Environmental Surveillance at Los Alamos during 2009



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It is the policy of Los Alamos National Laboratory that we will be responsible stewards of our environment. It is our policy to:

- Manage and operate our site in compliance with environmental laws and standards and in harmony with the natural and human environment
- Meet our environmental permit requirements
- Use continuous improvement processes to recognize, monitor and minimize the consequences to the environment stemming from our past, present, and future operations
- Prevent pollution
- Foster sustainable use of natural resources
- Work to increase the body of knowledge regarding our environment

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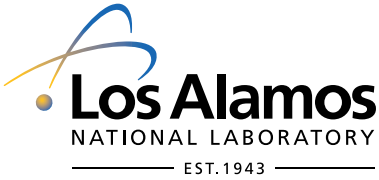
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Contents

ABSTRACT XIX
EXECUTIVE SUMMARY 1
1. INTRODUCTION 23
A. BACKGROUND AND REPORT PURPOSE 25
1. Introduction to Los Alamos National Laboratory 25
2. Purpose of this Report 26
B. ENVIRONMENTAL SETTING 27
1. Location 27
2. Geology and Hydrology 27
3. Biological Resources 29
4. Cultural Resources 30
5. Climate 30
C. LABORATORY ACTIVITIES AND FACILITIES 31
D. MANAGEMENT OF ENVIRONMENT, SAFETY, AND HEALTH 33
1. Environmental Management System 34
2. Waste Management Program 35
3. Pollution Prevention Program 36
4. Environmental Restoration Programs 39
5. Compliance and Surveillance Programs 40
E. RISK AND HAZARD REDUCTION 44
1. Estimation of Risk 44
2. Examples of Risk Reduction 44
F. REFERENCES 45
2. COMPLIANCE SUMMARY 47
A. INTRODUCTION 49
B. COMPLIANCE STATUS 49
1. Resource Conservation and Recovery Act 52
2. Comprehensive Environmental Response, Compensation, and Liability Act 56
3. Emergency Planning and Community Right-to-Know Act 56
4. Toxic Substances Control Act 58
5. Federal Insecticide, Fungicide, and Rodenticide Act 58
6. Clean Air Act 59
7. Clean Water Act 62
8. Safe Drinking Water Act 68
9. Groundwater 68
10. DOE Order 435.1 Radioactive Waste Management 70
11. National Environmental Policy Act 72
12. Endangered Species Act 72
13. Migratory Bird Treaty Act 74
14. Cultural Resources 74
C. UNPLANNED RELEASES 74
1. Air Releases 74
2. Liquid Releases 75
D. REFERENCES 76
3. RADIOLOGICAL AND NONRADIOLOGICAL DOSE ASSESSMENT 77
A. INTRODUCTION 79
B. RADIOLOGICAL DOSE ASSESSMENT FOR HUMANS 79

1. Overview of Radiological Dose Equivalents 79
2. Public Dose Calculations 80
3. Dose Calculations and Results 83
4. Estimation of Radiation Dose Equivalents for Naturally Occurring Radiation 86
5. Effect to an Individual from Laboratory Operations 87

C. BIOTA DOSE ASSESSMENT 88
1. Biota Dose Assessment Approach 88
2. Biota Dose Results 88

D. NONRADIOLOGICAL RISK ASSESSMENT 89
1. Overview 89
2. Results 89
3. Conclusion 91

E. REFERENCES 91

4. AIR SURVEILLANCE 93

A. AMBIENT AIR SAMPLING 95
1. Introduction 95
2. Air Monitoring Network 96
3. Sampling Procedures, Data Management, and Quality Assurance 96
4. Ambient Air Concentrations 100
5. Special Monitoring 109

B. STACK SAMPLING FOR RADIONUCLIDES 109
1. Introduction 109
2. Sampling Methodology 109
3. Sampling Procedures and Data Analysis 110
4. Analytical Results 111
5. Long-Term Trends 112

C. GAMMA AND NEUTRON RADIATION MONITORING PROGRAM 115
1. Introduction 115
2. Monitoring Network 115
3. Quality Assurance 116
4. Results 116

D. NONRADIOLOGICAL AMBIENT AIR MONITORING 116
1. Introduction 116
2. Air Monitoring Network and Equipment 117
3. Ambient Air Concentrations 117
4. Detonation and Burning of Explosives 118
5. Beryllium Sampling 118

E. METEOROLOGICAL MONITORING 118
1. Introduction 118
2. Monitoring Network 118
3. Sampling Procedures, Data Management, and Quality Assurance 118
4. Climatology 119
5. 2009 in Perspective 120

F. QUALITY ASSURANCE PROGRAM 123
1. Quality Assurance Program Development 123
2. Field Sampling Quality Assurance 123
3. Analytical Laboratory Quality Assessment 126
4. Analytical Laboratory Assessments 127

G. REFERENCES 127

5. GROUNDWATER MONITORING 129
A. INTRODUCTION 131
B. HYDROGEOLOGIC SETTING 131
1. Geologic Setting 131
2. Groundwater Occurrence 132
3. Overview of Groundwater Quality 134
C. GROUNDWATER STANDARDS AND SCREENING LEVELS 137
D. MONITORING NETWORK 138
1. Regional Aquifer and Intermediate Perched Groundwater Monitoring 139
2. Alluvial Groundwater Monitoring 139
3. Well Redevelopment and Conversion 139
4. Well Plugging and Abandonment 142
E. SUMMARY OF 2009 SAMPLING RESULTS 143
F. GROUNDWATER SAMPLING RESULTS BY CONSTITUENTS 147
1. Contaminant Distribution Maps 147
2. Organic Chemicals in Groundwater 148
3. Radioactivity in Groundwater 151
4. Perchlorate in Groundwater 152
G. GROUNDWATER SAMPLING RESULTS BY WATERSHED 152
1. Guaje Canyon (includes Rendija and Barrancas Canyons) 152
2. Los Alamos Canyon (includes Bayo, Acid, Pueblo, and DP Canyons) 153
3. Sandia Canyon 165
4. Mortandad Canyon (includes Ten Site Canyon and Cañada del Buey) 170
5. Pajarito Canyon (includes Twomile and Threemile Canyons) 182
6. Water Canyon (includes Cañon de Valle, Potrillo, Fence, and Indio Canyons) 188
7. Ancho Canyon 194
8. White Rock Canyon Springs 195
9. Pueblo de San Ildefonso 196
10. Buckman Well Field 196
H. QUALITY ASSURANCE OF GROUNDWATER, SURFACE WATER, AND SEDIMENT ANALYSES 196
1. Quality Control for Samples, Data Validation, and Analytical Results Review 197
2. Qualification and Performance Assessment of Analytical Laboratories 199
3. Department of Energy Contract Analytical Program Audits 201
I. REFERENCES 202
6. WATERSHED MONITORING 205
A. INTRODUCTION 207
B. HYDROLOGIC SETTING 207
C. SURFACE WATER AND SEDIMENT STANDARDS AND SCREENING LEVELS 210
1. New Mexico Surface Water Standards 210
2. Radionuclides in Surface Water 211
3. Nonradioactive Constituents in Surface Water 213
4. Sediment 214
D. SAMPLING LOCATIONS AND DATA ANALYSIS METHODS 214
1. Regional Monitoring Locations 214
2. On-Site and Perimeter Monitoring Locations 215
3. Sampling Procedures 215
E. WATERSHED SAMPLING RESULTS BY CONSTITUENTS 215
1. Radionuclides and Radioactivity in Surface Water and Sediment 220
2. Inorganic Chemicals in Surface Water and Sediment 223
3. Organic Chemicals in Surface Water and Sediment 226

F. CANYON-SPECIFIC RESULTS 228
1. Los Alamos Canyon (includes Acid, Barrancas, Bayo, DP, Guaje, Pueblo, and Rendija Canyons) 228
2. Sandia Canyon 234
3. Mortandad Canyon (includes Cañada del Buey and Effluent, Pratt, and Ten Site Canyons) 234
4. Pajarito Canyon (includes Twomile and Threemile Canyons) 238
5. Water Canyon (includes Cañon de Valle and Fence, Indio, and Potrillo Canyons) 240
6. Ancho Canyon 241
7. Chaquehui Canyon 241
G. POTENTIAL IMPACTS TO THE RIO GRANDE 242
1. Surface Water Sampling Results 242
2. Sediment Sampling Results 243
3. PCBs in Sediment 247
H. QUALITY ASSURANCE 249
I. REFERENCES 250
7. SOIL MONITORING 253
A. INTRODUCTION 255
B. SOIL COMPARISON LEVELS 256
C. INSTITUTIONAL MONITORING 256
1. Monitoring Network 256
2. Methods and Analysis 257
3. Radionuclides 259
4. TAL Elements 261
5. HE, PCBs, and SVOC Chemicals 261
D. FACILITY MONITORING 261
1. Monitoring Network for Area G at TA-54 261
2. Radionuclide Analytical Results for Area G 262
3. Monitoring Network for DARHT at TA-15 265
4. Radionuclide and Chemical Analytical Results for DARHT 267
E. SPECIAL MONITORING STUDIES 268
1. Cesium-137, Plutonium-238, and Plutonium-239/240 Concentrations in Soil Collected along the North Side of East Jemez Road 268
2. Chemical Concentrations in Soils Collected from Alfalfa Fields Irrigated with Rio Grande Water Upstream and Downstream of LANL 270
F. QUALITY ASSURANCE FOR THE SOIL, FOODSTUFFS, AND BIOTA MONITORING PROGRAM 272
1. Quality Assurance Program Development 272
2. Field Sampling Quality Assurance 272
3. Analytical Laboratory Quality Assessment 273
4. Field Data Quality Assessment Results 273
5. Analytical Data Quality Assessment Results 273
6. Analytical Laboratory Assessments 273
7. Program Audits 273
G. REFERENCES 274
8. FOODSTUFFS AND BIOTA MONITORING 277
A. FOODSTUFFS MONITORING 279
1. Introduction 279
2. Foodstuffs Comparison Levels 280
3. Crayfish Monitoring 280
4. Deer Monitoring 286

B. BIOTA MONITORING 286
1. Introduction 286
2. Biota Comparison Levels 287
3. Institutional Monitoring 288
4. Facility Monitoring 289
C. SPECIAL MONITORING STUDIES 293
1. Radionuclide and Chemical Concentrations in Biota Collected from Water/Silt Retention Areas: Los Alamos Canyon Weir and the Pajarito Flood Control Retention Structure 293
2. Radionuclide and Chemical Concentrations in Alfalfa Forage Irrigated with Rio Grande Water Upstream and Downstream of LANL 298
3. Benthic Macroinvertebrates Collected from the Rio Grande Upstream and Downstream of LANL 298
D. QUALITY ASSURANCE FOR THE SOIL, FOODSTUFFS AND BIOTA PROGRAM 300
E. REFERENCES 300
9. ENVIRONMENTAL RESTORATION 305
A. INTRODUCTION 307
1. Programs and Projects 307
2. Work Plans and Reports 308
3. Overview of Vapor Monitoring 316
B. CORRECTIVE ACTIONS PROGRAM ACCOMPLISHMENTS 317
1. Upper Los Alamos Canyon Aggregate Area 317
2. Upper Mortandad Canyon Aggregate Area 318
3. North Ancho Canyon Aggregate Area 318
4. Middle Cañada del Buey Aggregate Area 319
5. Guaje/Barrancas/Rendija Canyons Aggregate Area 320
6. Bayo Canyon Aggregate Area 321
7. TA-16-340 Complex [Consolidated Units 13-003(a)-99 and 16-003(n)-99 and SWMUs 16-003(o), 16-026(j2), and 16-029(f)] 321
8. Consolidated Unit 16-021(c)-99 (260 Outfall) Corrective Measures Implementation 322
9. MDA C 323
10. Los Alamos and Pueblo Canyons 324
11. Pajarito Canyon 325
12. Sandia Canyon 327
13. Cañada del Buey 329
14. North Canyons 330
C. TA-54 CLOSURE PROJECT ACCOMPLISHMENTS 331
1. MDA G 331
2. MDA H 332
D. TA-21 CLOSURE PROJECT ACCOMPLISHMENTS 333
1. MDA V 333
2. MDA T 334
3. MDA B 335
4. DP Site Aggregate Area 336
5. American Recovery and Reinvestment Act at TA-21 337
E. QUALITY ASSURANCE PROGRAM 338
1. Quality Assurance Program Development 338
2. Field Sampling Quality Assurance 338
3. Analytical Laboratory Quality Assessment 338
4. Analytical Laboratory Assessments 339
F. REFERENCES 340

10. ENVIRONMENTAL STEWARDSHIP 345
A. INTRODUCTION 347
B. LONG-TERM ENVIRONMENTAL DATA STEWARDSHIP 347
C. MONITORING OF THE RIO GRANDE 348
1. Monitoring Information 348
2. Water Quality in the Rio Grande 348
3. Fish in the Rio Grande 349
4. Crayfish in the Rio Grande 349
5. Benthic Macroinvertebrates in the Rio Grande 350
6. Irrigation with Rio Grande Waters 350
7. Sediments in the Rio Grande 350
8. Risk Assessments 351
D. REFERENCES 353
APPENDIX A 355
APPENDIX B 361
APPENDIX C 365
APPENDIX D 369
GLOSSARY 371
ACRONYMS AND ABBREVIATIONS 381
ELEMENTAL & CHEMICAL NOMENCLATURE 383

FIGURES

Figure ES-1. Regional location of Los Alamos National Laboratory. 4
Figure ES-2. Annual airborne pathway dose (mrem) to the off-site MEI over the past 10 years. 9
Figure ES-3. Illustration of geologic and hydrologic relationships in the Los Alamos area 12
Figure 1-1. Regional location of Los Alamos National Laboratory. 28
Figure 1-2. Major canyons and mesas on Laboratory land. 29
Figure 1-3. Technical Areas and Key Facilities of Los Alamos National Laboratory in relation to surrounding landholdings 32
Figure 1-4. Cubic meters of low-level radioactive (LLW), mixed transuranic (MTRU), transuranic (TRU), and mixed low-level radioactive (MLLW) wastes generated at LANL for the past 5 years. 37
Figure 1-5. Kilograms of non-hazardous waste, RCRA-regulated waste, and NMED-regulated wastes generated at LANL for the past 5 years. 38
Figure 2-1. Aggregate areas as defined for the NMED Consent Order and their status. 55
Figure 2-2. LANL criteria pollutant emissions from 2005 through 2009 for annual emissions inventory reporting. 61
Figure 2-3. Characterization wells in the intermediate and regional aquifers installed during 2009. 69
Figure 3-1. Annual collective dose (person-rem) to the population within 80 km of LANL over the past 10 years. 84
Figure 3-2. Annual airborne pathway (RAD-NESHAP) dose (mrem) to the MEI over the past 10 years. 85
Figure 3-3. Los Alamos County radiation background compared with average US background. 87
Figure 4-1. AIRNET locations at and near Los Alamos National Laboratory. 97
Figure 4-2. AIRNET station locations at Area G, TA-54, Los Alamos National Laboratory. 98
Figure 4-3. AIRNET station locations near TA-21, MDA B. 98
Figure 4-4. Regional and Pueblo AIRNET locations. 99
Figure 4-5. Gross alpha measurements for all sampling sites by date collected in 2009. 102
Figure 4-6. Gross beta measurements for all sampling sites by date collected in 2009. 102
Figure 4-7. Annual average concentrations of tritium by group. 103
Figure 4-8. Annual average concentrations of plutonium-238 by group. 105
Figure 4-9. Annual average concentrations of plutonium-239/240 by group. 105

Figure 4-10. Americium and plutonium concentrations at TA-54, Area G. 105
Figure 4-11. Annual average concentrations of Americium-241 by group. 106
Figure 4-12. Number of sites where enriched or depleted uranium has been detected since 2000. 108
Figure 4-13. Quarterly all-station average concentrations of uranium isotopes. 108
Figure 4-14. Plutonium emissions from sampled LANL stacks. 114
Figure 4-15. Uranium emissions from sampled LANL stacks. 114
Figure 4-16. Tritium emissions from sampled LANL stacks. 114
Figure 4-17. GMAP emissions from sampled LANL stacks. 115
Figure 4-18. Fraction of total annual stack emissions resulting from plutonium, uranium, tritium, and GMAP. 115
Figure 4-19. Thermoluminescent dosimeter locations at TA-54, Area G, as part of the Direct Penetrating Radiation Monitoring Network (DPRNET). 117
Figure 4-20. Location of meteorological monitoring towers and rain gauges. 119
Figure 4-21. Weather summary for Los Alamos for 2009 at the TA-6 meteorology station. 122
Figure 4-22. Temperature history for Los Alamos. 124
Figure 4-23. Total precipitation history for Los Alamos. 124
Figure 4-24. Daytime and nighttime wind roses for 2009. 125
Figure 5-1. Generalized geologic cross-section of the Pajarito Plateau. 132
Figure 5-2. Illustration of geologic and hydrologic relationships in the Pajarito Plateau, showing the three modes of groundwater occurrence. 133
Figure 5-3. Contour map of average water table elevations for the regional aquifer 134
Figure 5-4. Major liquid release sources (effluent discharge) potentially affecting groundwater. 136
Figure 5-5. Springs and wells used for alluvial groundwater monitoring. 140
Figure 5-6. Springs and wells used for intermediate-depth perched zone monitoring. 141
Figure 5-7. Wells used for regional aquifer monitoring. 142
Figure 5-8. Springs used for regional aquifer monitoring. 143
Figure 5-9. Springs and wells used for groundwater monitoring at the City of Santa Fe Buckman well field and on Pueblo de San Ildefonso lands. 145
Figure 5-10 Bis(2-ethylhexyl)phthalate concentration histories. 148
Figure 5-11. Bis(2-ethylhexyl)phthalate concentration history for regional aquifer monitoring well R-32. 149
Figure 5-12. Bis(2-ethylhexyl)phthalate concentration history for regional aquifer monitoring well R-36 149
Figure 5-13. Bis(2-ethylhexyl)phthalate concentration history for regional aquifer monitoring well R-38. 149
Figure 5-14. Bis(2-ethylhexyl)phthalate concentration history for regional aquifer monitoring well R-42. 150
Figure 5-15. Bis(2-ethylhexyl)phthalate concentration history for regional aquifer monitoring well R-46. 150
Figure 5-16. Bis(2-ethylhexyl)phthalate concentration history for intermediate groundwater well R-53i. 150
Figure 5-17. Location of groundwater contaminated by strontium-90 above the 8-pCi/L EPA MCL screening level 153
Figure 5-18. Location of groundwater contaminated by radioactivity: areas indicated have the sum of radioactivity from a DOE source above the 4-mrem/yr DOE DCG screening level. 154
Figure 5-19. Location of groundwater contaminated by perchlorate; the concentrations in the areas indicated are above the 4 µg/L NM Consent Order screening level. 155
Figure 5-20. Perchlorate in Pueblo Canyon intermediate and regional aquifer groundwater. 158
Figure 5-21. Fluoride in Pueblo Canyon intermediate and regional aquifer groundwater. 158
Figure 5-23. Location of groundwater containing nitrate above one half of the 10 mg/L NM groundwater standard. 160
Figure 5-24. Nitrate (as nitrogen) in Pueblo and lower Los Alamos Canyon alluvial and intermediate groundwater 161
Figure 5-25. Total plutonium-239/240 activity in Pueblo Canyon alluvial groundwater. 161
Figure 5-26. Location of groundwater containing chloride above one half of the 250 mg/L NM groundwater standard 162
Figure 5-27. Tritium in Los Alamos Canyon intermediate groundwater 163
Figure 5-28. Nitrate (as nitrogen) in Los Alamos Canyon intermediate groundwater. 164
Figure 5-29. Perchlorate in Los Alamos Canyon intermediate groundwater. 164
Figure 5-30. Perchlorate in Los Alamos Canyon intermediate groundwater. 164

