concentrations estimated by both the ISCST3 (with the census tract-based mobile on-road emissions) and AERMOD (with the link-based mobile on-road emissions) simulations at each of the 4 monitoring sites in the Meadowlands District from March 17, 2005 to March 13, 2007.

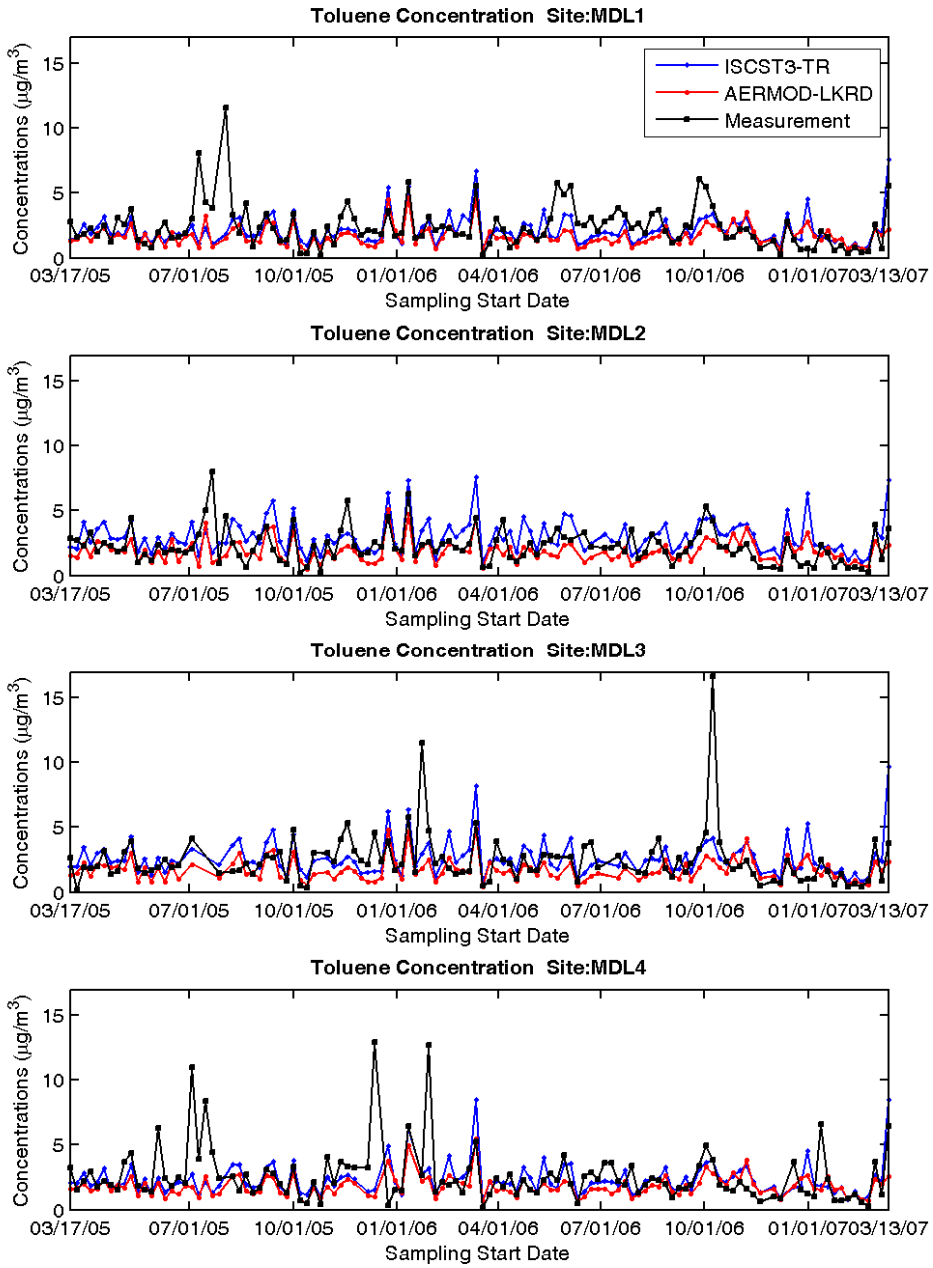


Figure F-2. Time-series profiles of Toluene ambient concentrations estimated by both the ISCST3 (with the census tract-based mobile on-road emissions) and AERMOD (with the link-based mobile on-road emissions) simulations at each of the 4 monitoring sites in the Meadowlands District from March 17, 2005 to March 13, 2007.