Figure 5-31. Strontium-90 in Los Alamos Canyon alluvial groundwater, showing both filtered and unfiltered results 165
Figure 5-32. Location of groundwater containing dissolved or hexavalent chromium above one half of the 50 µg/L NM groundwater standard.. 166
Figure 5-33. Filtered chromium in Sandia and Mortandad Canyon intermediate and regional aquifer groundwater..... 168
Figure 5-34. Nitrate (as nitrogen) in Sandia Canyon intermediate and regional aquifer groundwater.. 168
Figure 5-35. Fluoride in Sandia Canyon alluvial groundwater. 169
Figure 5-36. Perchlorate in Sandia Canyon surface water. 169
Figure 5-37. Perchlorate in Sandia Canyon alluvial groundwater. 169
Figure 5-38. Chloride in Sandia Canyon surface water. 170
Figure 5-39. Chloride in Sandia Canyon alluvial groundwater.. 170
Figure 5-40. Ratio of 1996–2009 average annual radionuclide activity in RLWTF discharges to the 100-mrem/yr public dose DOE DCGs, which are applicable to effluent releases..... 173
Figure 5-41. Ratio of 1996–2009 average annual nitrate plus nitrite (as nitrogen) and fluoride concentrations in RLWTF discharges to the NM groundwater standards. 173
Figure 5-42. Nitrate + nitrite (as nitrogen) in RLWTF effluent and Mortandad Canyon alluvial groundwater..... 174
Figure 5-43. Fluoride in RLWTF effluent and Mortandad Canyon alluvial groundwater. 174
Figure 5-44. Nitrate (as nitrogen) in Mortandad Canyon regional aquifer groundwater 175
Figure 5-45. Perchlorate in Mortandad Canyon regional aquifer well R-15..... 176
Figure 5-46. Nitrate (as nitrogen) in Mortandad Canyon intermediate groundwater. 176
Figure 5-47. Nitrate (as nitrogen) in Mortandad Canyon intermediate groundwater at Pine Rock Spring on Pueblo de San Ildefonso land. 176
Figure 5-48. Dioxane[1,4-] in Mortandad Canyon intermediate groundwater..... 177
Figure 5-49. Perchlorate in Mortandad Canyon intermediate groundwater; the Consent Order screening level is 4 µg/L. 177
Figure 5-50. Tritium in Mortandad Canyon intermediate groundwater. 178
Figure 5-51. Strontium-90 in Mortandad Canyon alluvial groundwater. For comparison purposes, the EPA MCL screening level is 8 pCi/L..... 179
Figure 5-52. Chloride in Mortandad Canyon surface water and alluvial groundwater. 180
Figure 5-53. Chloride in Mortandad Canyon surface water and alluvial groundwater. 180
Figure 5-54. Chloride histories for Mortandad Canyon alluvial groundwater. 181
Figure 5-55. Perchlorate in Mortandad Canyon alluvial groundwater..... 181
Figure 5-56. Trichloroethene in Pajarito Canyon regional aquifer well R-20 184
Figure 5-57. Location of groundwater containing RDX above one half of the EPA Human Health tap water screening level of 6.1 µg/L 185
Figure 5-58. RDX in Pajarito Canyon intermediate groundwater at Bulldog Spring 185
Figure 5-59. Histories for chloride in Pajarito Canyon intermediate groundwater at TA-3 wells 03-B-10 and 03-B-13 186
Figure 5-60. Histories at wells 03-B-10 and 03-B-13 for dichloroethene[1,1-] 187
Figure 5-61. Histories at wells 03-B-10 and 03-B-13 for 1,1,1–trichloroethane..... 187
Figure 5-62. Histories for chloride in Pajarito Canyon alluvial groundwater. 187
Figure 5-63. Histories for barium in Pajarito Canyon alluvial groundwater..... 188
Figure 5-64. Location of groundwater containing barium above one half of the NM groundwater standard of 1,000 µg/L. 190
Figure 5-65. Boron in Cañon de Valle tributary Martin Spring Canyon intermediate groundwater at Martin Spring..... 191
Figure 5-66. Boron in Cañon de Valle (tributary Martin Spring Canyon) alluvial groundwater..... 191
Figure 5-67. RDX in Cañon de Valle intermediate groundwater.. 192
Figure 5-68. RDX in Cañon de Valle intermediate groundwater.. 192
Figure 5-69. RDX in Cañon de Valle intermediate groundwater..... 192
Figure 5-70. Barium in Cañon de Valle alluvial groundwater.. 193
Figure 5-71. RDX in Cañon de Valle alluvial groundwater.. 193
Figure 5-72. Tetrachloroethene in Cañon de Valle alluvial and intermediate groundwater 194

Figure 5-73. Trichloroethene in Cañon de Valle alluvial and intermediate groundwater; the EPA MCL is 5 µg/L 194
Figure 6-1. Primary watersheds at Los Alamos National Laboratory. 208
Figure 6-2. Estimated storm water runoff in LANL canyons (Pueblo Canyon to Ancho Canyon) and precipitation at TA-6 during the months of June through October from 1995 through 2009. 210
Figure 6-3. Major drainages within Los Alamos National Laboratory land, showing designated stream segments. 213
Figure 6-4. Gaging stations sampled in 2009 within and in the vicinity of Los Alamos National Laboratory. 216
Figure 6-5. Other surface water locations sampled in 2009 within and in the vicinity of Los Alamos National Laboratory. 217
Figure 6-6. Surface water locations sampled in 2009 as part of a baseline PCB, metals, and gross alpha radiation study 218
Figure 6-7. Sediment locations sampled in 2009 within and in the vicinity of Los Alamos National Laboratory. 219
Figure 6-8. Sediment and storm water runoff sampling stations at TA-54 adjacent to MDA G. 220
Figure 6-9. Photograph of sample location along Rio Grande below the White Rock Overlook with the highest concentration of uranium-238 and other analytes. 222
Figure 6-10. Close-up of sampled layer at Location ID WR-609869, 0–8 cm deep, showing fine-grained sediment with mud cracks. 222
Figure 6-11. Variations in plutonium-239/240 concentration over time in active channel sediment in lower Pueblo Canyon 230
Figure 6-12. Variations in plutonium-239/240 concentration over time in active channel sediment in lower Acid Canyon 230
Figure 6-13. Variations in cesium-137 concentration over time in active channel sediment in lower DP Canyon. 231
Figure 6-14. Variations in americium-241 concentration over time in non-filtered surface water samples above Los Alamos Canyon weir (gage E042); all values above 0.05 pCi/L are detects. 231
Figure 6-15. Variations in plutonium-239/240 concentration over time in non-filtered surface water samples above Los Alamos Canyon weir (gage E042); all values above 0.04 pCi/L are detects. 232
Figure 6-16. Variations in strontium-90 concentration over time in non-filtered surface water samples in DP Canyon below TA-21 (gage E039); all values above 0.4 pCi/L are detects. 232
Figure 6-17. Average values for PCB congener homolog data from sediment samples collected in Los Alamos, Pueblo, and Sandia canyons. 233
Figure 6-18. Variations in chromium concentration over time in the active stream channel of Sandia Canyon below the wetland. 235
Figure 6-19. Variations in PCB concentration over time in the active stream channel of Sandia Canyon below t he wetland; values are the sum of detected Aroclors. 235
Figure 6-20. Variations in cesium-137 concentration over time in non-filtered surface water samples in Mortandad Canyon below Effluent Canyon (gage E200); all values are detects. 236
Figure 6-21. Variations in plutonium-238 concentration over time in non-filtered surface water samples in Mortandad Canyon below Effluent Canyon (gage E200); all values are detects. 236
Figure 6-22. Variations in tritium concentration over time in non-filtered surface water samples in Mortandad Canyon below Effluent Canyon (gage E200); all values above 130 pCi/L are detects. 237
Figure 6-23. Variations in cesium-137 concentration over time in active channel sediment in Mortandad Canyon below Effluent Canyon; most values are detects and are above the background value of 0.9 pCi/g. 237
Figure 6-24. Variations in plutonium-238 concentration over time in sediment in the MDA G-10.8 drainage in the Cañada del Buey watershed; all values are detects and are above the background value of 0.006 pCi/g. 238
Figure 6-25. Variations in zinc concentration over time in sediment at the MDA G-6 lower retention pond in the Pajarito Canyon watershed; all values are detects. 239
Figure 6-26. Time series of RDX concentrations in surface water samples from Cañon de Valle below MDA P (gage E256); all values are detects. 240
Figure 6-27. Photograph of sediment sampling area along the Rio Grande above Otowi Bridge; November 12, 2009. 243
Figure 6-28. Box plots comparing 2009 sediment sample results for barium along the Rio Grande with data from Abiquiu and Cochiti Reservoirs and the LANL sediment background data set. 244
Figure 6-29. Box plots comparing 2009 sediment sample results for chromium along the Rio Grande with data from Abiquiu and Cochiti Reservoirs and the LANL sediment background data set. 245
Figure 6-30. Box plots comparing 2009 sediment sample results for copper along the Rio Grande with data from Abiquiu and Cochiti Reservoirs and the LANL sediment background data set. 245

Figure 6-31. Relationships between barium concentration and silt and clay content in sediment samples collected along the Rio Grande and from Abiquiu and Cochiti Reservoirs and in the LANL sediment background data set. 246
Figure 6-32. Relationships between chromium concentration and silt and clay content in sediment samples collected along the Rio Grande and from Abiquiu and Cochiti Reservoirs and in the LANL sediment background data set. 246
Figure 6-33. Relationships between copper concentration and silt and clay content in sediment samples collected along the Rio Grande and from Abiquiu and Cochiti Reservoirs and in the LANL sediment background data set. 247
Figure 6-34. Average values for PCB congener homolog data from sediment samples collected along the Rio Grande, in lower Los Alamos Canyon, and from Ancho Canyon storm water. 248
Figure 7-1. On-site, perimeter, and regional soil sampling locations 258
Figure 7-2. Plutonium-239/240 concentrations in soil samples collected from three perimeter locations—across TA-8 (GT Site), west airport, and east airport stations.....259
Figure 7-3. Plutonium-239/240 concentrations in soil samples collected from the TA-21 (DP Site)..... 260
Figure 7-4. Americium-241 concentrations in soil samples collected from the TA-21 (DP Site) 260
Figure 7-5. Locations of soil samples collected around Area G in 2009.....262
Figure 7-6. Tritium in surface soil samples collected from the southern portions of Area G at TA-54 263
Figure 7-7. Americium-241 in surface soils collected from the northern, northeastern, and eastern portions of Area G 263
Figure 7-8. Plutonium-238 in surface soils collected from the northern, northeastern, and eastern portions of Area G 264
Figure 7-9. Plutonium-239/240 in surface soils collected from the northern, northeastern and eastern portions of Area G .. 264
Figure 7-10. Americium-241 in surface soil collected from the LANL/Pueblo of San Ildefonso boundary.....265
Figure 7-11. Plutonium-238 in surface soil collected from the LANL/Pueblo of San Ildefonso boundary 265
Figure 7-12. Soil, sediment, and biota sample locations at DARHT in 2009 266
Figure 7-13. Uranium-238 concentrations in surface soil collected within (near the firing point) and around the DARHT perimeter (north, west, south, and east side average) at TA-15 from 1996–1999 (pre-operations) to 2000–2009....267
Figure 7-14. Beryllium concentrations in soil collected within (near the firing point) and around the DARHT perimeter.....268
Figure 7-15. Soil sample locations along a 2.25-mile section on the north side of East Jemez Road.....269
Figure 7-16. Mean plutonium-239/240 concentrations in soil collected along a 2.25-mile section.....269
Figure 7-17. Mean total PCBs (± one standard deviation) in soil collected from alfalfa fields irrigated 271
Figure 7-18. The mean PCB homolog distribution in soil collected from alfalfa fields irrigated 272
Figure 8-1. Location of sampling reaches within the Rio Grande in relation to the location of LANL.....281
Figure 8-2. Collection of crayfish samples from the Rio Grande.....282
Figure 8-3. Times above the background of some TAL elements in whole body crayfish samples (n=3) collected from the Rio Grande directly downstream of LANL (Los Alamos Canyon) in 2009. 283
Figure 8-4. Mean (±1 standard deviation of results from six samples) total PCBs in whole body crayfish collected directly upstream (UpSm) and downstream (DnSm) of LANL (Los Alamos Canyon) in 2009 285
Figure 8-5. The mean PCB homolog distribution in whole body crayfish collected directly upstream and downstream of LANL (Los Alamos Canyon) in 2009 compared with various Aroclor profiles.....285
Figure 8-6. The PCB homolog distribution in muscle and bone tissues of a road-killed deer collected alongside Pajarito Road at TA-46 in 2009 compared with Aroclor 1242 and 1260 formulations. 287
Figure 8-7. Tritium in understory (US) and overstory (OS) vegetation collected from the south side of Area G 289
Figure 8-8. Uranium-238 in overstory vegetation collected from the north (N), east (E), south (S), and west (W) side of the DARHT facility at TA-15 from 1996–1999 (pre-operations) through 2000–2009 291
Figure 8-9. Uranium-238 concentrations in (whole body) mice (n = 5) collected from the north (N) and northeast (NE) side of the DARHT facility at TA-15 from 1997–1999 (pre-operations) through 2002–2009 291
Figure 8-10. Uranium-238 concentrations in bees collected from the northeast (NE) side of the DARHT facility at TA-15 from 1997–1999 (pre-operations) through 2003–2009 (during operations) 292
Figure 8-11. Populations, number of species, diversity, and evenness of birds occurring before (1999) and during (2009) operations at DARHT. 293
Figure 8-12. Radionuclide concentrations in whole body field mice samples collected on the upgradient 294
Figure 8-13. Mean concentrations of some of the TAL elements (mostly metals) in whole body mouse samples collected on the upgradient (2007-2008; n = 6) and downgradient (2009; n = 3) 295

Figure 8-14. Mean total PCB concentrations in whole body field mice collected on the upgradient side in 2007/08 296
Figure 8-15. Mean PCB homolog distribution for whole body field mice samples collected upgradient of the Los Alamos Canyon Weir compared with Aroclor 1260. 296
Figure 8-16. Mean total PCB concentrations in whole body field mice samples collected on the upgradient side of the Pajarito Canyon Flood Retention Structure from 2007 through 2009 297
Figure 8-17. Mean PCB homolog distribution of whole body field mice samples collected on the upgradient side of the Pajarito Canyon Flood Retention Structure from 2007 through and 2009 compared with Aroclor 1260...297
Figure 8-18. An artificial substrate (rock basket) sampler used to collect benthic macroinvertebrates in the Rio Grande.....299
Figure 8-19. An artificial substrate (rock basket) sampler is attached to a t-post set within pools in the Rio Grande; 299
Figure 9-1. Location of MDAs and other SWMUs or AOCs where remediation and/or characterization work was performed 315
Figure 9-2. Location of canyons and aggregate areas where remediation and/or characterization work was performed 315

TABLES

Table ES-1 Environmental Statutes under which LANL Operates and Compliance Status in 2009 7
Table ES-2 What are the Sources of Radiological Doses? 9
Table ES-3 Where Can We See LANL Impacts on Groundwater that Result in Values Near 12
Table ES-4 Where Can We See LANL Impacts on Surface Water that Result in Values Near or Above Screening Levels?....16
Table ES-5 Where Can We See LANL Impacts on Mesa-Top Surface Soil that Result in Values Near or Above Background or Screening Levels? 18
Table ES-6 Where Can We See LANL Impacts on Foodstuffs and Biota that Result in Values 20
Table 1-1 Key Facilities 33
Table 1-2 Approximate Numbers of Environmental Samples, Locations, and Analytes Collected in 2009..... 40
Table 2-1 Environmental Permits or Approvals under which the Laboratory Operated during 2009 50
Table 2-2 Environmental Inspections and Audits Conducted at the Laboratory during 2009 52
Table 2-3 Compliance with Emergency Planning and Community Right-to-Know Act during 2009 57
Table 2-4 Summary of 2009 Reported Releases under EPCRA Section 313.....58
Table 2-5 Herbicides and Pesticides Used at LANL in 2009 59
Table 2-6 Calculated Emissions of Regulated Air Pollutants Reported to NMED in 2009 60
Table 2-7 Volume of Effluent Discharge from NPDES Permitted Outfalls in 2009.....63
Table 2-8 Wells and Boreholes Installed in 2009 71
Table 2-9 Threatened, Endangered, and Other Sensitive Species Occurring or Potentially Occurring at LANL 73
Table 3-1 LANL Radiological Dose for Calendar Year 2008 87
Table 4-1 Average Background Concentrations of Radioactivity in the Regionala Atmosphere.....95
Table 4-2 Airborne Long-Lived Gross Alpha Concentrations for 2009 — Group Summaries 100
Table 4-3 Airborne Long-Lived Gross Beta Concentrations for 2009 — Group Summaries.....100
Table 4-4 Airborne Tritium as Tritiated Water Concentrations for 2009 — Group Summaries 103
Table 4-5 Airborne Plutonium-238 Concentrations for 2009 — Group Summaries 104
Table 4-6 Airborne Plutonium-239/240 Concentrations for 2009 — Group Summaries.....104
Table 4-7 Airborne Americium-241 Concentrations for 2009 — Group Summaries 106
Table 4-8 Airborne Uranium-234 Concentrations for 2009 — Group Summaries.....107
Table 4-9 Airborne Uranium-235 Concentrations for 2009 — Group Summaries.....107
Table 4-10 Airborne Uranium-238 Concentrations for 2009 — Group Summaries.....107
Table 4-11 Airborne Radioactive Emissions from LANL Buildings with Sampled Stacks in 2009 (Ci)..... 111
Table 4-12 Detailed Listing of Activation Products Released from Sampled LANL Stacks in 2009 (curies)..... 113
Table 4-13 Radionuclide Half-Lives 113
Table 4-14 PM-2.5 and PM-10 Concentration Data Summary for 2009 (µg/m3)..... 117
Table 4-15 Monthly and Annual Climatological Data for Los Alamos During 2009 121

Table 5-1 Application of Standards or Screening Levels to LANL Groundwater Monitoring Data 138
Table 5-2 Total Number of Groundwater Sample Results Collected by LANL in 2009 144
Table 5-3 Total Number of Groundwater Sample Results above Screening Levels in 2009 144
Table 5-4 Groundwater Analytes with Results above Screening Levels in 2009 146
Table 5-5 Radioactivity results above screening levels in regional aquifer groundwater for 2009 151
Table 5-6 Radioactivity results near screening levels in intermediate groundwater for 2009 151
Table 5-7 Radioactivity results above screening levels in alluvial groundwater for 2009 152
Table 5-8 Summary of Groundwater Contamination in Guaje Canyon (includes Rendija and Barrancas Canyons) 156
Table 5-9 Groundwater Quality in Guaje Canyon (includes Rendija and Barrancas Canyons) 156
Table 5-10 Summary of Groundwater Contamination in Los Alamos Canyon 156
Table 5-11 Groundwater Quality in Pueblo Canyon (includes Acid Canyon) 157
Table 5-12 Groundwater Quality in Los Alamos Canyon (includes DP Canyon) 163
Table 5-13 Summary of Groundwater Contamination in Sandia Canyon 165
Table 5-14 Groundwater Quality in Sandia Canyon 167
Table 5-15 Summary of Groundwater Contamination in Mortandad Canyon (includes Ten Site Canyon and Cañada del Buey) 171
Table 5-16 Groundwater Quality in Mortandad Canyon (includes Ten Site Canyon and Cañada del Buey) 171
Table 5-17 Summary of Groundwater Contamination in Pajarito Canyon (includes Twomile and Threemile Canyons) 182
Table 5-18 Groundwater Quality in Pajarito Canyon (includes Twomile and Threemile Canyons) 182
Table 5-19 Summary of Groundwater Contamination in Water Canyon (includes Cañon de Valle, Potrillo, Fence, and Indio Canyons) 188
Table 5-20 Groundwater Quality in Water Canyon (includes Cañon de Valle, Potrillo, Fence, and Indio Canyons) 189
Table 5-21 Summary of Groundwater Contamination in Ancho Canyon 195
Table 5-22 Summary of Groundwater Contamination in White Rock Canyon Springs 195
Table 5-23 Groundwater Quality in White Rock Canyon Springs 195
Table 5-24 Summary of Groundwater Contamination in White Rock Canyon Wells 196
Table 5-25 Groundwater Quality in White Rock Canyon Wells 196
Table 5-26 Secondary Data Validation Summary for Estimated Data 198
Table 5-27 Secondary Data Validation Summary for Rejected Data 198
Table 5-28 2009 Performance Evaluation Results at GEL 199
Table 6-1 Application of Surface Water and Sediment Standards and Screening Levels to Monitoring Data 212
Table 6-2 Summary of Results for Select Metals in Surface Water Samples from 2009 224
Table 7-1 Application of Soil Standards and Other Reference Levels to LANL Monitoring Data 256
Table 7-2 Location of Alfalfa Fields Sampled for PCBs 270
Table 8-1 Standards and Other Reference Levels Applied to Fish 281
Table 8-2 Locations, Types, and Numbers of Fish Collected 288
Table 9-1 Work Plans Submitted and/or Approved in 2009 308
Table 9-2 Reports Submitted and/or Approved in 2009 310
Table 9-3 Additional Plans and Reports Submitted in 2009 312
Table 9-4 Vapor Monitoring Locations 316
Table A-1 DOE Dose Limits for External and Internal Exposures 356
Table A-2 DOE's Derived Concentration Guides for Watera 357
Table A-3 National (40 CFR 50) and New Mexico (20.2.3 NMAC) Ambient Air Quality Standards 358
Table B-1 Approximate Conversion Factors for Selected US Customary Units 361
Table B-2 Prefixes Used with SI (Metric) Units 362
Table B-3 Common Measurement Abbreviations and Measurement Symbols 362

SUPPLEMENTAL DATA TABLES (INCLUDED ON ATTACHED CD)

Table S2-1 NPDES Outfall Data 2009.xls
Table S2-2 NPDES Outfall Field Data for 2009.xls
Table S4-1 Measured biweekly concentrations of gross alpha activity 2009.xls
Table S4-2 Measured biweekly concentrations of gross beta activity 2009.xls
Table S4-3 Measured biweekly concentrations of tritium activity 2009.xls
Table S4-4 Measured quarterly concentrations of plutonium-238 activity 2009.xls
Table S4-5 Measured quarterly concentrations of plutonium-239 activity 2009.xls
Table S4-6 Measured quarterly concentrations of americium-241 activity 2009.xls
Table S4-7 Measured quarterly concentrations of uranium-234 activity 2009.xls
Table S4-8 Measured quarterly concentrations of uranium-235 activity 2009.xls
Table S4-9 Measured quarterly concentrations of uranium-238 activity 2009.xls
Table S4-10 Neutron and Gamma Doses 2009.xls
Table S5-1 09 Other Code Definitions.xls
Table S5-2 09 GW Radiochemistry.xls
Table S5-3 09 GW Low-detect Tritium.xls
Table S5-4 09 GW Rad Screening.xls
Table S5-5 09 Lab Qual Codes.xls
Table S5-6 09 Secondary Validation Flag Codes.xls
Table S5-7 09 Secondary Validation Reason Codes.xls
Table S5-8 09 GW Gen Inorganic Chem.xls
Table S5-9 09 GW Perchorate.xls
Table S5-10 09 GW Metals.xls
Table S5-11 09 GW Organic Samples Collected.xls
Table S5-12 09 GW Organic Detections.xls
Table S5-13 Summary of TA-50 Radionuclide, Nitrate, and Fluoride Discharges.xls
Table S6-1 Radiochemical Analyses of Surface Water for 2009.xls
Table S6-2 Trace Level Tritium Measurements in Surface Water for 2009.xls
Table S6-3 Radionuclides in Stream Sediments for 2009.xls
Table S6-4 General Chemical Quality of Surface Water for 2009.xls
Table S6-5 Metals in Surface Water for 2009.xls
Table S6-6 Metals in Sediments for 2009.xls
Table S6-7 Organic Chemical Analyses of Surface Water in 2009.xls
Table S6-8 Organic Chemicals Detected in Surface Water for 2009.xls
Table S6-9 Organic Chemical Analyses in Sediments for 2009.xls
Table S6-10 Organic Chemicals Detected in Sediments in 2009.xls
Table S6-11 Particle Size Data for Sediment Samples for 2009.xls
Table S7-1 Radionuclide Concentrations in Soils from Perimeter and LANL.xls
Table S7-2 Target Analyte List Elements in Soils Collected from Perimeter and LANL.xls
Table S7-3 High Explosives in Soil Collected from Perimeter and LANL Locations.xls
Table S7-4 Polychlorinated Byphenal Arochlors in Soil Collected from Perimeter.xls
Table S7-5 Semivolatile Organic Compounds in Soil Collected from Perimeter.xls

Table S7-6 Concentrations of Selected Radionuclides in Soil Collected Around Area G.xls
Table S7-7 Radionuclide Concentrations in Soil and Sediment Collected Around DARHT.xls
Table S7-8 TAL Elements in Soil and Sediment from DARHT.xls
Table S7-9 High Explosive Concentrations in Soil Collected from DARHT.xls
Table S7-10 Cesium-137, Plutonium-238 and Plutonium-239,240 Concentrations along E Jemez Road.xls
Table S7-11 Radionuclide Concentrations in Soil Collected from Alfalfa Fields.xls
Table S7-12 TAL Elements in Soil Collected from Alfalfa Fields.xls
Table S7-13 High Explosives in Soil from Alfalfa Fields.xls
Table S7-14 Semivolatile Organic Compounds in Soil from Alfalfa Fields.xls
Table S7-15 PCB Congeners in Soil from Alfalfa Fields.xls
Table S8-1 Radionuclides in Composite Samples of Whole Body Crayfish.xls
Table S8-2 TAL Elements in Whole Body Crayfish.xls
Table S8-3A Weights, Percent Lipids, and PCB Concentrations in Whole Body Crayfish.xls
Table S8-3B PCB Congener and Homolog Distributions in Whole Body Crayfish.xls
Table S8-4 Radionuclide Concentrations in Muscle and Bone of Road Killed Deer.xls
Table S8-5 TAL Element Concentrations in Muscle and Bone of Deer.xls
Table S8-6 PCB Congener and Homolog Distributions in Muscle and Bone of Deer.xls
Table S8-7 Radionuclide Concentrations in Native Overstory Vegetation.xls
Table S8-8 TAL Elements in Native Overstory Vegetation Collected from Perimeter.xls
Table S8-9 Concentrations of Selected Radionuclides in Native Overstory Vegetation.xls
Table S8-10 Radionuclide Concentrations in Native Overstory Vegetation.xls
Table S8-11 TAL Elements in Native Overstory Vegetation.xls
Table S8-12 Radionuclide Concentrations in a Composite Field Mouse.xls
Table S8-13 TAL Elements in a Field Mouse.xls
Table S8-14 Radionuclide Concentrations in Honey Bees Collected from DARHT.xls
Table S8-15 TAL Elements in Honey Bees Collected DARHT.xls
Table S8-16 Populations, Composition, and Diversity of Birds Collected near the DARHT Facility.xls
Table S8-17 TAL Elements in Birds Colleted North and NE of DARHT.xls
Table S8-18A Radionuclides in Field Mouse Samples Collected Downgradient of LA Weir.xls
Table S8-18B TAL Elements in Field Mouse Samples Collected Downgradient of LA Weir.xls
Table S8-19 PCB Congeners, Homologs, and Totals in Field Mice Downgradient of LA Weir.xls
Table S8-20 Rad in Vegetation and Mouse Upgradient of Paj Flood Ret Structure.xls
Table S8-21 TAL Elements in Vegetation and Mouse Upgradient of Paj Flood Ret Structure.xls
Table S8-22 PCB in Mice Upgradient of Paj Flood Ret Structure.xls
Table S8-23 Rad in Alfalfa Irrigated with Rio Grande Waters Upstream and Downstream of LANL.xls
Table S8-24 TAL Elements in Alfalfa Irrigated with Rio Grande Waters Upstream and Downstream of LANL.xls
Table S8-25 Phys and Chem Characteristics of Water from Rio Grande at Macroinv Traps.xls
Table S8-26 Benthic Macroinvertebrate Taxa and Abundance in the Rio Grande.xls
Table S8-27 Benthic Macroinvertebrate Bioassessment of the Rio Grande.xls

Abstract

Environmental Surveillance at Los Alamos reports are prepared annually by the Los Alamos National Laboratory (the Laboratory) environmental organization, as required by US Department of Energy Order 5400.1, *General Environmental Protection Program,* and US Department of Energy Order 231.1A, *Environment, Safety, and Health Reporting*.

These annual reports summarize environmental data that are used to determine compliance with applicable federal, state, and local environmental laws and regulations, executive orders, and departmental policies. Additional data, beyond the minimum required, are also gathered and reported as part of the Laboratory's efforts to ensure public safety and to monitor environmental quality at and near the Laboratory.

Chapter 1 provides an overview of the Laboratory's major environmental programs and explains the risks and the actions taken to reduce risks at the Laboratory from environmental legacies and waste management operations. Chapter 2 reports the Laboratory's compliance status for 2009. Chapter 3 provides a summary of the maximum radiological dose the public and biota populations could have potentially received from Laboratory operations and discusses chemical exposures. The environmental surveillance and monitoring data are organized by environmental media (air in Chapter 4; water and sediments in Chapters 5 and 6; soils in Chapter 7; and foodstuffs and biota in Chapter 8) in a format to meet the needs of a general and scientific audience. Chapter 9 provides a summary of the status of environmental restoration work around LANL. The new Chapter 10 describes the Laboratory's environmental stewardship efforts and provides an overview of the health of the Rio Grande. A glossary and a list of acronyms and abbreviations are in the back of the report. Appendix A explains the standards for environmental contaminants, Appendix B explains the units of measurements used in this report, Appendix C describes the Laboratory's technical areas and their associated programs, and Appendix D provides web links to more information.

In printed copies of this report, we have also enclosed a compact disc with a copy of the full report in Adobe Acrobat (PDF) format and detailed supplemental tables of data from 2009 in Microsoft Excel format. These files are also available for download from the web.

An on-line web survey for providing comments, suggestions, and other input on the report is available at the web address given below. Inquiries or comments regarding these annual reports may be directed to

US Department of Energy Office of Environmental Operations 3747 West Jemez Road Los Alamos, NM 87544 Telephone: 505-667-5491	or	Los Alamos National Laboratory WES Division P.O. Box 1663, MS M992 Los Alamos, NM 87545 Telephone: 505-667-0808

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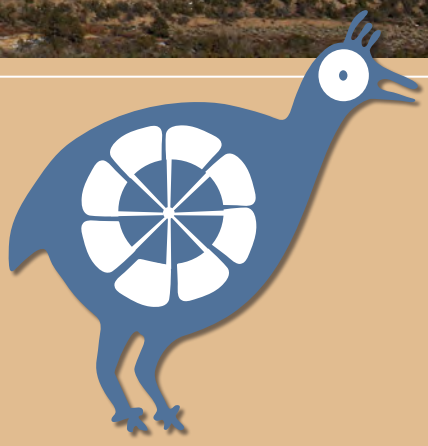
ESR Coordinator
Los Alamos National Laboratory
P.O. Box 1663, MS M992
Los Alamos, NM 87545
Telephone: 505-665-0636
e-mail: dewart@lanl.gov

This report is also available on the World Wide Web at
http://www.lanl.gov/environment/all/esr.shtml

Environmental Surveillance at Los Alamos during 2009

Executive Summary





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Executive Summary

Los Alamos National Laboratory (LANL or the Laboratory) is located in Los Alamos County in north-central New Mexico (NM), approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe (Figure ES-1). The 40-square-mile Laboratory is situated on the Pajarito Plateau, a series of mesas separated by deep east-to-west-oriented canyons cut by stream channels. Mesa tops range in elevation from approximately 7,800 feet on the flanks of the Jemez Mountains to about 6,200 feet above the Rio Grande at White Rock Canyon. Most Laboratory and Los Alamos County community developments are confined to the mesa tops. With the exception of the towns of Los Alamos and White Rock, the surrounding land is largely undeveloped, and large tracts of land north, west, and south of the Laboratory site are held by the Santa Fe National Forest, the US Bureau of Land Management, Bandelier National Monument, the US General Services Administration, and Los Alamos County. In addition, Pueblo de San Ildefonso borders the Laboratory to the east.

The mission of LANL is to develop and apply science and technology to (1) ensure the safety and reliability of the US nuclear deterrent, (2) reduce global threats, and (3) solve other emerging national security challenges. Meeting this diverse mission requires excellence in science and technology to solve multiple national and international challenges. Inseparable from the Laboratory's focus on excellence in science and technology is its commitment to environmental stewardship and full compliance with environmental protection laws. Part of LANL's commitment is to report on its environmental performance. This report

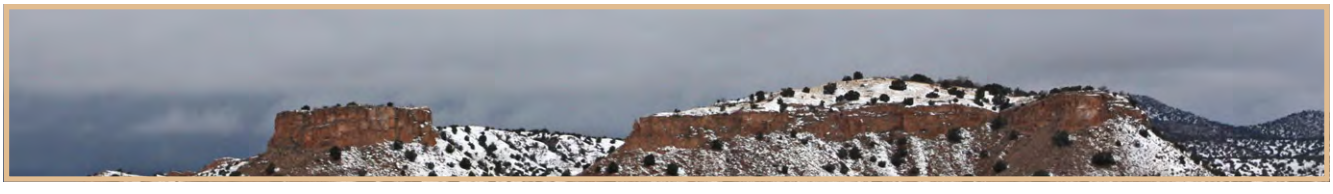
- characterizes LANL's environmental management, including effluent releases, environmental monitoring, and estimated radiological doses to the public and the environment,
- summarizes environmental occurrences and responses,
- confirms compliance with environmental standards and requirements, and
- highlights significant programs and efforts.

Environmental Management System

As part of its commitment to protect the environment and improve its environmental performance, LANL continued the implementation of its Environmental Management System (EMS) pursuant to US Department of Energy (DOE) Order 450.1A and the international standard ISO14000-2004. DOE defines an EMS as "a continuous cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental missions and goals." The EMS provides a systematic method for assessing mission activities, determining the environmental impacts of those activities, prioritizing improvements, and measuring results.

- ***A recertification audit in 2009 by an independent registrar found that the Laboratory's EMS met all requirements for certification.***
- ***NNSA again recognized the success of the EMS management by giving the Laboratory the 2009 NNSA "Best in Class Award" and the "DOE E-Star" Award for institutional improvements made through the EMS from 2006 through 2008.***

In April 2006, LANL became the first National Nuclear Security Agency (NNSA) national laboratory and the first University of California-operated facility to receive full certification of its EMS. LANL's EMS was re-certified in 2009 after a thorough re-certification audit found that all requirements for certification were met. The auditors also noted that there was significant evidence that the EMS was maturing as a management system and that significant risk reduction measures were in place and working. Additionally, the program received NNSA's "Best in Class" Award and the "DOE E-Star" for the institutional improvements identified and implemented through the EMS from 2006 through 2008.



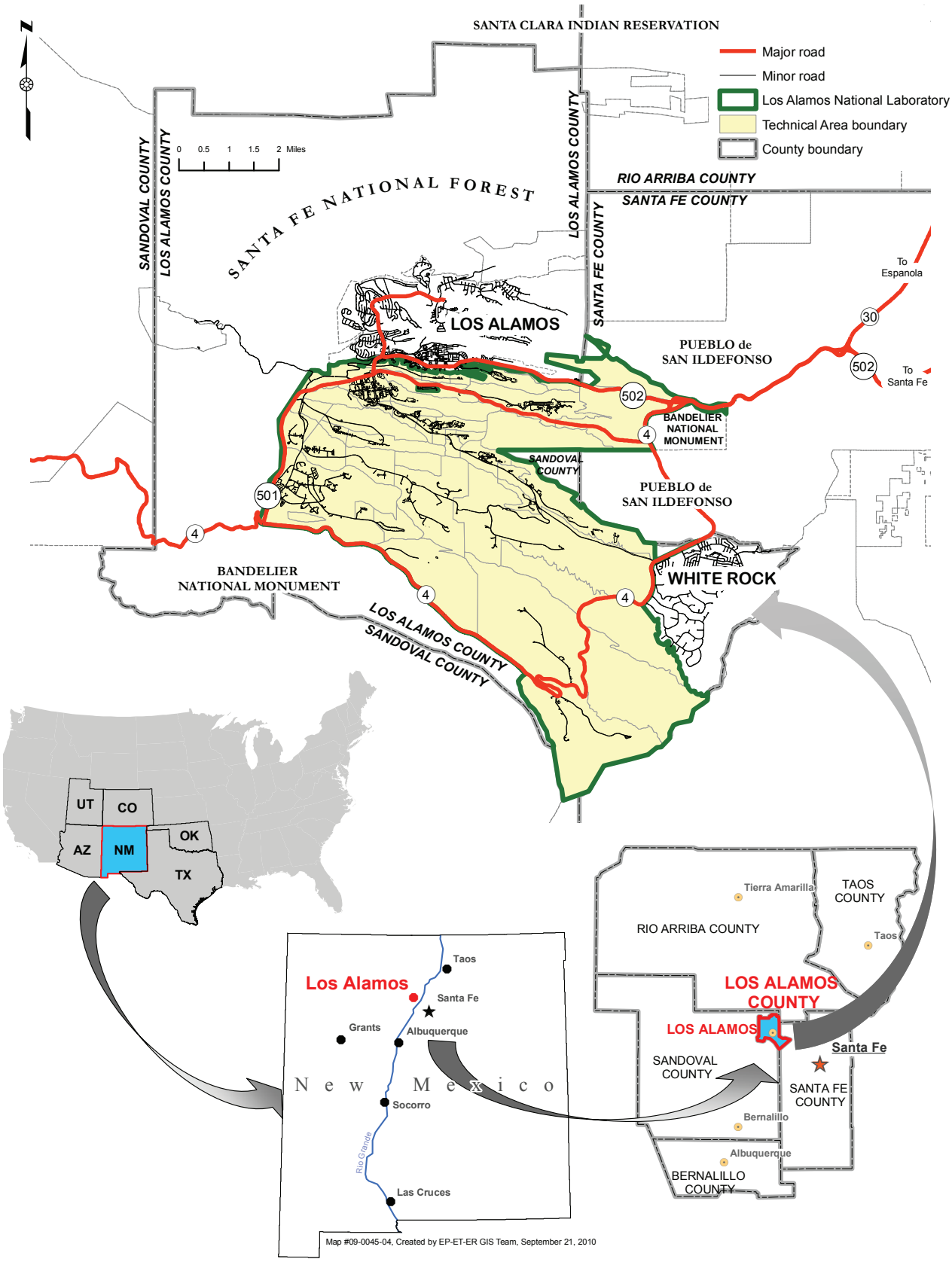


Figure ES-1. Regional location of Los Alamos National Laboratory.

The Pollution Prevention Program implements waste minimization, pollution prevention, sustainable design, and conservation projects to enhance operational efficiency, reduce life-cycle costs of programs or projects, and reduce risk to the environment. Reducing waste directly contributes to the efficient performance of the Laboratory's national security, energy, and science missions. LANL was awarded four NNSA awards in 2009:

The NNSA Best in Class Awards are as follows:

- RCRA-less Oxidation approach: replaces toxic Resource Conservation and Recovery Act (RCRA)-listed salts with non-toxic reagents for actinide separation schemes
- Radiological Laboratory/Utility/Office Building (RLUOB) Integrated Planning, Design, Procurement, and Construction: approximately 85% (by weight) of RLUOB construction waste was recycled or reused

The NNSA Environmental Stewardship Awards are as follows:

- Electronic Recycling Program: a new electronics recycling program shipped 93,554 lbs of e-waste to a company at Terrell, TX, where the electronics are crushed and recycled
- Alternative Fuel Use: At the end of 2009, one-half of LANL's fleet of vehicles was flex-fuel and 75 percent of the security officers' fleet in Los Alamos was powered by E-85 fuel

Federal Facility Compliance Agreement

The Laboratory's Federal Facility Compliance Agreement (FFCA), in effect since 2005, was replaced in February 2009 by an Individual Permit (IP) issued by the US Environmental Protection Agency (EPA). The permit became effective on April 1 and was subsequently appealed by a coalition of regional citizens' groups. Since that time, the final conditions of the IP continue to be negotiated under a proposed settlement agreement between Los Alamos National Security, LLC, DOE, EPA, and the citizens' groups. As a result of the permit appeal negotiations, it is expected that issuance of a modified IP will have requirements different from the original 2009 permit. During 2009, the DOE and the Laboratory continued to monitor and sample storm water under the previous requirements of the FFCA with the EPA and the NM Environment Department (NMED). LANL installed 52 new site-specific surface water samplers, maintained 60 runoff gage stations, collected 85 storm water samples, installed 150 new erosion control measures, and conducted over 1,000 inspections at 290 sites.