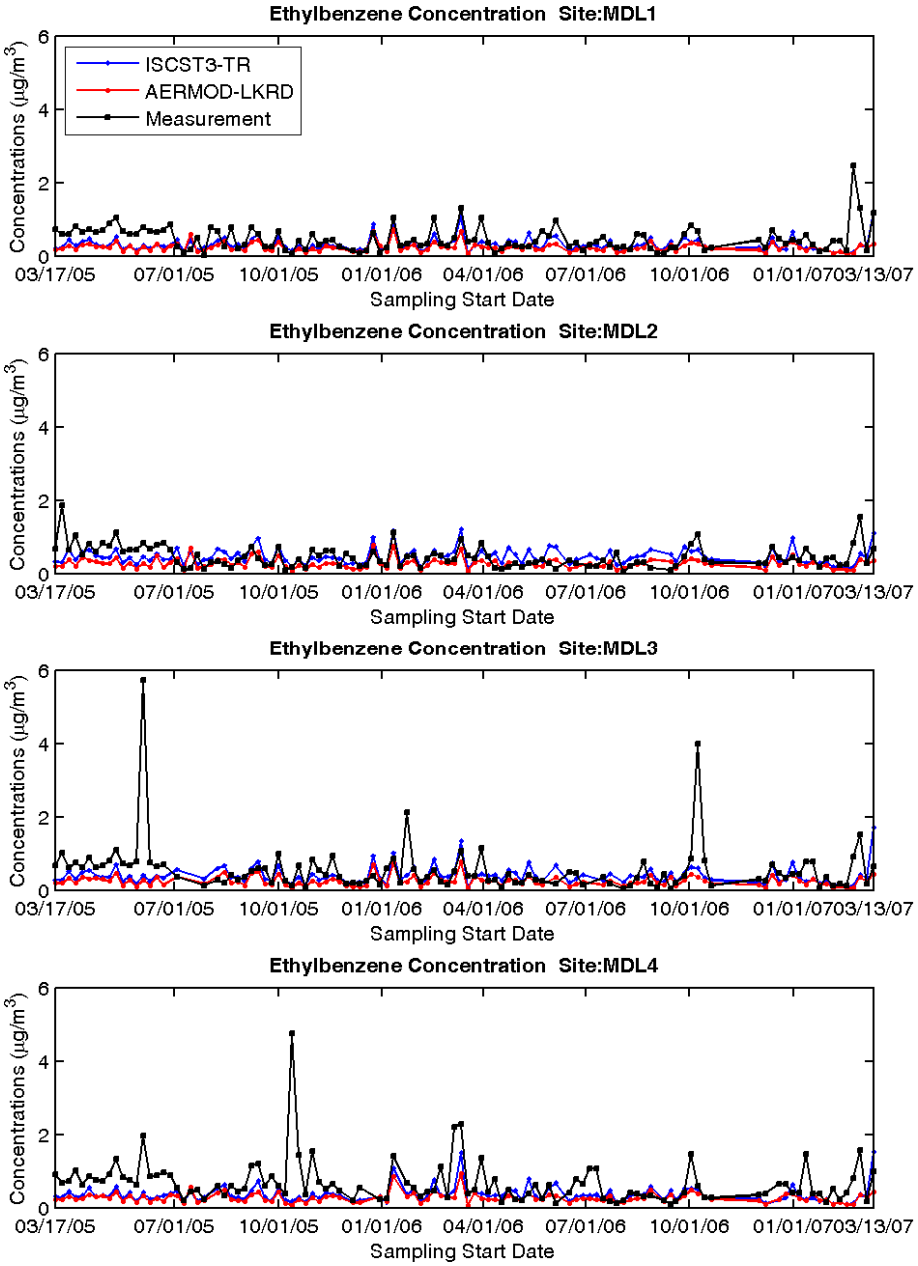


Figure F-3. Time-series profiles of Ethylbenzene ambient concentrations estimated by both the ISCST3 (with the census tract-based mobile on-road emissions) and AERMOD (with the link-based mobile on-road emissions) simulations at each of the 4 monitoring sites in the Meadowlands District from March 17, 2005 to March 13, 2007.