Compliance Order on Consent

The March 2005 Compliance Order on Consent (the Consent Order) between LANL, DOE, and NMED is the principal regulatory driver for LANL's environmental restoration programs. The Consent Order contains requirements for investigation and cleanup of solid waste management units (SWMUs) and areas of concern (AOCs) at the Laboratory. The major activities conducted by the Laboratory included investigations and cleanup actions. All major deliverables of the Consent Order were met by the Laboratory during 2009. The projects wrote and/or revised 26 work plans and 22 reports and submitted them to NMED. A total of 181 documents or reports were submitted to NMED. In October 2009, the NMED Hazardous Waste Bureau issued a Notice of Violation to DOE and LANL for alleged violations during the 2009 RCRA compliance inspection, though no penalty was assessed because these findings were adequately addressed during the inspection. DOE and LANS paid NMED penalties of $126,000 for a report that did not contain all the monitoring data required. DOE paid a penalty of $1,300,000 for failing to complete the plugging and abandonment of a well by the specified deadline.

- ***The Consent Order is the principal regulatory driver for the Laboratory's environmental restoration activities and the Water Stewardship Program. It specifies actions that the Laboratory must complete to characterize contaminated sites and monitor the movement of contaminants.***
- ***The Laboratory met all major deliverables of the Consent Order.***
- ***The NMED issued two Notices of Violation to LANL and DOE related to issues found during a RCRA inspection and for failing to plug and abandon a well by the specified date.***

Design of Surveillance System and Sample Locations

The Laboratory uses data from monitoring (surveillance) of known release points and multiple receptors (people, air, water, soil, sediment, foodstuffs, plants, and animals) over a long time period as a basis for policy and to determine actions to protect the environment. We collect data from the surrounding region to establish baseline environmental conditions in areas not influenced by LANL operations. We conduct regional monitoring to determine whether LANL operations are impacting areas beyond LANL's boundaries. Examples of regional monitoring include the radiological ambient air sampling network (AIRNET); soil, foodstuffs, and biota (plants and animals) sampling as far away as Dixon, NM (40 direct miles away); and sediment monitoring along the Rio Grande as far upriver as Abiquiu Reservoir and downriver as Cochiti Reservoir. We also collect data on-site and at the Laboratory perimeter to determine if operations are impacting LANL or neighboring properties (e.g., ueblo and Los Alamos County lands). Perimeter monitoring also measures the highest potential impact to the public. To better quantify releases, we monitor at specific discharge or release points or other locations on LANL property that are known to or have the potential to release contaminants. During 2009, the Laboratory collected almost 9,400 environmental monitoring samples from more than 700 locations and received almost 249,000 analyses or measurements on these samples.

Risk Reduction

Risk is evaluated either as current (present-day) or prospective (future) risk. The Laboratory assesses hazards and the corresponding risks by evaluating environmental data, measurements, inventories of buried or stored materials, and potential exposure pathways and scenarios. We use models, data, and computer programs to assist with these estimates.

- ***Past risk reduction successes include the reduction in the number of outfalls (plant and process discharges) and the volume of water released from them, the reduction in air emissions over the past several years, changes to effluent treatment processes at the TA-50 Radioactive Liquid Waste Treatment Facility, and the removal of contaminated material and waste at former waste disposal sites.***
- ***Ongoing risk reduction efforts include the transport of waste from Area G to permanent disposal at WIPP, studies of the movement of contaminants in groundwater, and planned or active cleanup operations at former waste and radionuclide processing sites.***

Over the years, the Laboratory has decreased its release of materials into the environment and has reduced the amount of legacy contamination. Examples include the reduction in both the number of outfalls (plant and process discharges) and the volume of water released, the reduction in air emissions, changes to effluent treatment processes at the Technical Area (TA)-50 Radioactive Liquid Waste Treatment Facility (RLWTF), and the removal of contaminated material and waste at sites such as Material Disposal Area (MDA) P. These efforts have significantly reduced or eliminated potential exposure and risk to workers, the public, and the environment.

Examples of ongoing risk reduction activities include the transport of stored legacy transuranic waste from Area G to the Waste Isolation Pilot Plant (WIPP) in Carlsbad, NM, the planned cleanup and remediation of the former plutonium processing facility at TA-21, ongoing studies of groundwater contamination to evaluate future hazards and risks, and numerous investigations and corrective actions at potentially contaminated sites.

Compliance

The Laboratory uses the status of compliance with environmental requirements as a key indicator of its environmental performance. Federal and state regulations provide specific requirements and standards to implement these statutes and maintain environmental quality. The EPA and NMED are the principal administrative authorities for these laws. The Laboratory is also subject to DOE requirements for control of radionuclides. Table ES-1 presents a summary of the Laboratory's status in regard to environmental statutes and regulations for 2009.



Table ES-1
Environmental Statutes under which LANL Operates and Compliance Status in 2009

Federal Statute	What it Covers	Status
Resource Conservation and Recovery Act (RCRA)	Generation, management, and disposal of hazardous waste and cleanup of inactive, historical waste sites	The Laboratory completed 1,467 self-assessments that resulted in a non-conformance finding rate of 3.07%. All major deliverables required by the Consent Order were submitted to NMED on time. NMED issued a Notice of Violation to DOE and LANL for alleged violations during the compliance inspection, though no penalty was assessed because these findings were adequately addressed during the inspection. DOE and LANS paid NMED penalties of $126,000 for a report that did not contain all the monitoring data required.DOE paid a penalty of $1,300,000 for failing to complete the plugging and abandonment of a well by the specified deadline. LANL discovered three issues with hazardous waste packaging or labeling. All instances were corrected and did not result in actual or potential hazards to the environment or personnel. LANL is in compliance with groundwater monitoring requirements. LANL installed eight intermediate perched and six regional aquifer wells.
Clean Air Act	Air quality and emissions into the air from facility operations	The Laboratory was well below all permit limits for emissions to the air. Non-radiological air emissions were very similar to emissions over the previous four years and remain relatively constant. The annual dose to the maximally exposed individual (MEI) from radioactive air emissions was 0.55 mrem, which is the same as the very low dose for the previous year. LANL provided the first greenhouse gas emissions report to NMED. LANL removed 7,914 lbs of ozone-depleting refrigerants from inventory.
Comprehensive Environmental Response and Liability Act	Pollution and contaminants on property	No land transfers occurred in 2009. The LANL Natural Resource Trustee Council completed a pre-assessment screen in November 2009 and determined that a full-scale assessment is appropriate.
Clean Water Act	Water quality and effluent discharges from facility operations	Seven of 1,361 samples collected from industrial outfalls and none of the 76 samples collected from the Sanitary Wastewater Systems Plant's outfall exceeded effluent limits. Exceedences were for pH, residual chlorine levels, total suspended solids, or polychlorinated biphenyl (PCB) level concentration. The Laboratory conducted 471 storm water inspections and 99% of the Laboratory's 52 permitted construction sites were compliant with National Pollutant Discharge Elimination System requirements. The new Individual Permit (IP) was issued by EPA but subsequently appealed and implementation suspended. Under former Federal Facility Compliance Agreement (FFCA) requirements, the Laboratory installed 52 new site-specific surface water samplers, maintained 60 runoff gage stations, collected 85 storm water samples, installed 150 new erosion control measures, and conducted over 1,000 inspections at 290 sites.
Groundwater Discharge Plans	Discharges of water to groundwater	The Laboratory operated under one approved and two pending Discharge Plans submitted to or approved by the NMED. The approved plan regulates discharges from the sanitary wastewater treatment facility at TA-46 and the pending plans cover the TA-50 RLWTF and 21 domestic septic systems.
Aboveground Storage Tank Compliance Program	Liquid storage tank monitoring and compliance	Three tank systems were closed out with NMED in 2009. Three tank systems are operational and four are under temporary closure status. LANL completed additional characterization of the 2002 diesel release from a tank at TA-21.
Toxic Substances Control Act	Chemicals such as PCBs	The Laboratory shipped 263 containers of PCB waste, 1,941 lbs of capacitors, and 2,605 lbs of fluorescent light ballasts for disposal or recycling to EPA-permitted disposal and treatment facilities.
Federal Insecticide, Fungicide, and Rodenticide Act	Storage and use of pesticides and herbicides	The Laboratory remained in compliance with regulatory requirements regarding use of pesticides and herbicides. The Laboratory used 76.75 oz of insecticides, 127 gal. of herbicides, 600 lbs of fertilizers, 3,392 lbs plus 5.5 gal. of water treatment chemicals, and 5 gal. of color marker.

Table ES-1 (continued)

Federal Statute	What it Covers	Status
Emergency Planning and Community Right-to-Know Act	The public's right to know about chemicals released into the community	The Laboratory reported releases, waste disposal, and waste transfers totaling 9,790 lbs of lead, mostly at the firing range. No updates to Emergency Planning Notifications were necessary in 2009. Chemical Inventory Reports were updated to the Los Alamos County fire and police departments for 20 chemicals or explosives. There were no releases that triggered state or federal reporting requirements.
Endangered Species Act (ESA) and Migratory Bird Treaty Act (MBTA)	Rare species of plants and animals	The Laboratory maintained compliance with the ESA and MBTA and reviewed 612 excavation permits, 115 project profiles, and seven storm water plans for potential impacts to threatened or endangered species. The Laboratory conducted annual surveys for Mexican spotted owl, southwestern willow flycatcher, Jemez Mountains salamander, and grey vireo.
National Historic Preservation Act (NHPA) and others	Cultural resources	The Laboratory maintained compliance with the NHPA. The Laboratory conducted 40 projects that required some field verification of previous survey information and identified 21 new archaeological sites and seven new historic buildings. Five historic buildings were determined eligible for the National Register of Historic Places.
National Environmental Policy Act	Projects evaluated for environmental impacts	The Laboratory and NNSA released a second limited Record of Decision in July 2009 that accepts six additional elements of the Expanded Operations Alternative in the Site-wide Environmental Impact Statement of 2008.

Unplanned Releases

There were no unplanned airborne releases and no unplanned releases of radioactive liquids from LANL in 2009. There were 28 spills or releases of non-radioactive liquids, most of which were potable water, steam condensate, or domestic wastewater. Other liquids included propylene glycol, diesel fuel, hydraulic fluid, and groundwater communicating from upper aquifers to lower aquifers in monitoring wells. LANL reported all liquid releases to NMED; the releases will be administratively closed upon final inspection.

Radiological Dose Assessment

- ***As in 2008, the location of the hypothetical maximally exposed individual (MEI) for airborne radionuclides was determined to be at East Gate near the eastern edge of Los Alamos. This location received a combination of low levels of radiation from LANSCE and other stack emissions.***
- ***Radiation dose to the MEI was the same as the very low level calculated in 2008.***

Humans, plants, and animals potentially receive radiation doses from various Laboratory operations (Table ES-2). The DOE dose limits for the public and biota are the mandated criteria that are used to determine whether a measurement represents a potential exposure concern. Figure ES-2 shows doses to the hypothetical maximally exposed individual (MEI) via the air pathway over the last 10 years at an off-site location; this location was at East Gate in 2009, as it was in 2008 and in all years before 2006. (In 2006, it was at the Los Alamos County Airport terminal and in 2007 at a location along DP Road.) The annual dose to the MEI for the airborne pathway was approximately 0.55 mrem, the same as in 2008, and well under the regulatory limit of 10 mrem (Figure ES-2). During 2009, the population within 80 km of LANL received a collective dose of about 0.57 person-rem, down from 0.79 person-rem in 2008. The doses received in 2009 from LANL operations by an average Los Alamos residence and an average White Rock residence totaled about 0.035 mrem and 0.025 mrem, respectively. The maximum all-pathways dose, composed almost entirely of direct radiation from waste stored at TA-54, Area G, could result in an exposure of 1 mrem per year to a hypothetical individual in the adjacent sacred area of Pueblo de San Ildefonso.

Biota Dose

The DOE biota dose limits are intended to protect populations of plants and animals, especially with respect to preventing the impairment of reproductive capability within the biota population. All radionuclide concentrations

in vegetation sampled were far below the plant 0.1 rad/day biota dose screening level (10% of 1 rad/day dose limit), and all radionuclide concentrations in terrestrial animals sampled were far below the terrestrial animal 0.01 rad/day biota dose screening level (10% of 0.1 rad/day dose limit) (Table ES-2).

Table ES-2
What are the Sources of Radiological Doses?

Source	Recipient	Dose	Location	Trends
Background (includes human-made sources)	Humans	~700 mrem/yr*	Not applicable	Not applicable
Air	Humans	0.55 mrem/yr	East Gate in eastern Los Alamos	Similar to very low level in previous two years
Direct radiation	Humans	1 mrem/yr	San Ildefonso – offsite	Same as previous year
Food	Humans	<0.1 mrem/yr	All sites	Steady
Drinking water	Humans	<0.1 mrem/yr	All sites	Steady
All	Terrestrial animals	<20 mrad/day	TA-15 "EF site," TA-21 MDA B	Steady
All	Terrestrial plants	<50 mrad/day	TA-21 MDA B	Steady

* Increased from previous years due to new information about average medical doses.

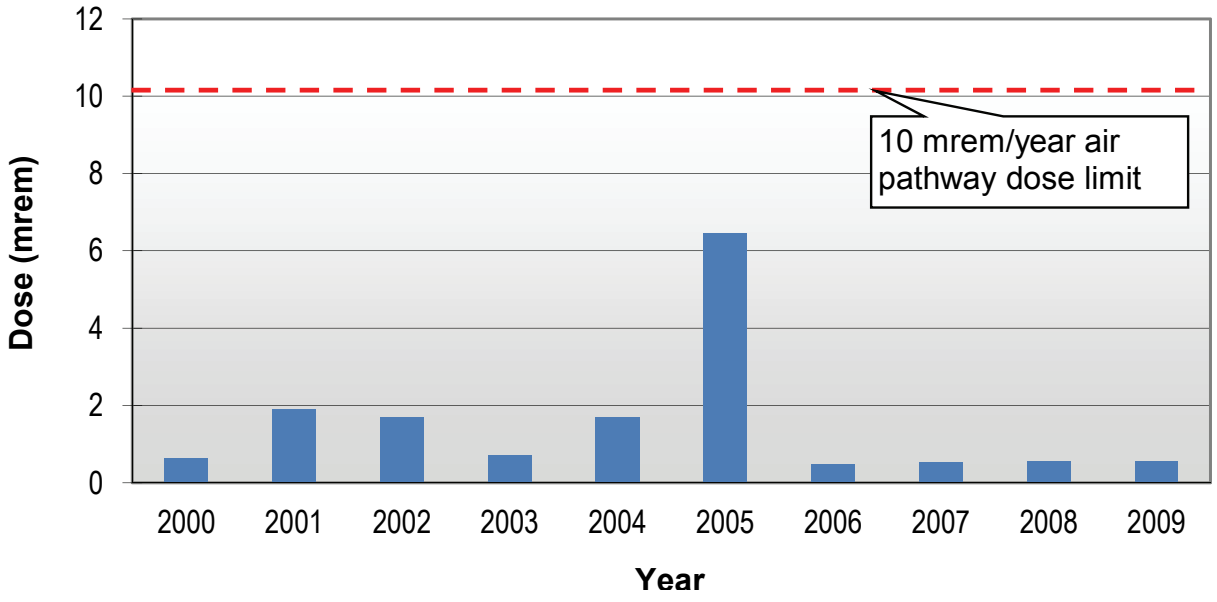


Figure ES-2. Annual airborne pathway dose (mrem) to the off-site MEI over the past 10 years. The 2009 location of the calculated MEI is at East Gate near the eastern side of Los Alamos County.

Radiological Air Emissions

The Laboratory measures the emissions of radionuclides at the emission sources (building stacks) and categorizes these radioactive stack emissions into one of four types: (1) particulate matter, (2) vaporous activation products, (3) tritium, and (4) gaseous air activation products (radioactive elements created by the Los Alamos Neutron Science Center [LANSCE] particle accelerator beam). In addition, the Laboratory collects air samples at general locations within LANL boundaries, at the LANL perimeter, and regionally to estimate the extent and concentration of radionuclides that may be released from Laboratory operations. These radionuclides include isotopes of plutonium, americium, uranium, and tritium.

- *The total radiation dose in 2009 to the nearest off-site member of the public from LANL radioactive air emissions remained very low.*
- *Emissions of short-lived air activation products from LANSCE contributed the largest proportion of radioactive air emissions.*
- *Tritium emissions decreased compared with 2008 and thus contributed an even smaller proportion (less than 10%) of the total radioactive emissions.*
- *Combined airborne emissions of other radionuclides such as plutonium and uranium contributed much less than a millionth of the total radioactive emissions.*

LANL continued to monitor 26 stacks for emissions of radioactive material to the ambient air. Total stack emissions during 2009 were approximately 796 curies (Ci), a decrease from 1,600 Ci in 2008, and includes 60 Ci of diffuse emissions from the LANSCE facility and other smaller sources. Tritium emissions composed about 80 Ci (780 in 2008) of the total. Short-lived air activation products from LANSCE stacks and diffuse emissions contributed 716 Ci (815 Ci in 2008) of the total. Most of the curies from LANSCE are from very short-lived radionuclides that decay significantly before reaching the location of the MEI. Combined airborne emissions of other radionuclides, such as plutonium, uranium, americium, and thorium, were less than 0.000027 Ci (an increase from 2008) and emissions of particulate/vapor activation products were up at 0.141 Ci (0.021 in 2008).

Radionuclide concentrations in ambient air samples in 2009 were generally comparable with concentrations in prior years. As in past years, the AIRNET system detected slightly elevated radionuclides from known areas of contamination. No new or increased airborne radioactivity was detected. At regional locations away from Los Alamos, all air sample measurements were consistent with background levels. Annual mean radionuclide concentrations at all LANL perimeter stations were less than 1% of the EPA dose limit for the public. Measurable amounts of tritium were reported at most on-site locations and at perimeter locations, but no elevated levels were detected in 2009. The highest off-site tritium concentration was 0.25% of the EPA public dose limit. The highest on-site tritium measurement (less than 3% of the DOE limit for worker exposure) was made at Area G near areas containing tritium-contaminated waste. Plutonium-239/240 from historical activities at LANL's old main technical area was detected near the Ashley Hotel and Suites (formerly Los Alamos Inn) at about 1.3% of the EPA public dose limit, and at very low levels near MDA B where soil disturbance from road construction occurred in preparation for remediation of the MDA. On-site detections of plutonium occurred at Area G (an area with known low levels of contamination) at levels substantially below 0.5% of the DOE limit for workplace exposure. The highest quarterly americium-241 levels were 0.1% and 0.01% of the public and worker limits, respectively. The maximum annual uranium concentrations were from natural uranium at locations with high dust levels from local soil disturbances. There was one detection of enriched uranium (near the eastern end of DP Road) and 15 likely detections of depleted uranium (which has lower radioactivity than natural uranium). All the depleted uranium detections occurred in the same quarter and appear to be from the same event. The source of this depleted uranium was probably legacy waste on LANL property lofted by strong winds.

- *As in previous years, PM 10 and PM 2.5 particulate measurements in ambient air were well below EPA standards.*
- *Most of the particles measured by the PM 10 and PM 2.5 samplers are from natural sources such as dust and wildfire smoke.*

- *No increased concentrations of radionuclides in ambient air were detected at regional sampling locations nor at most perimeter locations.*
- *As in previous years, there were no detections of radionuclides above background at Pueblo and regional locations.*
- *The highest mean air concentrations at perimeter locations were below 1% of the applicable EPA limits.*

Non-Radiological Air Emissions and Air Quality

LANL demonstrated full compliance with all Clean Air Act requirements. Except for a short delay in installing a datalogger at the asphalt plant, LANL met all permit reporting requirements and deadlines. Emissions of criteria pollutants (nitrogen oxides, sulfur oxides, carbon monoxide, particulate matter, volatile organic compounds, and hazardous air pollutants) were slightly lower than the average of the previous five years. In 2009, the TA-3 power

plant and boilers located across the Laboratory were the major contributors of nitrogen oxides, carbon monoxide, and particulate matter. Science research and development activities were responsible for most of the volatile organic compound and hazardous air pollutant emissions. In 2009, LANL provided the first greenhouse gas emissions report to NMED, as required by a new state regulation. The 2008 emissions of carbon dioxide (reported in 2009) were approximately 57,430 metric tons of carbon dioxide equivalents from the combustion of fossil fuels. During 2009, LANL removed over 7,900 pounds of ozone-depleting refrigerants from the active inventory.

Air monitoring for particles with diameters of 10 micrometers (μm) or less (PM-10) and for particles with diameters of 2.5 μm or less (PM-2.5) continued at one White Rock and one Los Alamos location. The annual averages at both locations for PM-10 was about 14 micrograms (μg)/m^3 (same as 2008) and about 7 μg/m^3 for PM-2.5 (8 μg/m^3 in 2008 and about 47% of the EPA standard) and were mostly caused by natural dust and wildfire smoke. In addition, the 24-hour maxima for both PM-10 and PM-2.5 at both locations did not exceed 25% and 57% of the respective EPA standards.

The Laboratory analyzed air filter samples from 38 sites for beryllium, aluminum, and calcium. These sites are located near potential beryllium sources at LANL and in nearby communities. All concentrations measured this year were below 1% of the National Emission Standards for Hazardous Air Pollutants standard of 10 ng/m^3 and were similar to those of recent years. Past studies closely correlated beryllium concentrations with aluminum concentrations, which indicates that all measurements of beryllium are from naturally occurring beryllium in re-suspended dust. Aluminum and calcium are used to evaluate elevated uranium measurements and no unusual concentrations were measured.

Groundwater Monitoring

Groundwater at the Laboratory occurs as a regional aquifer (water-bearing rock capable of yielding significant quantities of water to wells and springs) at depths ranging from 600 to 1,200 feet and as perched groundwater of limited thickness and horizontal extent, either in canyon alluvium or at intermediate depths of a few hundred feet (Figure ES-3). All water produced by the Los Alamos County water supply system comes from the regional aquifer and meets federal and state drinking water standards. No drinking water is supplied from the alluvial and intermediate groundwater.

- ***LANL continues to investigate the hexavalent chromium found at up to 20 times the NM groundwater standard in the regional aquifer under Mortandad Canyon and nearby Sandia Canyon.***
- ***Two of the 14 new monitoring wells installed in 2009 were installed as part of the ongoing characterization of the chromium contamination of the regional groundwater.***
- ***Two other wells were rehabilitated to improve their reliability and representativeness for sampling groundwater.***

In 2009, LANL installed six perched intermediate groundwater monitoring wells and eight regional aquifer monitoring wells. One well was installed south of Los Alamos Canyon to assess the southern extent of perched water identified in the canyon bottom, two wells were installed as part of the ongoing chromium contamination investigation, one well was installed in support of the MDA C investigation, six wells were installed to supplement the groundwater monitoring network around TA-54, and four wells were installed to monitor groundwater associated with historical TA-16 activities. In addition to the new wells, LANL rehabilitated two wells to improve their reliability and representativeness of the sampled groundwater.

Laboratory contaminants have affected deep groundwater, including intermediate perched zones and the regional aquifer, primarily through liquid effluent disposal. Since the early 1990s, the Laboratory has significantly reduced both the number of industrial outfalls (from 141 to 15 active) and the volume of water released (by 90%). From 1993 to 1997, total estimated average release was 1,300 million gal./yr; in 2006 through 2009, the annual releases were 222 million gal., 178 million gal., 158 million gal., and 133 million gal., respectively. In 2009, 1,430 of 1,437 industrial and sanitary samples met applicable federal and state standards for surface water discharges. Exceedences were recorded for pH, total residual chlorine, total suspended solids,

and PCBs. Where Laboratory contaminants are found at depth, the setting is either a canyon where alluvial groundwater is usually present (perhaps because of natural runoff or Laboratory effluents) or a location where large amounts of liquid effluent have been discharged (e.g., Mortandad Canyon and upper Sandia Canyon). During 2009, LANL received and evaluated over 162,000 analytical results for groundwater wells and springs alone. Table ES-3 summarizes contaminants detected in portions of the groundwater system.

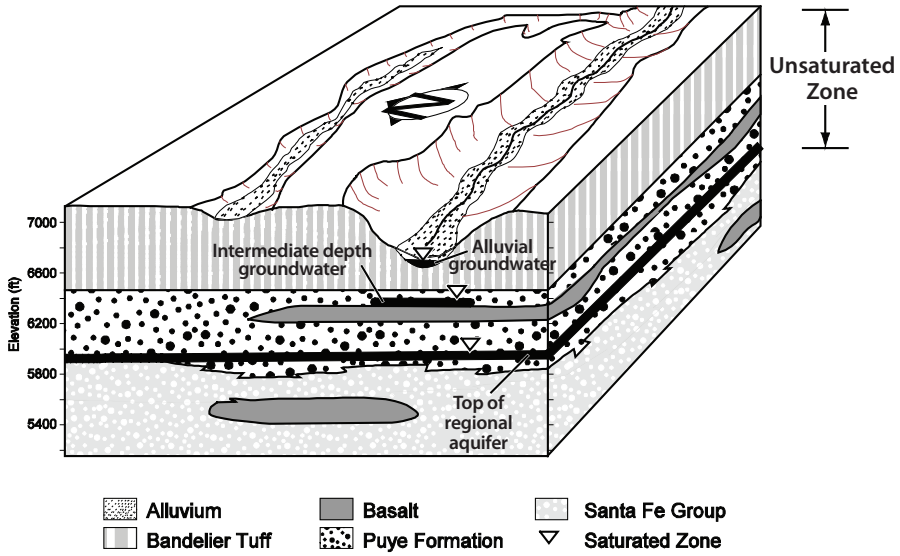


Figure ES-3. Illustration of geologic and hydrologic relationships in the Los Alamos area, showing the three modes of groundwater occurrence.

Table ES-3
Where Can We See LANL Impacts on Groundwater that Result in Values Near

Chemical	On-Site	Off-Site	Significance	Trends
Trichloroethane [1,1,1-]; dichloroethene[1,1-]	Regional aquifer Pajarito Canyon	No	Near PM-2, not found in that well.	Present for one year, approaching 60% of EPA screening level
Chromium	Regional aquifer in Mortandad Canyon, intermediate groundwater in Mortandad and Sandia Canyons	No	Found in regional aquifer above groundwater standards; not affecting drinking water supply wells; source eliminated in 1972.	Fairly steady over four years
Nitrate	Alluvial and intermediate groundwater in Pueblo and lower Los Alamos Canyons, regional groundwater in Sandia Canyon and Mortandad Canyon	Pueblo and Los Alamos Canyons	In Pueblo and lower Los Alamos Canyons, may be due to Los Alamos County's Bayo Sewage Treatment Plant; otherwise due to past effluent discharges	Generally variable in Pueblo, steady in Mortandad, Sandia
Fluoride	Intermediate groundwater in Pueblo Canyon, alluvial groundwater in DP and Mortandad Canyons	Pueblo Canyon	Result of past effluent releases; not affecting drinking water supply wells	In alluvium, slow decrease in concentration due to effluent quality improvement
Fluoride, uranium, nitrate, total dissolved solids	No	Pine Rock Spring, Pueblo de San Ildefonso	Water quality apparently affected by irrigation with sanitary effluent at Overlook Park	Steady over several years

Table ES-3 (continued)

Chemical	On-Site	Off-Site	Significance	Trends
Boron	Intermediate groundwater in Cañon de Valle	No	Not used as drinking water supply; limited in extent	Generally stable, seasonal fluctuations
Barium	Alluvial groundwater in Cañon de Valle and Water, Pajarito, and Mortandad Canyons	No	Not used as drinking water supply; limited in extent	Generally stable in Cañon de Valle, in others likely due to cation-exchange with road salts
RDX	Alluvial and intermediate groundwater in Cañon de Valle, intermediate groundwater in Pajarito Canyon	No	Not used as drinking water supply; limited in extent	Generally stable, seasonal fluctuations
Dioxane[1,4-]	Intermediate groundwater in Mortandad and Pajarito Canyons	No	Not used as drinking water supply; limited in extent	Fairly steady over three years in Mortandad; seasonal variation in Pajarito
Trichloroethane [1,1,1-]; dichloroethene[1,1-]	Intermediate groundwater near main warehouse	No	Not used as drinking water supply; limited in extent	Seasonally variable
Tetrachloroethene [1,1,1-], Trichloroethene	Alluvial and intermediate groundwater in Cañon de Valle	No	Not used as drinking water supply; limited in extent	Generally stable, seasonal fluctuations
Tritium	Intermediate groundwater in Mortandad Canyon	No	Not used as a drinking water supply	Decline over four years of sampling
Strontium-90	Alluvial groundwater in DP/Los Alamos and Mortandad Canyons	No	Not used as a drinking water supply; has not penetrated to deeper groundwater	Mainly fixed in location; some decrease due to effluent quality improvement
Chloride, total dissolved solids	Alluvial groundwater in Pueblo, DP, Sandia, Mortandad, Pajarito Canyons, intermediate groundwater near TA-3 main warehouse and in Sandia Canyon	Pueblo Canyon	May be caused by road salt in snowmelt runoff	Values generally highest in winter or spring samples
Perchlorate	Alluvial, intermediate, and regional groundwater in Mortandad Canyon; intermediate in Los Alamos Canyon; regional aquifer in Pueblo Canyon	Pueblo Canyon	Reflects past outfall discharges that have ceased	Decreasing in Mortandad Canyon alluvial groundwater due to effluent quality improvement; insufficient data for other groundwater
Bis(2-ethylhexyl) phthalate	Several new wells, regional aquifer monitoring wells	No	Used in plastics and sometimes appears in samples from wells with new sampling equipment or drilling	None

- *All water produced by the Los Alamos County water supply system comes from the regional aquifer and meets federal and state drinking water standards. No drinking water is supplied from the alluvial and intermediate groundwater.*
- *One unused drinking water supply well, Otowi-1, has been affected by levels of perchlorate at 16% of the EPA interim health advisory for drinking water and at 58% of the NM Consent Order screening level of 4 µg/L. No water from this well is used by Los Alamos County.*

Drainages that received liquid radioactive effluents in the past include Mortandad Canyon, Pueblo Canyon from its tributary Acid Canyon, and Los Alamos Canyon. Mortandad continues to receive discharges of treated effluent from the RLWTF. For the last nine years, including 2009, the RLWTF has met all DOE radiological discharge standards. For 2009, the RLWTF discharge of radionuclides was only 22% of established guidelines. Concentrations of nitrate, fluoride, and total dissolved solids in the effluent decreased substantially. A system for removing perchlorate from the RLWTF effluent became operational on March 26, 2002. Since then, perchlorate was detected in effluent samples only for five weeks in 2008.

The contaminated alluvial and intermediate perched groundwater bodies are separated from the regional aquifer by hundreds of feet of dry rock, so infiltration from the shallow groundwater occurs slowly. As a result, less contamination reaches the regional aquifer than the shallow perched groundwater bodies, and impacts on the regional aquifer are small.

Beginning in late 2008, trichloroethene was detected at 1,147 feet in Pajarito Canyon regional aquifer monitoring well R-20. Trichloroethene detections have continued for five consecutive sample events through the end of 2009. The concentrations have increased to 60% of the 5 µg/L EPA screening level.

The Laboratory detected hexavalent chromium and nitrate in several regional aquifer monitoring wells. The hexavalent chromium was found at eight and 20 times above the NM groundwater standard in two regional aquifer wells in Mortandad Canyon and at 70% of the standard in a regional well in nearby Sandia Canyon. A new intermediate zone well in Sandia Canyon contains chromium at 11.2 times the standard and supports LANL's model for the path of the chromium contamination from Sandia Canyon downward and slightly south into the regional aquifer below Mortandad Canyon. Nitrate was up to 70% of the NM groundwater standard in three regional aquifer monitoring wells. Perchlorate was also above the NM screening level in two regional aquifer wells.

One unused drinking water well in the Los Alamos area has been impacted by past Laboratory discharges of perchlorate. Well O-1 in Pueblo Canyon contains perchlorate at up to 16% of the EPA interim health advisory for perchlorate in drinking water of 15 µg/L and at 58% of the NM Consent Order screening level of 4 µg/L. Perchlorate is detected in most groundwater samples analyzed across northern NM. Naturally occurring perchlorate concentrations range from about 0.1 µg/L to 1.8 µg/L.

- *Beginning in late 2008, trichloroethene was detected in Pajarito Canyon regional aquifer monitoring well R-20 for five consecutive sample events through the end of 2009. The concentrations have increased to 60% of the 5 µg/L EPA screening level.*
- *Four of the 14 new monitoring wells installed in 2009 were installed to monitor groundwater in the area where trichloroethene was found.*

The intermediate groundwater in various locations shows localized levels of tritium, organic chemicals (RDX, chlorinated solvents, dioxane[1,4-]), and inorganic chemicals (hexavalent chromium, barium, boron, perchlorate, fluoride, and nitrate) from Laboratory operations.

The Laboratory uses federal and state drinking water and human health standards as "screening levels" to evaluate radionuclide concentrations in all groundwater, even though many of these standards only apply to drinking water. Only in the alluvial groundwater in portions of Mortandad and DP/Los Alamos Canyons does the total radionuclide activity from LANL discharges exceed the dose limit that is applicable to drinking water (4 mrem/yr). This is mainly due to the presence of strontium-90. The maximum strontium-90 concentrations in Mortandad Canyon and DP/Los Alamos Canyon alluvial groundwater were also above the EPA's drinking water standard though this water is not used for drinking water supply.

Watershed Monitoring

Watersheds that drain LANL property are dry for most of the year. Of the more than 80 miles of watercourse, approximately three miles are naturally perennial and approximately four miles are perennial water created by effluent discharges (most notably in upper Sandia Canyon). Snowmelt runoff originating in the Jemez Mountains can extend across the Laboratory to the Rio Grande. Storm water runoff transporting sediment can leave the Laboratory boundary, but is short-lived. The surface water within the Laboratory is not a source of municipal, industrial, or irrigation water, though wildlife does use the water. It is not a source of livestock watering west of NM State Highway 4 because there are no livestock in this area.

None of the streams within the Laboratory boundary average more than one cubic foot per second (cfs) of flow annually. It is unusual for the combined mean daily flow from all LANL canyons to be greater than 10 cfs. The largest flows in 2009 occurred on July 30, with a total estimated mean daily flow of 7.2 cfs resulting from storm water runoff in three canyons (Ancho Canyon, Cañada del Buey, and Los Alamos Canyon). By comparison, the average daily flow in the Rio Grande at Otowi Bridge on July 30 was 1,040 cfs, or approximately 145 times higher than the flow from LANL.

- ***Polychlorinated biphenyls (PCBs) are often measured in storm water in Sandia and Los Alamos Canyons above screening levels. PCBs are also detected above screening levels in runoff from the Los Alamos townsite and in background areas, the latter derived from regional atmospheric fallout.***
- ***Radioactive elements from past Laboratory operations are being transported by runoff events. All radionuclide levels are well below applicable guidelines or screening levels.***
- ***PCBs, radionuclides, and other contaminants adsorb onto sediment particles and thus overall water concentrations can be reduced by slowing the stream flows, reducing erosion, and allowing suspended sediment to settle out.***

Excluding effluent, stream flow in 2009 on the Pajarito Plateau was dominated by storm water runoff, mostly occurring in July. No snowmelt runoff was recorded crossing the eastern Laboratory boundary. Total storm water runoff measured at downstream gages in the canyons leaving the Laboratory was estimated at about 24 acre-feet, the least since 1995, the first year for which runoff estimates are available for all the canyons. In addition, approximately 28 acre-feet of effluent released from the Los Alamos County wastewater treatment plant is estimated to have passed the eastern LANL boundary in Pueblo Canyon.

- ***The overall quality of most surface water within the Los Alamos area is very good.***
- ***Of the more than 100 analytes measured, most are within normal ranges or at concentrations below regulatory standards or risk-based advisory levels.***
- ***Nearly every major watershed, however, shows some effect from Laboratory operations.***

There were no unusual storm water runoff events at LANL in 2009. The largest recorded flood was measured in Ancho Canyon below NM State Highway 4 (stream gage E275) on July 30, with an estimated peak discharge of 414 cfs. This was the fourth largest event in the 15 years of record at this station and occurred in response to a typical short-duration summer thunderstorm. No significant new sediment deposits resulted from this flood. All other recorded runoff events at LANL in 2009 had peak discharges of 60 cfs or less.

The overall quality of most surface water in the Los Alamos area is good, with low levels of dissolved solutes. Of the more than 100 analytes measured in sediment and surface water within the Laboratory, most are at concentrations far below standards and screening levels. However, nearly every major watershed indicates some effect from Laboratory operations, often for just a few analytes. Table ES-4 lists the locations of Laboratory-impacted surface water. All radionuclide levels are well below applicable guidelines or standards.

Laboratory activities have caused contamination of sediment in several canyons, mainly because of past industrial effluent discharges. These discharges and contaminated sediment also affect the quality of storm water runoff, which carries much of this sediment during short periods of intense flow. In some cases, sediment contamination is present from Laboratory operations conducted more than 50 years ago. However, all measured sediment contaminant levels are below screening levels for recreational uses.

Table ES-4
Where Can We See LANL Impacts on Surface Water that Result in Values Near or Above Screening Levels?

LANL Impact	On-Site	Off-Site	Significance	Trends
Specific radionuclides	No	No	No LANL-derived radionuclides exceeded DOE biota concentration guides or derived concentration guidelines in 2009	Steady
Gross alpha radioactivity	Pueblo and Los Alamos Canyons	No	38% of storm water results from 2009 greater than screening level. Major source is naturally occurring radioactivity in sediments, except in Mortandad, Pueblo, and Los Alamos Canyons where there are LANL contributions	Steady
Copper	DP and Sandia Canyons	No	Copper was elevated in 2009 at sites that receive runoff from developed areas, including the Los Alamos townsite	Steady
Cyanide	Pajarito Canyon	No	Cyanide was elevated in one sample collected from a small tributary drainage below Material Disposal Area G	Steady
Zinc	Mortandad and Sandia Canyons	No	Zinc was elevated only from locations with small drainage areas receiving runoff from paved roads and other developed areas	
High explosives	Cañon de Valle	No	RDX above screening levels in two samples from one location within the Laboratory; subject of corrective measures	Steady
Polychlorinated biphenyls (PCBs)	Los Alamos and Sandia Canyons	No	Above screening levels. Wildlife exposure potential in Sandia Canyon. PCBs are also above screening levels in drainages receiving runoff from developed areas, including the Los Alamos townsite, and in background areas on Santa Fe National Forest land, resulting from regional atmospheric fallout	Steady
Volatile organic compounds	Sandia Canyon	No	Bromodichloromethane and chloroform were above screening levels in samples collected from one location	Steady

- ***The highest concentrations of LANL-derived radionuclides in surface water samples were measured in various canyons (Chaquehui, DP, Los Alamos, and Mortandad Canyons). All measurements are consistent with previous years and are below screening levels.***
- ***The highest concentrations of radionuclides in sediment were obtained from a fine-grained sample from the Mortandad Canyon sediment traps, and are consistent with previous years.***

Consistent with previous years, many surface water samples in 2009 had gross alpha radiation greater than the surface water standard of 15 pCi/L for livestock watering. Of the 77 non-filtered samples analyzed from the Pajarito Plateau, 38% exceeded 15pCi/L, including samples from sites with no upstream releases of radionuclides from Laboratory activities (such as Chupaderos Canyon, north of Los Alamos). Laboratory impacts are relatively small and the majority of the alpha radiation in surface water on the plateau is due to the decay of naturally occurring isotopes in sediment and soil carried in storm water runoff from uncontaminated areas. This is supported by the generally positive correlation between gross alpha radiation and suspended sediment in non-filtered surface water samples.

We measured the highest concentrations of radionuclides with potential Laboratory contributions in surface water samples from Chaquehui, DP, Los Alamos, and Mortandad Canyons. The highest concentrations of americium-241 and plutonium-239/240 were measured in a sample collected in Los Alamos Canyon downstream from known releases of radioactive effluents from TA-1 and TA-21. The highest concentrations of

cesium-137, plutonium-238, and tritium were measured in a sample collected in Mortandad Canyon, downstream from the active RLWTF outfall. The highest concentration of strontium-90 was in a sample collected from DP Canyon below TA-21, below a former outfall that also released treated radioactive effluent. The highest concentrations of uranium-234, uranium-235, and uranium-238 were measured in a sample collected in Chaquehui Canyon at TA-33, a site with known releases of uranium. With the exception of the uranium isotopes in Chaquehui Canyon, all the other measurements discussed above are consistent with recent years, although there have been no other storm water samples collected from Chaquehui Canyon since 2005 to use for comparison.