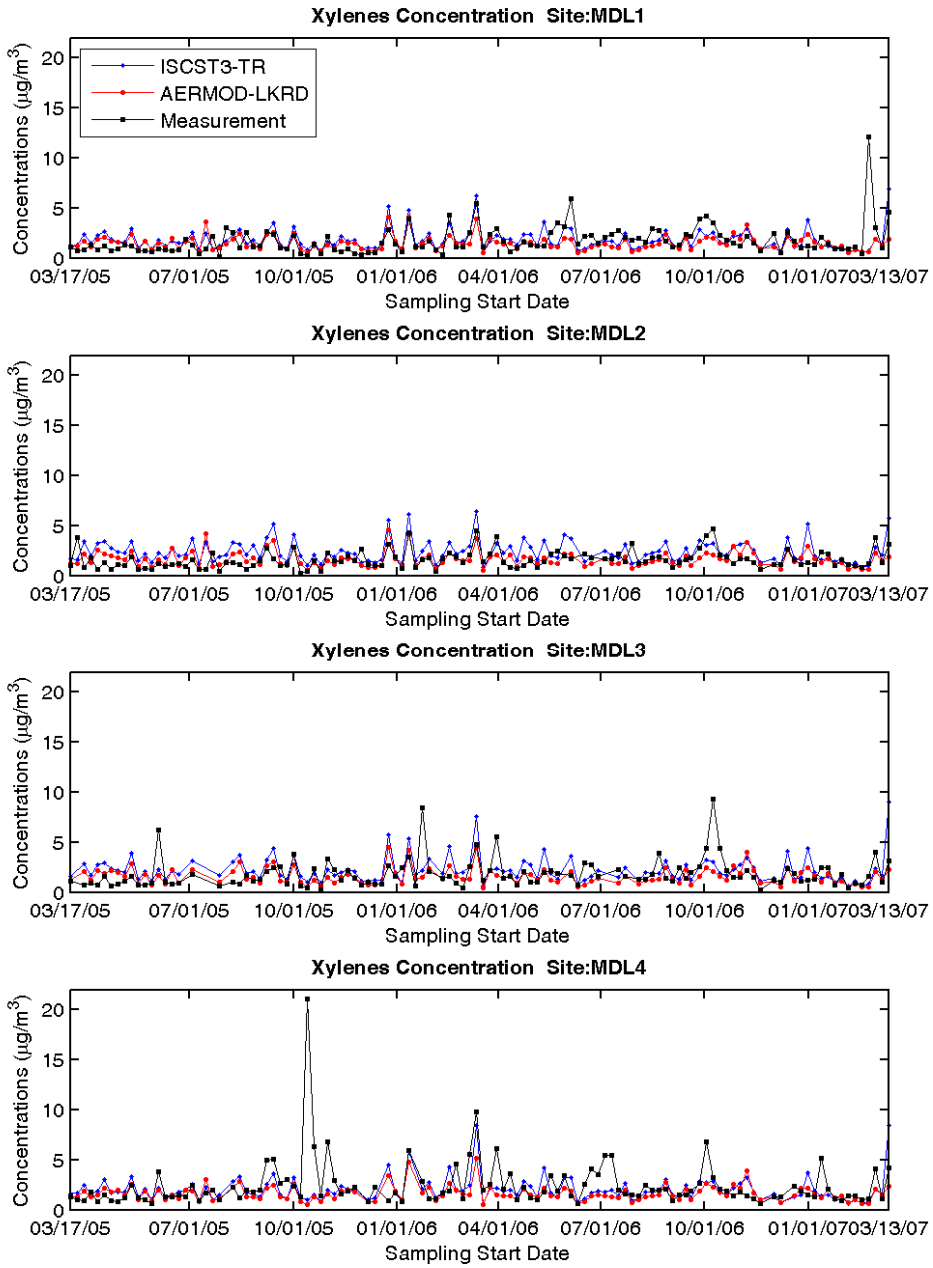


Figure F-4. Time-series profiles of Xylenes ambient concentrations estimated by both the ISCST3 (with the census tract-based mobile on-road emissions) and AERMOD (with the link-based mobile on-road emissions) simulations at each of the 4 monitoring sites in the Meadowlands District from March 17, 2005 to March 13, 2007.

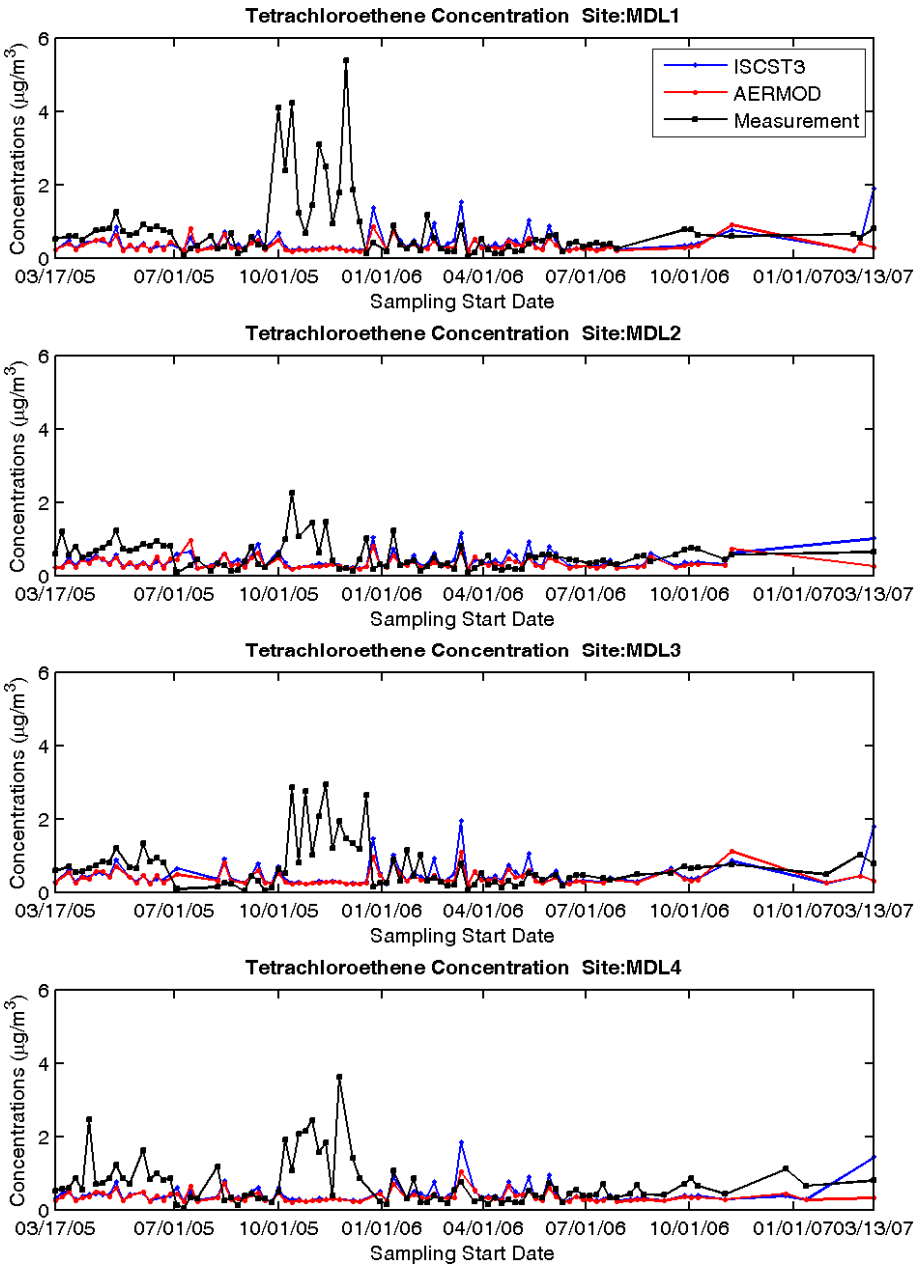


Figure F-5. Time-series profiles of Tetrachloroethene ambient concentrations estimated by both the ISCST3 and AERMOD simulations at each of the 4 monitoring sites in the Meadowlands District from March 17, 2005 to March 13, 2007.