- ***Concentrations of many inorganic chemicals are elevated in sediment along the Rio Grande and in the bottoms of Abiquiu and Cochiti Reservoirs relative to background levels because of different background source rock types along the Rio Grande and because the finer-grained sediment along the river and in the reservoirs can adsorb more chemicals in the same volume.***
- ***Monitoring results show no measurable effects of PCBs from LANL in the Rio Grande.***

Four radionuclides in sediment were detected above background concentrations in 2009: americium-241, cesium-137, plutonium-238, and plutonium-239/240. The maximum values for all four were from a fine-grained sediment layer at the Mortandad Canyon sediment traps, down canyon from the RLWTF, and were consistent with results from previous years.

Six inorganic chemicals were detected above screening levels in surface water samples from the Laboratory in 2009: aluminum, arsenic, copper, cyanide, manganese, and zinc. The distribution of aluminum, arsenic, and manganese indicates that they are derived from natural sources. Copper and zinc are only above screening levels in drainages that receive runoff from developed areas, including the Los Alamos townsite. Cyanide was only above the screening level in a single sample, from a small tributary drainage to Pajarito Canyon at TA-54.

The high explosive RDX was detected above the screening level in two surface water samples from Cañon de Valle, downstream from a high explosive machining facility at TA-16. These results are consistent with previous years. Corrective measures were implemented to address this high explosive contamination in 2009 and 2010.

The PCBs Aroclor-1254 and Aroclor-1260 were detected above the water screening level of 0.00064 µg/L in Los Alamos and Sandia Canyons. These results are consistent with previous years. PCBs were also measured above the screening level in runoff from developed areas, including the Los Alamos townsite, and in background areas, such as Chupaderos Canyon north of Los Alamos. The PCBs in background areas are derived from regional atmospheric fallout. In 2001, the Laboratory excavated PCB-contaminated soil at a former transformer storage area in the Sandia Canyon watershed, and in 2008, we began interim measures to address the transport of PCBs in storm water in Los Alamos and Pueblo Canyons. Monitoring results show no measurable levels of PCBs from LANL in the Rio Grande.

The volatile organic compounds bromodichloromethane and chloroform were detected above screening levels in samples collected from one location in upper Sandia Canyon. These results are consistent with previous years.

Concentrations of many inorganic chemicals are elevated in sediment along the Rio Grande and from the bottoms of Abiquiu and Cochiti Reservoirs relative to background levels in Pajarito Plateau sediment. These differences are due in part to different background source rock types along the Rio Grande, but also to the finer-grained nature of sediment along the river and in the reservoirs. Comparing data from samples with similar particle size characteristics upriver and downriver from LANL drainages indicates that there are no recognizable LANL influences on concentrations of metals in Rio Grande sediment.

We obtained PCB congener data from 20 sediment samples along the Rio Grande during low-water conditions in November 2009. Five samples were collected upriver from Los Alamos Canyon and five samples each from three different areas downriver from LANL drainages. Congener data were also obtained from 18 samples in the Los Alamos Canyon watershed for comparison. The congener data allow evaluation of similarities or differences in the PCBs present above LANL drainages and also allow further comparison with PCBs present in LANL

canyons. Consistent with data from 2008, the mixtures of PCB congeners upriver and downriver from LANL sources are essentially identical, but different than the PCB signature in LANL canyons. These congener data therefore show no measureable evidence of LANL contributions to PCBs along the Rio Grande.

The PCB data from the Rio Grande were also combined with data on suspended sediment flux to estimate PCB flux in the river above LANL drainages. These data indicate that, on average, about 0.16 to 0.35 kg of PCBs are transported past Otowi Bridge each year. In comparison, a preliminary estimate of PCB flux from Los Alamos Canyon is about 0.005 kg/yr, or 1% to 3% of the flux in the Rio Grande.

Soil Monitoring

LANL conducted large-scale soil sampling within and around the perimeter of LANL in 2009. Table ES-5 summarizes soil sampling results. In general, results confirmed the results from previous sampling events and show on-site and perimeter areas contained radionuclides at very low (activity) concentrations and most were either not detected or below regional statistical reference levels (RSRLs) (equal to the average plus three standard deviations). The few samples with radionuclide concentrations above the RSRLs were collected near known or expected areas of contamination. These samples are below residential screening levels and thus do not pose a potential unacceptable dose to the public.

Table ES-5
Where Can We See LANL Impacts on Mesa-Top Surface Soil that Result in Values Near or Above Background or Screening Levels?

LANL Impact	On-Site	Off-Site	Significance	Trends
Tritium	Above background at some sites, particularly at TA-54, Area G	No	Far below residential screening levels	Consistently detected in the south sections of Area G, but not increasing
Plutonium-239/240	Above background along State Road 502 at TA-73 (downwind of TA-21) and at TA-54, Area G	Above background along State Road 502 on the west side of the airport (downwind of TA-21)	Far below residential screening levels	Plutonium-239/240 downwind of TA-21 is highly variable from sample to sample but is generally not increasing. Also, it is consistently detected on the north, northeast, and eastern sections of Area G, mostly not increasing
Other radionuclides	Mostly depleted uranium at the Dual Axis Radiographic Hydrodynamic Test (DARHT) facility	Mostly no	Far below residential screening levels	Uranium-238 at DARHT increased through 2006 but decreased after 2007 likely because of the use of steel containment vessels
Inorganic chemicals	Few detections	Mostly no	Far below residential screening levels	Steady
PCBs (Aroclors)	Most samples below detection limits	No	Far below residential screening levels	None
High explosives	Not detected	No	Minimal potential for exposure	None
Semi-Volatile Organic Compounds	Few detections	No	Far below residential screening levels	None

We also annually collect soil samples from two locations on the Pueblo de San Ildefonso land downwind of TA-54, Area G. Radionuclides and metals in these soil samples were below background or near background and were consistent with levels measured in previous years.

The annual samples from around the perimeter of Area G contained above-background concentrations of tritium, americium-241, plutonium-238, and plutonium-239/240 at levels similar to those found in previous years. The highest levels of tritium around Area G were detected at the southern end, and the highest levels of the americium and plutonium were detected around the northern, northeastern, and eastern sections. Although americium-241, plutonium-238, and plutonium-239/240 in soil along the northern, northeastern, and eastern sections of Area G are slightly elevated, all levels are well below residential screening levels used to trigger investigations and decrease rapidly with distance from Area G.

- ***Soil samples from all off-site locations show radionuclides and metals have not increased over the past years and are mostly at background levels.***
- ***Soil samples from all on-site locations show no increases and some decreases of radionuclides and metals from previous years.***

At the Dual Axis Radiographic Hydrodynamic Test (DARHT) facility, uranium-238 from near a firing point showed significantly lower levels than measured in the past three years and is well below residential screening levels. High explosives were not detected in any samples around DARHT.

Fourteen soil samples on the north side of East Jemez Road along a 2.25-mile section were collected for the analysis of plutonium-239/240 (and other radionuclides like cesium-137 and plutonium-238). These sites are located on the south side of historic plutonium processing operations at TA-1 and TA-21. Results show no elevated levels of plutonium-238 and cesium, and the slightly elevated levels of plutonium-239/240 were still well below residential screening levels.

In 2009, we conducted additional sampling of soils from alfalfa fields irrigated with Rio Grande water from areas that were upstream and downstream from LANL. The upstream locations (background) were collected from three fields that were located just north of Española and one field was located on Pueblo de San Ildefonso land on the west side of the Rio Grande; and the five downstream locations were located below Cochiti Reservoir. Radionuclides and metals from upstream and downstream fields were not statistically different. No high explosives or semi-volatile organic compounds were detected in any of the field soils. PCBs collected from downstream fields were very low; upstream fields ranged in concentration from 126 to 6,080 pg/g, indicating some possible point source contamination. Though the average PCB concentration upstream is higher than downstream, the difference is not statistically significant because of the great variability in the values.

Foodstuffs Monitoring

In 2009, we collected crayfish (crawfish, crawdads, or mudbugs) (*Orconectes* spp.) from the Rio Grande within upstream and downstream reaches relative to the location of LANL. Upstream (or background) samples were collected starting from the Otowi Bridge north to the Black Mesa area (about a three-mile stretch) and downstream samples were collected from the Los Alamos Canyon confluence south (about a one-mile stretch). The concentrations of radionuclides were very low, similar between locations, and similar to levels in bottom-feeding fish collected from these same upstream and downstream reaches in past years. Some metals were higher in downstream crayfish as compared with upstream; however, the differences were small. PCB concentrations were low as compared with the fish consumption limit and are similar to other studies involving bottom-feeding fish and sediment that showed similar PCB concentrations between upstream and downstream locations. These data indicate that LANL is not a significant source of PCBs to the Rio Grande.

- ***Radionuclides, most metals, and PCBs in crayfish collected downstream of LANL were similar to upstream reaches, and indicate that LANL is not a significant source of contaminants to the Rio Grande.***

Biota Monitoring

Table ES-6 summarizes biota sampling results. In plants collected around Area G, only tritium and plutonium were detected in a few samples closest to the boundary fence and adjacent to known sources of these radionuclides.

Table ES-6
Where Can We See LANL Impacts on Foodstuffs and Biota that Result in Values

Media	LANL Impact	On-Site	Off-Site	Significance	Trends
Wild edible plants	Radionuclides	Tritium in plants from Cañada del Buey	Above background concentrations for strontium-90 in plants from Mortandad Canyon on Pueblo de San Ildefonso land in 2006	Far below screening level; higher strontium-90 in wild plants is a function of low calcium in the soil and not a result of increased contamination levels	Steady
	Inorganic chemicals	No	No	None	Steady
Native vegetation	Radionuclides	Mostly tritium and plutonium-239/240 at Area G; and depleted uranium at DARHT	No	Far below screening levels	Tritium and plutonium-239/240 are steady at Area G; uranium-238 in trees at DARHT increased through 2006, decreased after 2007
	Inorganic chemicals	Few detections	No	None	Steady for most metals
Small mammals, bees, and birds	Radionuclides	Depleted uranium at DARHT; some radionuclides in biota upstream of the Los Alamos Canyon Weir and the Pajarito Canyon Flood Retention Structure	No	Far below screening levels	Depleted uranium decreasing at DARHT
	Inorganic chemicals	Some detections in a bird at DARHT	No	One sample out of two	Steady
	PCBs	Detected in mice at the Los Alamos Canyon Weir	No	Far below soil ecological screening levels	Steady at Los Alamos Canyon Weir; PCBs in field mice significantly lower 4.5 miles downstream in Los Alamos Canyon
	Species diversity	Abundance and species diversity of birds at DARHT during operations are similar to baseline	None collected	No stress to birds near DARHT	Steady

In vegetation around the DARHT facility, no significantly elevated levels of radionuclides were detected; the levels are lower than in previous years, which may be because testing is now conducted in metal vessels instead of in the open. Mice at DARHT were not elevated in any radionuclides. Bees contained slightly higher levels of tritium, barium, and copper than previous years.

PCBs in mice are elevated around the Los Alamos Canyon Weir but are significantly lower in mice about 4.5 miles downstream. The concentrations of all radionuclides, metals, and PCBs in small mammals collected down gradient of the weir were below screening levels. Above the Pajarito Canyon Flood Retention Structure, no contaminants are significantly elevated in sampled biota.

For the first time, LANL sampled benthic macroinvertebrates in the Rio Grande upstream and downstream from LANL properties. Rock baskets were set in pools in the river for six weeks, the organisms living in the rocks were collected, and the variety and number of organisms were counted and classified. The numbers and types of organisms, quantified by metrics or indices, can provide an indication of water quality within

a stream system. In general, the results show a thriving benthic macroinvertebrate community both upstream and downstream of LANL. This indicates that potential Laboratory contributions, if any, are not significantly impacting the aquatic benthic macroinvertebrate community.

Environmental Restoration Program

Corrective actions proposed and/or conducted at LANL in 2009 follow the requirements of the NMED Consent Order. The goal of the investigation efforts is to ensure that waste and contaminants from past operations do not threaten human or environmental health and safety. The investigation activities are designed to characterize SWMUs, AOCs, consolidated units, aggregate areas, canyons, and watersheds. The characterization activities conducted include surface and subsurface sampling, drilling boreholes, geophysical studies, and installation of monitoring wells. Corrective action activities performed included the removal of structures (e.g., buildings, septic systems, sumps, and drain lines), excavation of contaminated media, and confirmatory sampling. These activities define the nature and extent of contamination and determine the potential risks and doses to human health and the environment.

- ***Characterization and cleanup of sites contaminated or potentially contaminated by past LANL activities follow the Consent Order.***
- ***LANL submitted 26 investigation work plans and 22 investigation reports to NMED in 2009.***

Accomplishments in 2009 include the completion of investigation activities, approvals of proposed investigation activities, and approvals of the work completed at some sites. Numerous sampling campaigns were conducted in 2009 and included sampling of locations in the area of the original Laboratory technical areas within the Los Alamos townsite; borehole sampling and excavation of soil at former firing sites and explosives development buildings; sampling and digging of test pits in Bayo Canyon where radioactive materials were used; sampling of former septic systems that served abandoned or decommissioned buildings; installing and testing vapor extraction systems near the TA-54 Area G waste storage site; sampling of sediment deposits in Sandia, Pajarito, and North Ancho Canyon watersheds; studying biota including sampling and nest box monitoring in Sandia and Pajarito Canyons; sampling of sediment in Cañada del Buey; and removal of contaminated soil and tuff at TA-21. In addition, corrective measures were implemented at Consolidated Unit 16-021(c)-99 (260 Outfall) at TA-16. After results are received and interpreted, LANL documents the investigation activities in reports to NMED. During 2009, environmental restoration activities collected more than 3,400 samples from more than 920 locations and requested more than 423,000 analyses or measurements on these samples.

- ***Vegetation at Area G contained elevated levels of radionuclides near known sources.***
- ***Biota samples at DARHT contained depleted uranium but the levels were lower than previous years probably because of new contained testing measures.***
- ***Biota samples collected above the Los Alamos Canyon Weir contained slightly elevated levels of some radionuclides and PCBs but far below screening levels.***

In 2009, LANL submitted 26 new or revised investigation work plans and 22 new or revised investigation reports to NMED. Four historical investigation reports were also submitted as companion documents to new work plans. In 2009, NMED approved a total of 13 plans and four reports, most with modifications or directions. In addition, LANL submitted 36 periodic monitoring reports on sampling activities, 62 plans and reports on groundwater monitoring well activities, and 15 miscellaneous reports or plans.

Monitoring of the Rio Grande

Data from samples of water, sediment, soil, alfalfa, fish, crayfish, and benthic macroinvertebrates, some collected for the first time in 2009 and others collected periodically over the past almost 30 years, show no measureable impact from LANL to the Rio Grande. These data do show, however, elevated levels of mercury and PCBs are present in the river and derive from sources upstream.

Benthic macroinvertebrates collected from the Rio Grande show a diverse and healthy community both upstream and downstream of Los Alamos Canyon, with some measures better in downstream locations.

LANL installed sediment capture structures to help reduce the sediment from LANL property reaching the Rio Grande. Automated storm flow monitoring stations have been installed to notify Buckman Direct Diversion Project personnel of major flow events reaching the Rio Grande. Past risk assessments of the potential risk to the public from chemicals and radioactive materials released from the Cerro Grande fire found minimal exposure risks.

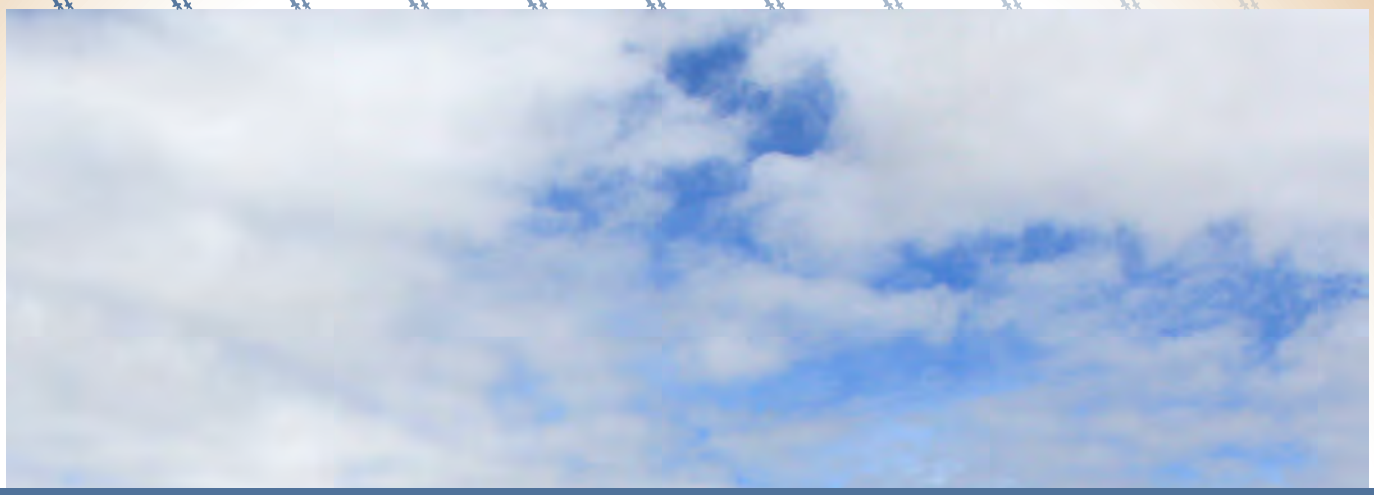
- ***The levels of PCBs and mercury are similar in sediments, fish, and crayfish from the Rio Grande taken upstream and downstream of the Laboratory and indicate a significant upstream source.***
- ***The types of PCBs in sediments, fish, and crayfish samples taken from the Rio Grande are different from the types detected in sediments on LANL property and indicate a different source.***
- ***Samples of all types of media from in and around the Rio Grande show no measurable contaminants from LANL, because potential LANL contributions are masked by normal analytical variability or because upstream contributions are much higher.***

In 2009, LANL sampled soil and alfalfa forage irrigated with Rio Grande water upstream and downstream of LANL. Radionuclides, metals, high explosives, PCBs, and semi-volatile organic compounds in soil from fields downstream of LANL were all similar to those from upstream sources.

Past fish sampling data have shown, on average, no differences between fish collected upstream and downstream of LANL, though fish contain elevated levels of mercury and PCBs. Crayfish were sampled for the first time in 2009 and some metals were statistically higher in crayfish collected downstream compared with crayfish collected upstream of LANL. These differences could be caused by LANL impacts to the Rio Grande or they may be explained by natural variability. The results were based on only three samples from each site and additional sampling in the future should help determine the nature and extent of the differences. Radionuclides and other elements in crayfish were similar between upstream and downstream samples.

In summary, any LANL contributions to the Rio Grande are masked and overwhelmed by contaminants from upriver sources. With the exception of mercury and PCBs in fish, the levels of contaminants in the Rio Grande are below all levels of concern.





1. Introduction



contributing authors:
David Fuehne, Ben Poff, Denny Hjeresen, John Isaacson, Scot Johnson, Terry Morgan, David Paulson, Sonja Salzman, David Rogers

To Read About **Turn to Page**

Background and Report Purpose 25
Environmental Setting 27
Laboratory Activities and Facilities 31
Management of Environment, Safety, and Health 33
Risk and Hazard Reduction 43
References 45

A. BACKGROUND AND REPORT PURPOSE

1. Introduction to Los Alamos National Laboratory

In March 1943, a small group of scientists came to Los Alamos for Project Y of the Manhattan Project. Their goal was to develop the world's first nuclear weapon. Although planners originally expected that the task would require only 100 scientists, by 1945, when the first nuclear bomb was tested at Trinity Site in southern New Mexico, more than 3,000 civilian and military personnel were working at Los Alamos Laboratory. In 1947, Los Alamos Laboratory became Los Alamos Scientific Laboratory, which in turn became Los Alamos National Laboratory (LANL or the Laboratory) in 1981. Through May 2006, the Laboratory was managed by the Regents of the University of California through the Los Alamos Site Office of the US Department of Energy (DOE). In June 2006, a new management organization, Los Alamos National Security (LANS), LLC, took over management of the Laboratory.

The Laboratory's original mission to design, develop, and test nuclear weapons has broadened and evolved as technologies, priorities, and the world community have changed. The current mission is to develop and apply science and technology to

- Ensure the safety and reliability of the United States' nuclear deterrent;
- Reduce global threats; and
- Solve other emerging national security challenges (LANL 2005a).