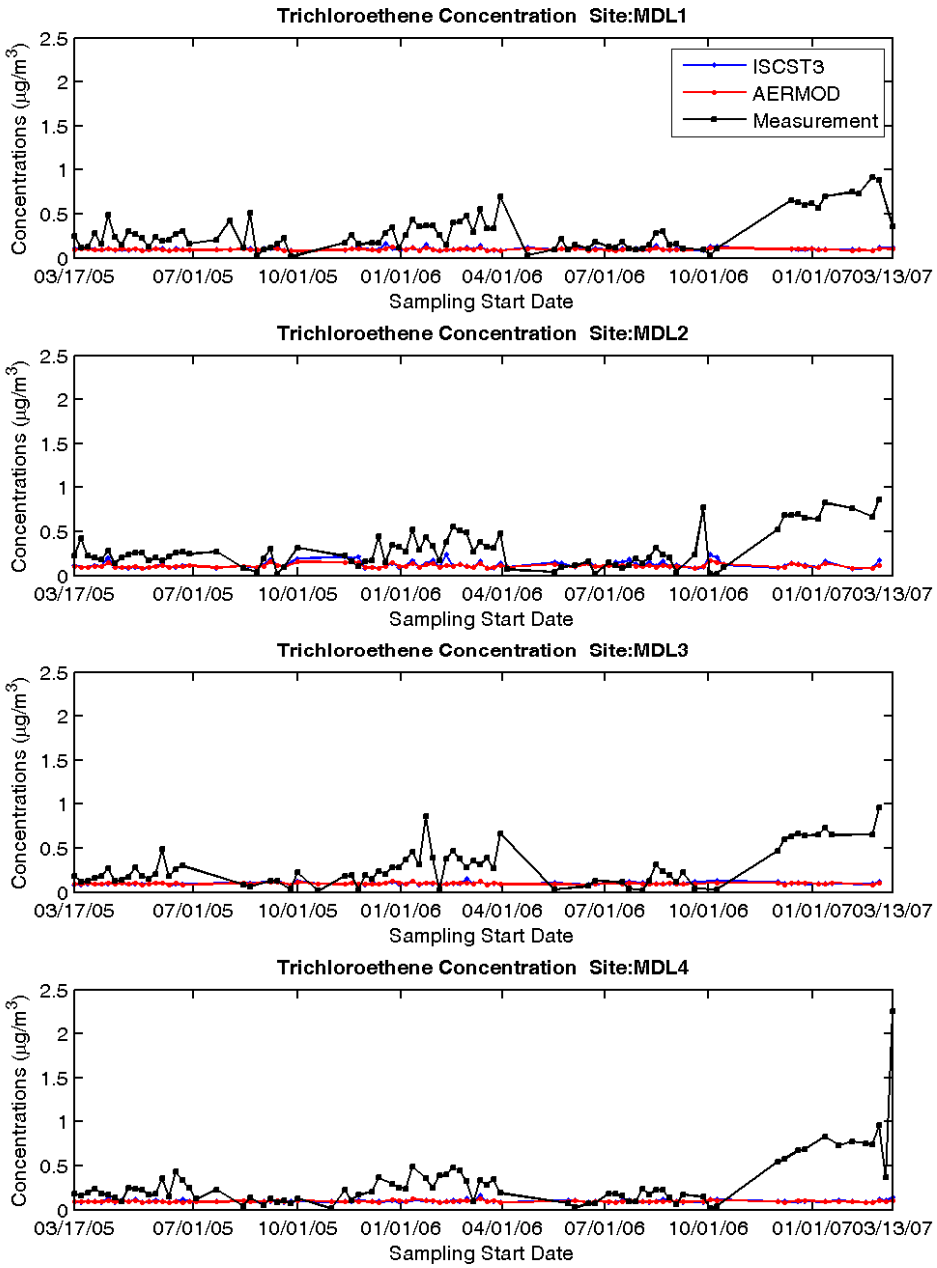


Figure F-6. Time-series profiles of Trichloroethene ambient concentrations estimated by both the ISCST3 and AERMOD simulations at each of the 4 monitoring sites in the Meadowlands District from March 17, 2005 to March 13, 2007.

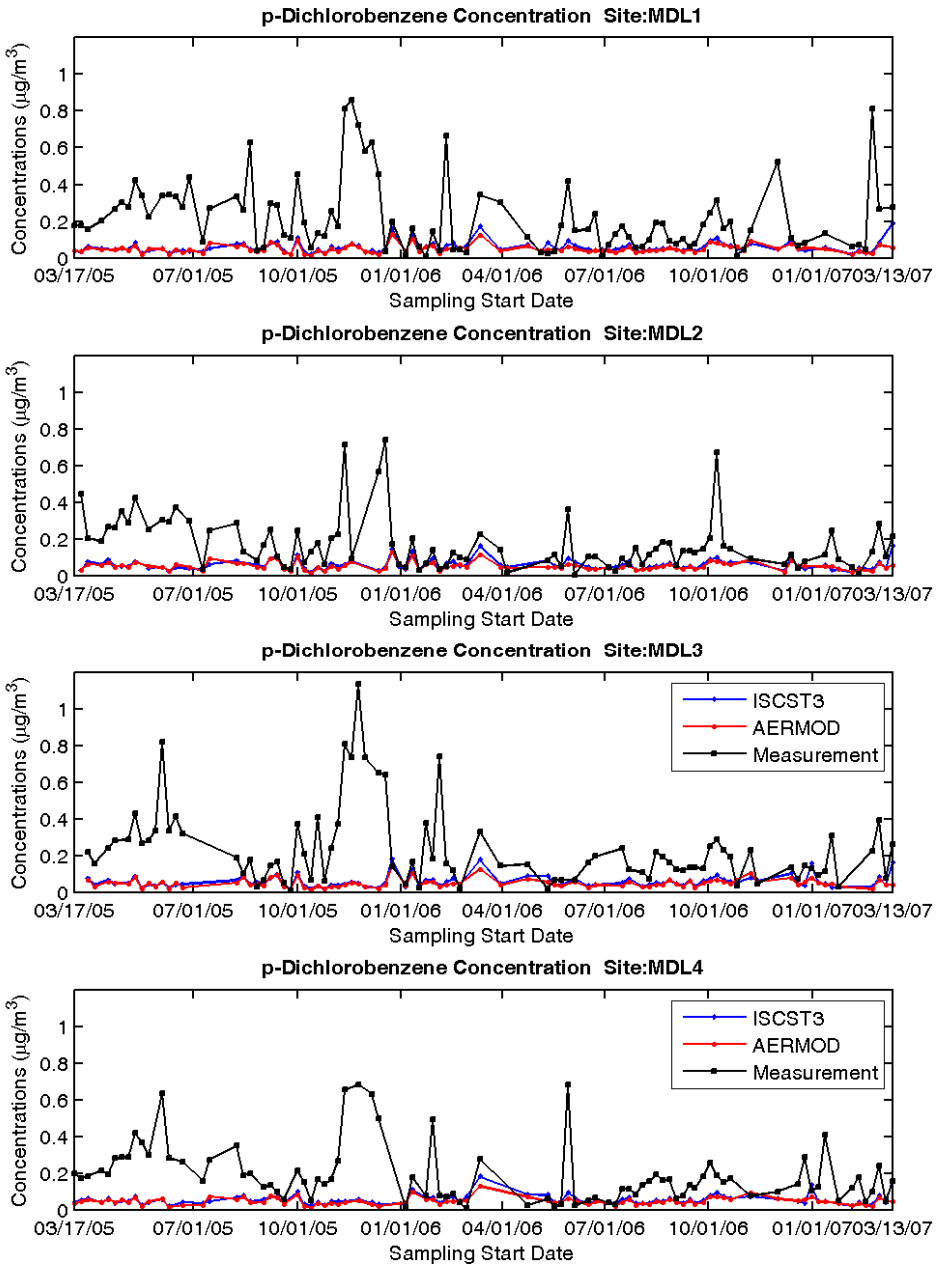
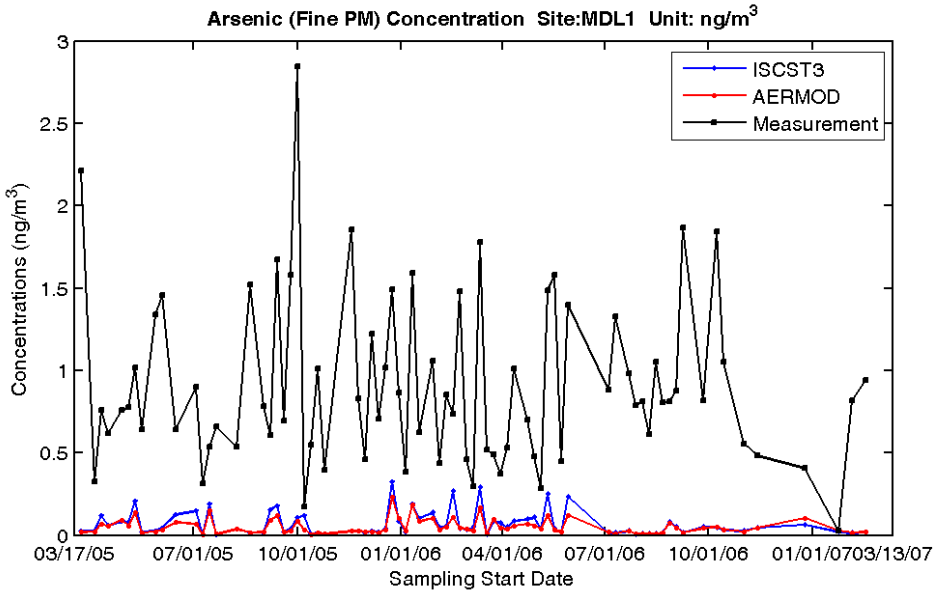


Figure F-7. Time-series profiles of p-Dichlorobenzene ambient concentrations estimated by both the ISCST3 and AERMOD simulations at each of the 4 monitoring sites in the Meadowlands District from March 17, 2005 to March 13, 2007.