LANL defines its vision as: "Los Alamos, the premier national security science laboratory." The Laboratory has identified 12 strategic goals to implement its vision and mission:

- Make safety and security integral to every activity we do.
- Implement an information security system that reduces risk while providing exemplary service and productivity.
- Establish excellence in environmental stewardship.
- Assess the safety, reliability, and performance of LANL weapons systems.
- Transform the Laboratory and the nation's nuclear weapons stockpile to achieve the 2030 vision, in partnership with the [DOE] Complex.

- Leverage our science and technology advantage to anticipate, counter, and defeat global threats and meet national priorities, including energy security.
- Be the premier national security science laboratory and realize our vision for a capabilities-based organization.
- Provide efficient, responsive, and secure infrastructure and disciplined operations that effectively support the Laboratory mission and its workforce.
- Implement a management system based upon performance that drives mission and operational excellence.
- Deliver improved business processes, systems, and tools that meet the needs of our employees, reduce the cost of doing business, and improve the Laboratory's mission performance.
- Communicate effectively with our employees, customers, community, stakeholders, and the public at large.
- Develop employees and create a work environment to achieve employee and Laboratory success.

Inseparable from the Laboratory's commitment to excellence in science and technology is its commitment to complete all work in a safe, secure, and environmentally responsible manner. The Laboratory uses Integrated Safety Management (ISM) to set, implement, and sustain safety performance and meet environmental expectations. In addition, the Laboratory uses an International Standards Organization (ISO) 14001-2004 registered Environmental Management System (EMS) as part of ISM to focus on environmental performance, protection, and stewardship. (See Section D, Management of Environment, Safety, and Health, of this chapter for additional information.) The foundation of the EMS and the demonstration of the Laboratory's commitment comprise the LANL environmental policy:

- We approach our work as responsible stewards of our environment to achieve our mission.
- We prevent pollution by identifying and minimizing environmental risk.
- We set quantifiable objectives, monitor progress and compliance, and minimize consequences to the environment, stemming from our past, present, and future operations.
- We do not compromise the environment for personal, programmatic, or operational reasons.

2. Purpose of this Report

As part of the Laboratory's commitment to our environmental policy, we monitor and report on how Laboratory activities are affecting the environment. The objectives of this environmental surveillance report, as directed by DOE Order 231.1A (DOE 2004), are to

- Characterize site environmental management performance, including effluent releases, environmental monitoring, and estimated radiological doses to the public from releases of radioactive materials at DOE sites.
- Summarize environmental occurrences and responses reported during the calendar year.
- Confirm compliance with environmental standards and requirements.
- Highlight significant programs and efforts, including environmental performance indicators and/or performance measures programs.

The Laboratory establishes annual environmental objectives, targets, and key performance indicators, beyond the DOE requirements, through the EMS. The current objectives are to

- Ensure integrated compliance improvement.

- Achieve Laboratory-wide reductions in waste generation.
- Meet or exceed DOE energy and fuel conservation goals established for the Laboratory as defined by its Energy Management Program.

B. ENVIRONMENTAL SETTING

1. Location

The Laboratory and the associated residential and commercial areas of Los Alamos and White Rock are located in Los Alamos County, in north-central New Mexico, approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe (Figure 1-1). The 40-square-mile Laboratory is situated on the Pajarito Plateau, which consists of a series of finger-like mesas separated by deep east-to-west-oriented canyons cut by streams. Mesa tops range in elevation from approximately 7,800 ft on the flanks of the Jemez Mountains to about 6,200 ft at the edge of White Rock Canyon. Most Laboratory and community developments are confined to the mesa tops.

The surrounding land is largely undeveloped and large tracts of land north, west, and south of the Laboratory site are held by the Santa Fe National Forest, the US Bureau of Land Management, Bandelier National Monument, the US General Services Administration, and Los Alamos County. The Pueblo de San Ildefonso borders the Laboratory to the east.

2. Geology and Hydrology

The Laboratory lies at the western boundary of the Rio Grande Rift, a major North American tectonic feature. Three major potentially active local faults constitute the modern rift boundary. Studies indicate that the seismic surface rupture hazard associated with these faults is localized (Gardner et al., 1999). Most of the finger-like mesas in the Los Alamos area (Figure 1-2) are formed from Bandelier Tuff, which includes ash fall, ash fall pumice, and rhyolite tuff. Deposited by major eruptions in the Jemez Mountains volcanic center 1.2–1.6 million years ago, the tuff is more than 1,000 ft thick in the western part of the plateau and thins to about 260 ft eastward above the Rio Grande.

On the western part of the Pajarito Plateau, the Bandelier Tuff overlaps onto the Tschicoma Formation, which consists of older volcanics that form the Jemez Mountains. The tuff is underlain by the conglomerate of the Puye Formation in the central plateau and near the Rio Grande. The Cerros del Rio Basalts interfinger with the conglomerate along the river. These formations overlie the sediments of the Santa Fe Group, which extend across the Rio Grande Valley and are more than 3,300 ft thick.

Surface water in the Los Alamos region occurs primarily as short-lived or intermittent reaches of streams. Perennial springs on the flanks of the Jemez Mountains supply base flow into the upper reaches of some canyons, but the volume is insufficient to maintain surface flows across the Laboratory property before the water is depleted by evaporation, transpiration, and infiltration.



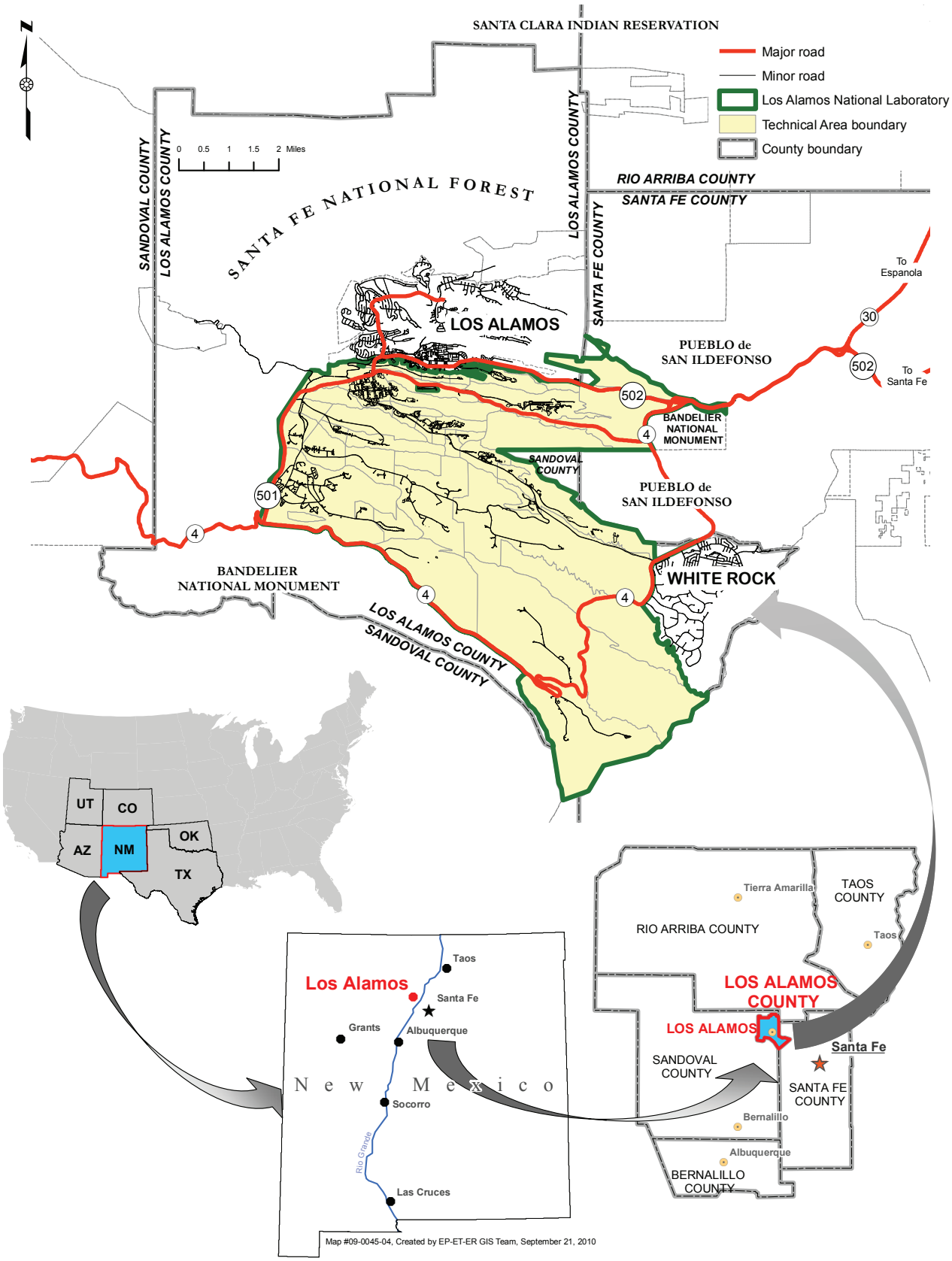


Figure 1-1. Regional location of Los Alamos National Laboratory.

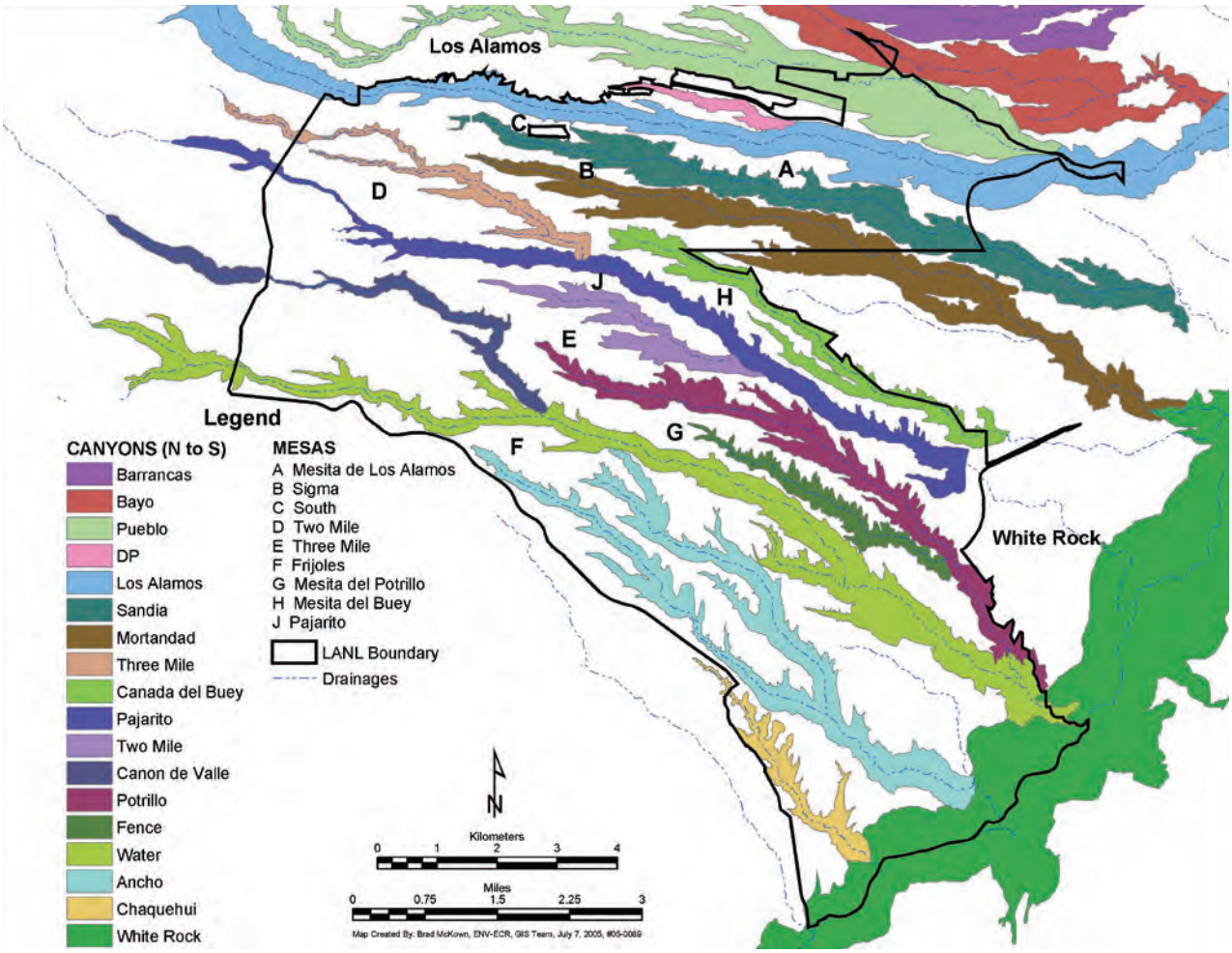


Figure 1-2. Major canyons and mesas on Laboratory land.

Groundwater in the Los Alamos area occurs in three modes: (1) water in shallow alluvium in canyons, (2) intermediate perched water (a body of groundwater above a less permeable layer that is separated from the underlying main body of groundwater by an unsaturated zone), and (3) the regional aquifer, which is the only aquifer in the area capable of serving as a municipal water supply. Water in the regional aquifer is in artesian conditions under the eastern part of the Pajarito Plateau near the Rio Grande (Purtymun and Johansen 1974). The source of most recharge to the regional aquifer appears to be infiltration of precipitation that falls on the Jemez Mountains. The regional aquifer discharges into the Rio Grande through springs in White Rock Canyon. The 11.5-mi reach of the river in White Rock Canyon, between Otowi Bridge and the mouth of Rio de los Frijoles, receives an estimated 4,300–5,500 acre-feet of water from the regional aquifer.

3. Biological Resources

The Pajarito Plateau, including the Los Alamos area, is biologically diverse. This diversity of ecosystems is due partly to the dramatic 5,000-ft elevation gradient from the Rio Grande on the east of the plateau up to the Jemez Mountains 12 mi (20 km) to the west and partly to the many steep canyons that dissect the area. Five major vegetative cover types are found in Los Alamos County. The juniper (*Juniperus monosperma* Englem. Sarg.)-savanna community is found along the Rio Grande on the eastern border of the plateau and extends upward on the south-facing sides of canyons at elevations between 5,600 and 6,200 ft. The piñon (*Pinus edulis* Engelm.)-juniper cover type, generally between 6,200 to 6,900 ft in elevation, covers large portions of the mesa tops and north-facing slopes at the lower elevations. Ponderosa pine (Pinus ponderosa P. and C. Lawson) communities are

found in the western portion of the plateau between 6,900 and 7,500 ft in elevation. These three vegetation types predominate the plateau, each occupying roughly one-third of the Laboratory site. The mixed conifer cover type, at an elevation of 7,500 to 9,500 ft, overlaps the Ponderosa pine community in the deeper canyons and on north-facing slopes and extends from the higher mesas onto the slopes of the Jemez Mountains. The spruce (*Picea* spp.)-fir (*Abies* spp.) cover type is at higher elevations of 9,500 to 10,500 ft. Several wetlands and riparian areas enrich the diversity of plants and animals found on the plateau.

In May 2000, the Cerro Grande fire burned more than 43,000 acres of forest in and around LANL. Most of the habitat damage occurred on Forest Service property to the west and north of LANL. Approximately 7,684 acres, or 28% of the vegetation at LANL, was burned to varying degrees by the fire. However, few areas on LANL property were burned severely.

The extreme drought conditions prevalent in the Los Alamos area and all of New Mexico from 1998 through 2003 resulted directly and indirectly in the mortality of many trees. Between 2002 and 2005, more than 90% of the piñon trees greater than 10 ft tall died in the Los Alamos area. Lower levels of mortality also occurred in ponderosa and mixed conifer stands. Mixed conifers on north-facing canyon slopes at lower elevations experienced widespread mortality. These changes likely will have long-lasting impacts to vegetation community composition and distribution.

4. Cultural Resources

The Pajarito Plateau is an archaeologically rich area. Approximately 86% of DOE land in Los Alamos County has been surveyed for prehistoric and historic cultural resources, and more than 1,800 sites have been recorded. During fiscal year 2006, sites that have been excavated since the 1950s were removed from the overall site count numbers. Thus, there are fewer recorded sites than the number reported in previous years. More than 85% of the resources are Ancestral Pueblo and date from the 13th, 14th, and 15th centuries. Most of the sites are found in the piñon-juniper vegetation zone, with 80% located between 5,800 and 7,100 ft. Almost three-quarters of all cultural resources are found on mesa tops. Buildings and structures from the Manhattan Project and the early Cold War period (1943–1963) are being evaluated for eligibility for listing in the National Register of Historic Places, and more than 500 buildings have been evaluated to date. In addition, "key facilities" (facilities considered of national historic significance) dating from 1963 to the end of the Cold War in 1990 are being evaluated.

5. Climate

Los Alamos County has a temperate, semiarid mountain climate. Large differences in locally observed temperature and precipitation exist because of the 1,000-ft elevation change across the Laboratory site and the complex topography. Four distinct seasons occur in Los Alamos County. Winters are generally mild, with occasional winter storms. Spring is the windiest season. Summer is the rainy season, with occasional afternoon thunderstorms. Fall is typically dry, cool, and calm.

Daily temperatures are highly variable (a 23°F range on average). On average, winter temperatures range from 30°F to 50°F during the daytime and from 15°F to 25°F during the nighttime. The Sangre de Cristo mountains to the east of the Rio Grande Valley act as a barrier to wintertime arctic air masses that descend into the central United States, making the occurrence of local subzero temperatures rare. On average, summer temperatures range from 70°F to 88°F during the daytime and from 50°F to 59°F during the nighttime.

From 1971 to 2000, the average annual precipitation (which includes both rain and the water equivalent of frozen precipitation) was 18.95 in., and the average annual snowfall amount was 58.7 in. (Note: By convention, full decades are used to calculate climate averages [WMO 1984].) The months of July and August account for 36% of the annual precipitation and encompass the bulk of the rainy season, which typically begins in early July and ends in early September. Afternoon thunderstorms form as moist air from the Pacific Ocean and the Gulf of Mexico is convected and/or orographically lifted by the Jemez Mountains. The thunderstorms yield short, heavy downpours and an abundance of lightning. Local lightning density, among the highest in the United States, is estimated at 15 strikes per square mile per year. Lightning is most commonly observed between May and September (about 97% of the local lightning activity).

The complex topography of the Pajarito Plateau influences local wind patterns. Often a distinct diurnal cycle of winds occurs. Daytime winds measured in the Los Alamos area are predominately from the south, consistent with the typical upslope flow of heated daytime air moving up the Rio Grande valley. Nighttime winds (sunset to sunrise) on the Pajarito Plateau are lighter and more variable than daytime winds and typically from the west, resulting from a combination of prevailing winds from the west and downslope flow of cooled mountain air. Winds atop Pajarito Mountain are more representative of upper-level flows and primarily range from the northwest to the southwest, mainly because of the prevailing westerly winds.

C. LABORATORY ACTIVITIES AND FACILITIES

The Laboratory is divided into technical areas (TAs) used for building sites, experimental areas, support facilities, roads, and utility rights-of-way (Appendix C and Figure 1-3). However, these uses account for only a small part of the total land area; much of the LANL land provides buffer areas for security and safety or is held in reserve for future use. The Laboratory has about 2,000 structures, with approximately 8.6 million square feet under roof, spread over an area of approximately 40 square miles.

DOE National Nuclear Security Administration (NNSA) issued a new Site-Wide Environmental Impact Statement (SWEIS) in May 2008 (DOE 2008a) and a limited Record of Decision (ROD) in September 2008 (DOE 2008b). In the SWEIS, LANL identified 15 Laboratory facilities as "Key Facilities" for the purposes of facilitating a logical and comprehensive evaluation of the potential environmental impacts of LANL operations (Table 1-1). Operations in the Key Facilities represent the majority of exposures associated with LANL operations. The facilities identified as "key" are those that house activities critical to meeting work assignments given to LANL and also:

- House operations that could potentially cause significant environmental impacts,
- Are of most interest or concern to the public based on scoping comments received, or
- Would be the facilities most subject to change as a result of programmatic decisions.