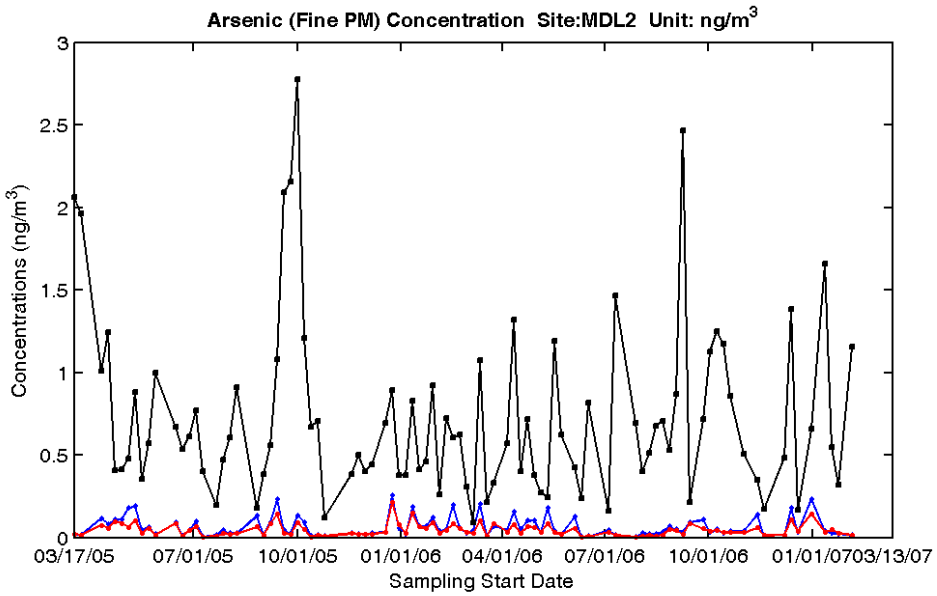


Figure F-8. Time-series profiles of As (fine PM) ambient concentrations estimated by both the ISCST3 and AERMOD simulations at each of the 2 monitoring sites in the Meadowlands District from March 17, 2005 to March 13, 2007.

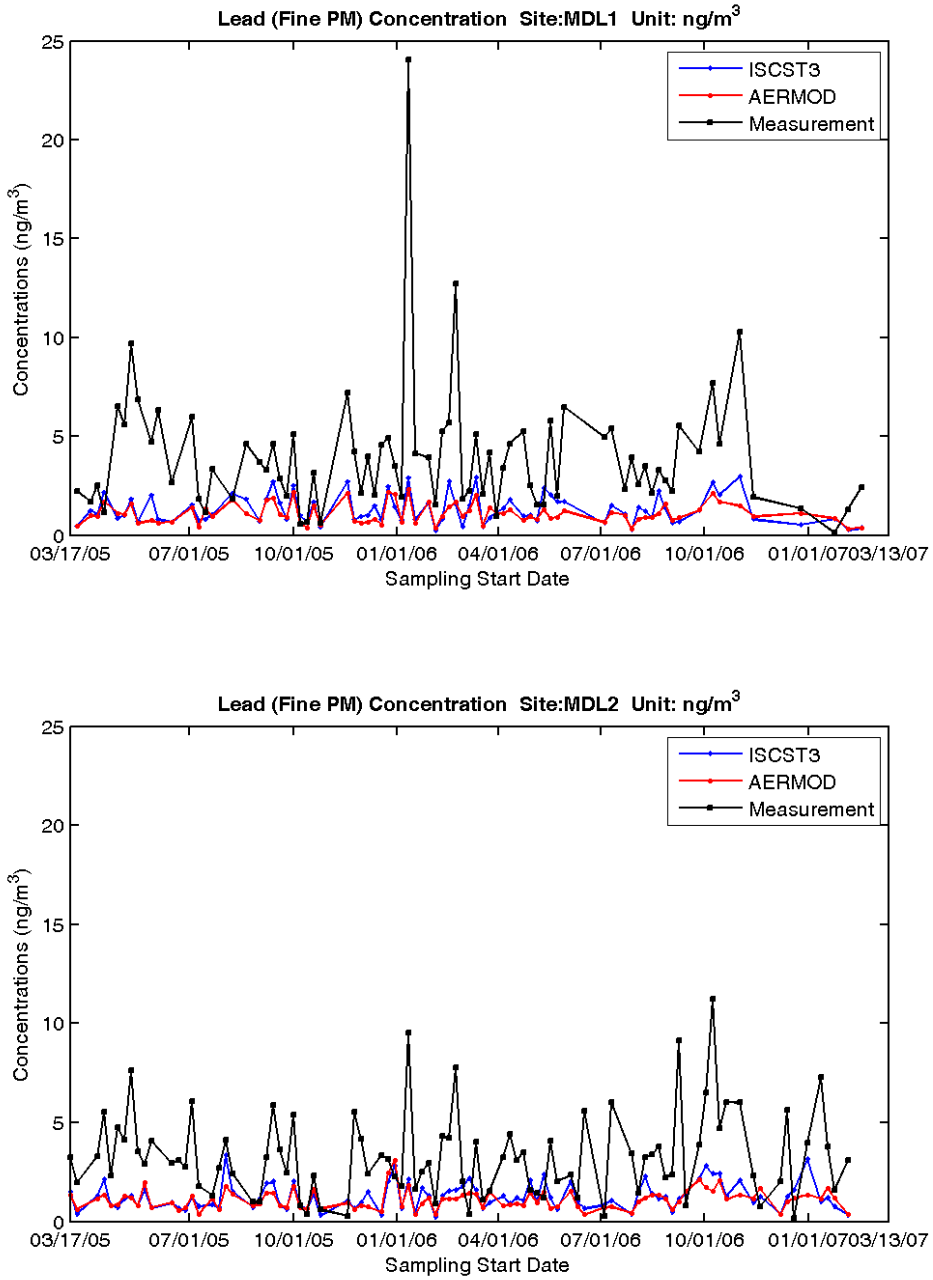
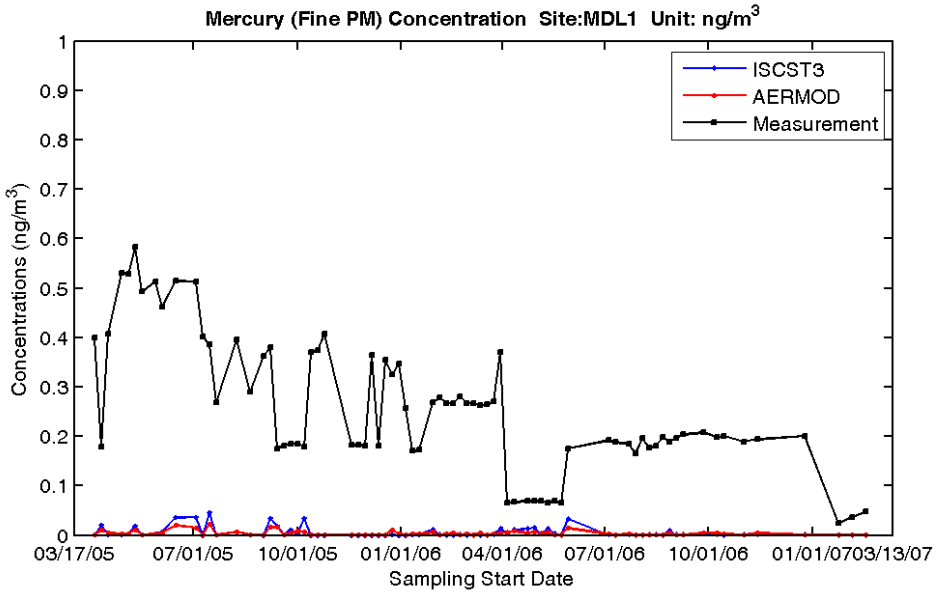


Figure F-9. Time-series profiles of Pb (fine PM) ambient concentrations estimated by both the ISCST3 and AERMOD simulations at each of the 2 monitoring sites in the Meadowlands District from March 17, 2005 to March 13, 2007.



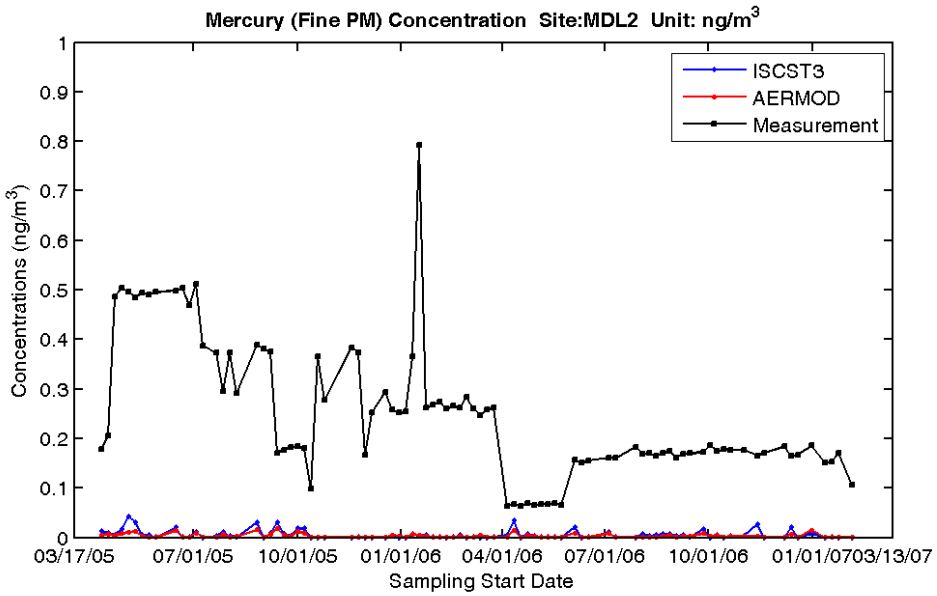


Figure F-10. Time-series profiles of Hg (fine PM) ambient concentrations estimated by both the ISCST3 and AERMOD simulations at each of the 2 monitoring sites in the Meadowlands District from March 17, 2005 to March 13, 2007.