In the SWEIS, the remaining LANL facilities were identified as "Non-Key Facilities" because these facilities do not meet the above criteria. The Non-Key Facilities comprise all or the majority of 30 of LANL's 48 TAs and approximately 14,224 acres of LANL's 26,480 acres (Table 1-1). The Non-Key Facilities also currently employ about 42% of the total LANL workforce. The Non-Key Facilities include such important buildings and operations as the Nonproliferation and International Security Center (NISC), the new National Security Sciences Building (NSSB), which is now the main administration building, and the TA-46 sewage treatment facility.



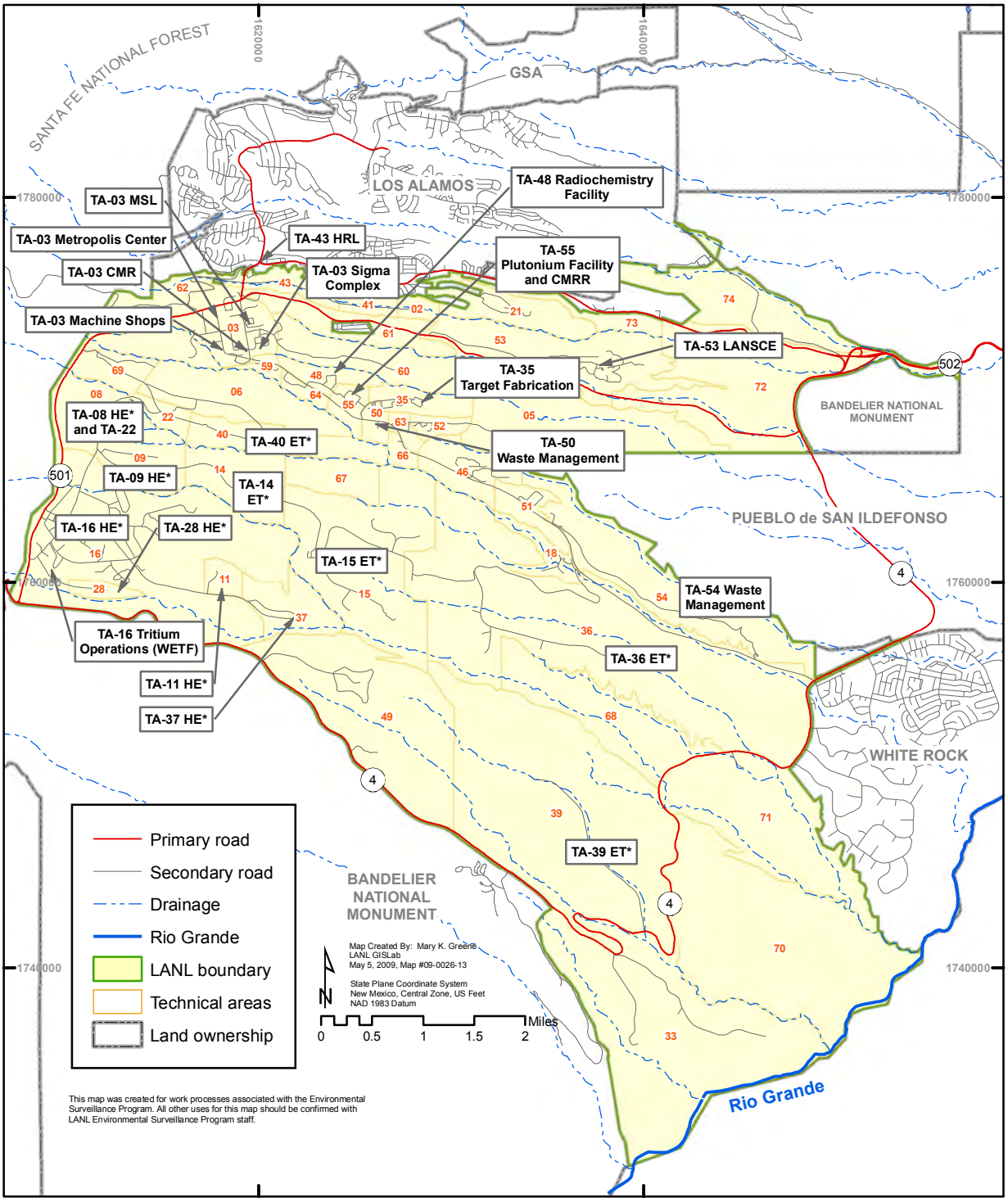


Figure 1-3. Technical Areas and Key Facilities of Los Alamos National Laboratory in relation to surrounding landholdings (*ET = Explosive testing; HE = High explosive processing).

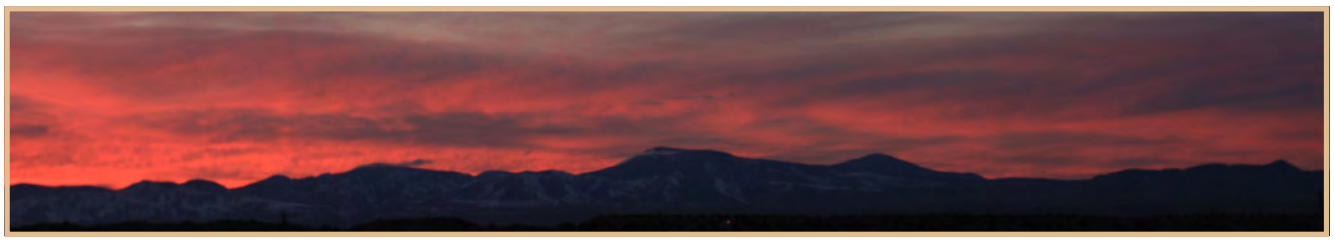


Table 1-1
Key Facilities*

Facility	Technical Areas
Plutonium Complex	TA-55
Tritium Facilities	TA-16
Chemistry and Metallurgy Research (CMR) Building	TA-03
Sigma Complex	TA-03
Materials Science Laboratory (MSL)	TA-03
Target Fabrication Facility (TFF)	TA-35
Machine Shops	TA-03
Nicholas C. Metropolis Center for Modeling and Simulation	TA-03
High-Explosives Processing	TA-08, -09, -11, -16, -22, -37
High-Explosives Testing	TA-14, -15, -36, -39, -40
Los Alamos Neutron Science Center (LANSCE)	TA-53
Biosciences Facilities (formerly Health Research Laboratory)	TA-43, -03, -16, -35, -46
Radiochemistry Facility	TA-48
Radioactive Liquid Waste Treatment Facility (RLWTF)	TA-50
Solid Radioactive and Chemical Waste Facilities	TA-50, TA-54

*Data from 2008 SWEIS.

D. MANAGEMENT OF ENVIRONMENT, SAFETY, AND HEALTH

Safety, environmental protection, and compliance with environmental, safety, and health (ES&H) laws and regulations are underlying values of all Laboratory work. The Laboratory uses ISM to create a worker-based safety and environmental compliance culture in which all workers commit to safety and environmental protection in their daily work. A seamless integration of ES&H with the work being done is fundamental to the compliance culture. ISM provides the Laboratory with a comprehensive, systematic, standards-based, performance-driven management system for setting, implementing, and sustaining safety performance and meeting environmental expectations. The term "integrated" is used to indicate that safety, protection of the environment, and compliance with ES&H laws and regulations are an integral part of how the Laboratory conducts its work. ISM is the way LANL meets the ethical commitment to avoid injury to people and the environment and the business imperative to meet the safety and environmental requirements of the contract for managing and operating the Laboratory.

Each Laboratory organization is responsible for its own environmental management and performance. Line management provides leadership and ensures ES&H performance is within the context of the Laboratory's values and mission. Laboratory managers establish and manage ES&H initiatives, determine and communicate expectations, allocate resources, assess performance, and are held accountable for safety performance.

Environmental characterization, remediation, surveillance, and waste management programs are part of the Environmental Programs (EP) Directorate. Environmental permitting, the environmental management system, pollution prevention, integrated environmental review, land transfer, the SWEIS, and other environmental risk reduction activities are managed within the Environmental Protection Division in the Environment, Safety, Health, and Quality (ESH&Q) Directorate. An organizational chart and description is available at http://www.lanl.gov/organization/. The major environmental programs and management system are described below.

1. Environmental Management System

The Laboratory is committed to protecting the environment while conducting its important national security and energy-related missions. DOE Order 450.1A, Environmental Protection Program, requires all DOE sites to "implement sound stewardship practices that are protective of the air, water, land, and other natural and cultural resources impacted by DOE operations and by which DOE cost-effectively meets or exceeds compliance with applicable environmental; public health; and resource protection laws, regulations, and DOE requirements." The order further states this objective must be accomplished by implementing an Environmental Management Systems (EMS) at each DOE site.

LANL has implemented a pollution-prevention-based EMS, meeting the DOE Order 450.1A requirement to have an EMS implemented by December 31, 2005.

An EMS is a systematic method for assessing mission activities, determining the environmental impacts of those activities, prioritizing improvements, and measuring results. DOE Order 450.1A defines an EMS as "a continuous cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental missions and goals." This DOE order mandates that the EMS be integrated with an existing management system already established pursuant to DOE Policy 450.4. Although it significantly exceeds DOE Order 450.1A requirements, LANL pursued and achieved registration to the ISO 14001-2004 standard in April 2006.

A key feature of the Laboratory EMS is the focus on ensuring that it is integrated with existing procedures and systems wherever possible. The intent is for the EMS to consolidate these existing programs into a systematic process for environmental performance improvement. The ISM provides an important foundation for the five core elements of the EMS:

The ISM provides an important foundation for the five core elements of the EMS:

1. Policy and Commitment
2. Planning
3. Implementation and Operation
4. Checking and Corrective Action
5. Management Review

More information about the EMS may be found at http://www.lanl.gov/environment/risk/ems.shtml.

The EMS met several milestones in 2009. Multi-disciplinary teams from each Directorate executed the EMS process. These organizations identified their activities, products, and services and their potential environmental aspects. They prioritized these aspects to determine which were significant and developed an Environmental Action Plan designed to prevent or eliminate the environmental risk associated with those aspects. A trained support person from the EMS Management Team, whose members were trained in ISO 14001:2004 systems, aided the Directorate teams.

All 15 Directorates completed the Directorate Environmental Action Plans. Together, these plans committed to nearly 600 environmental improvement and pollution prevention actions covering fiscal years 2006 and 2007. For fiscal years 2008 through 2009, an additional 424 improvements actions were implemented. In addition, new action plans were developed for implementation in 2010.

Certification to the ISO 14001-2004 standard requires extensive management review. External audits of the system have been conducted as follows:

- Kansas City Plant Pre-Audit, September 2004 (three auditors, three days)
- National Sanitation Foundation-International Strategic Registration, Ltd.(NSF-ISR, an independent third-party ISO 14001 registrar) Pre-Assessment, September 2005 (two auditors, three days)

- NSF-ISR Desk Audit, November 2005 (one auditor, two days)
- NSF-ISR Readiness Review, Phase 1 Audit, January 2006 (two auditors, three days)
- NSF-ISR Certification Audit, Phase 2 Audit, March 2006 (five auditors, five days)
- NSF-ISR Surveillance Audit 1, September 2006 (two auditors, three days)
- NSF-ISR Surveillance Audit 2, April 2007 (two auditors, three days)
- NSF-ISR Surveillance Audit 3, October 2007 (two auditors, three days)
- NSF-ISR Surveillance Audit 4, May 2008 (two auditors, three days)
- NSF-ISR Surveillance Audit 5, October 2008 (two auditors, three days)
- NSF-ISR Re-certification Audit, March 2009 (three auditors, five days)

These audits covered most of the Directorates and Divisions and all major support contractors and included interviews conducted from the Principal Associate Director level to individual staff and students chosen at random by the auditors. The auditors concluded that the Laboratory's EMS meets all the requirements of the ISO 14001-2004 standard with no major non-conformities and recommended that LANL maintain full certification. On April 13, 2006, LANL received full certification of its EMS to the ISO 14001-2004 standard. LANL was the first NNSA national laboratory and was the first University of California-operated facility to receive this distinction. In March, 2009, NSF-ISR conducted a thorough re-certification audit (as required by ISO 14001-2004) of the LANL EMS and found that all requirements for certification were met. The auditors also noted that there was significant evidence that the EMS was maturing as a management system and that significant risk reduction measures were in place and working.

NNSA and DOE recognized the success of the EMS management and the unique approach by giving the Laboratory the 2009 NNSA "Best in Class" Award and the "DOE E-Star" for the institutional improvements identified and implemented through the EMS from 2006 to 2008.

A second important component of the EMS is the institutional environmental stewardship and management support programs. These programs, described in the following sections, assist with the integration of job and work-specific evaluations and ensure natural and cultural resources are managed from a Laboratory-wide perspective.

2. Waste Management Program

Research programs that support the Laboratory's mission generate contaminated waste that must be properly managed to avoid risks to human health, the environment, or national security. Remediation of sites contaminated by past Laboratory operations also generates substantial volumes of waste. The Laboratory generates Resource Conservation and Recovery Act (RCRA) regulated waste, Toxic Substances Control Act regulated waste, low-level radioactive waste (both solid and liquid), mixed low-level waste, transuranic waste, administratively controlled waste, medical waste, New Mexico Special Waste, and sanitary solid and liquid waste. Certain wastes are treated and/or disposed of at the Laboratory, but most wastes are shipped off-site for treatment and final disposal.

The Laboratory's goal is to minimize hazardous and non-hazardous waste generation as much as is technically and economically feasible, as discussed in Section 3, *Pollution Prevention Program*, below. The Laboratory also strives to conduct waste management operations in a manner that maintains excellence in safety, compliance, environment, health, and waste management operations. This goal is accomplished through the following program tenets:

- Ensuring a safe and healthy workplace;
- Minimizing adverse impact to the general public;
- Minimizing adverse impact to the environment; and
- Ensuring compliance with all applicable laws, standards, and regulations governing environment, safety, and health.

LANL manages all waste management and disposal operations, except sanitary solid and liquid wastes, under its Environmental Programs Directorate. TA-54, Area G, managed by the Waste Disposition Project, is the Laboratory's primary solid radioactive and hazardous waste handling site. Thousands of drums of packaged transuranic waste are securely stored at this site awaiting transport to the DOE's Waste Isolation Pilot Plant (WIPP) near Carlsbad, NM. The site also receives, processes, and disposes of approximately 4,000 m^3 of low–level radioactive waste per year. In the past, wastes were often buried in or released to pits or trenches around the Laboratory; several of these areas, known as Material Disposal Areas (MDAs), have been remediated, and the remainder are either being investigated or undergoing remediation as discussed in Section 4, *Environmental Protection Programs,* below.

The Radioactive Liquid Waste Program manages the RLWTF at TA-50. The RLWTF treats approximately 1.6 million gal/year of radioactive liquid waste.

The Water Quality and RCRA Group in the Environmental Protection Division provides guidance and support to Laboratory waste generators on compliance with all waste handling requirements. Within the EP Directorate, both the Waste Disposition Project and the Waste and Environmental Services Division provide direct support to waste generators on specific aspects of waste packaging, waste acceptance criteria, and transportation of hazardous and radioactive wastes for proper treatment and disposal.

The Waste Disposition Project also operates the "Green is Clean Program" to reduce low-level radioactive waste generation through a waste segregation and verification program. Generators segregate clean waste from radioactive-contaminated waste and ship it to TA-54, Area G, for verification through a very sensitive radioactive measurement system.

3. Pollution Prevention Program

The Pollution Prevention (P2) Program implements waste minimization, pollution prevention, sustainable design, and conservation projects to enhance operational efficiency, reduce life-cycle costs of programs or projects, and reduce risks to the environment. Reducing waste directly contributes to the efficient performance of the Laboratory's national security, energy, and science missions. Specific P2 activities include the following:

- Collecting data and reporting on DOE P2 goals;
- Forecasting waste volume to identify P2 opportunities;
- Conducting P2 opportunity assessments for customer divisions;
- Providing technical support for pollution prevention;
- Funding specific waste reduction projects through the LANL Generator Set-Aside Fund Program;
- Supporting affirmative procurement efforts;
- Conducting an annual LANL P2 awards program to recognize achievements;
- Supporting sustainable design for the construction of new buildings; and
- Communicating P2 issues to the Laboratory community.

Pollution Prevention Projects in fiscal year 2009 yielded $6 million in savings to the Laboratory. The P2 Program received an overall performance rating of "Good" for fiscal year 2009. The P2 Program collectively avoided the generation of 3 cubic meters of transuranic waste; recycled or reduced 16.5 cubic meters of mixed low level waste; avoided 116,188 kg hazardous waste; reduced, reused or recycled 10,581 metric tons of solid waste; avoided 385 cubic meters of low level waste; eliminated 2,000,000 gallons of water use; diverted 241,000 liters of liquid waste from the Radioactive Liquid Waste Treatment Facility; eliminated 25,000 liters of high explosive waste water discharge; and avoided hundreds of labor hours.

The Pollution Prevention Program measures reductions in routine waste as part of prevention performance tracking and measurement per DOE guidance. Routine waste includes waste from ongoing processes and does not include waste from spills, clean-up, demolition and decommissioning, construction, or any material that is recycled. The rationale is that prevention measures are most successfully applied to ongoing processes rather than one-time or unplanned activities. Non-routine waste from clean up, demolition, and construction are generally larger than routine waste. However, the Pollution Prevention Program works with all waste generators to reduce unnecessary waste, routine or non-routine. Figures 1-4 and 1-5 show routine waste generation from 2004 through 2009. Waste generation, as a whole, does not always reflect the amount of prevention occurring at the site since reductions in one area may be offset by new waste-generating processes coming on-line. LANL continues to document significant waste reductions, even with new processes contributing new waste to the system. Note that radioactive and mixed waste is reported in volume and hazardous waste is reported in weight.

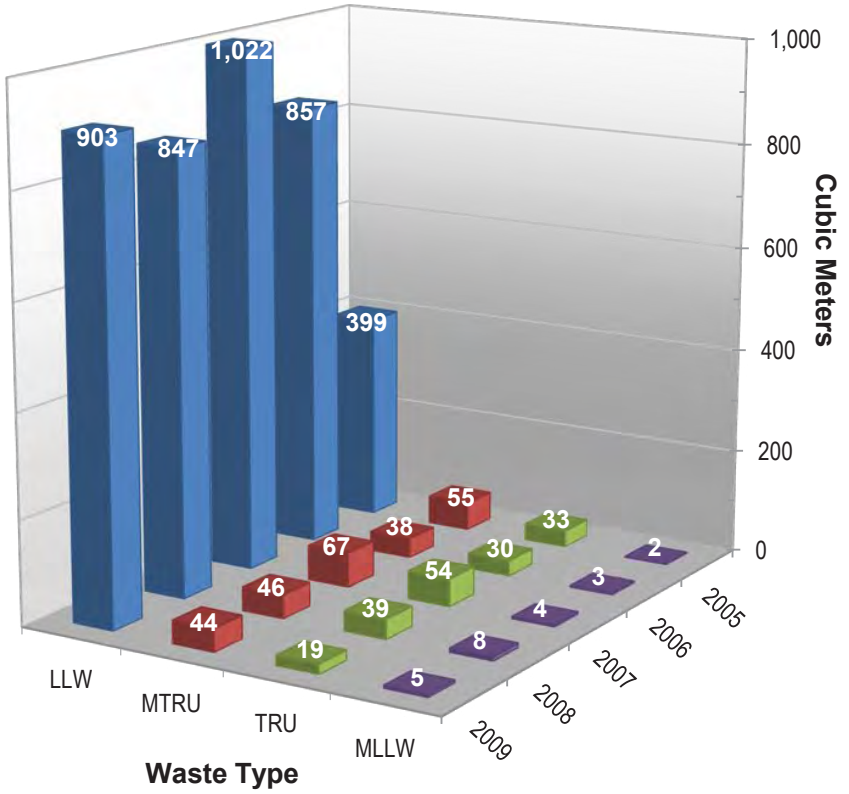


Figure 1-4. Cubic meters of low-level radioactive (LLW), mixed transuranic (MTRU), transuranic (TRU), and mixed low-level radioactive (MLLW) wastes generated at LANL for the past 5 years.

"Green purchasing" is mandated by an executive order and calls for considering environmental factors in purchasing decisions in addition to traditional factors such as performance, price, health, and safety. Green purchasing, also known as affirmative procurement, is procurement of products or services considered to be environmentally preferable, meaning those products that have a comparatively smaller negative effect on human health and the environment. The aim is to eliminate waste, prevent pollution, and improve the quality of the environment. In fiscal year 2009, the Laboratory continued to ensure that new contracts for office supplies and other goods and services included a strong emphasis on green product offerings.

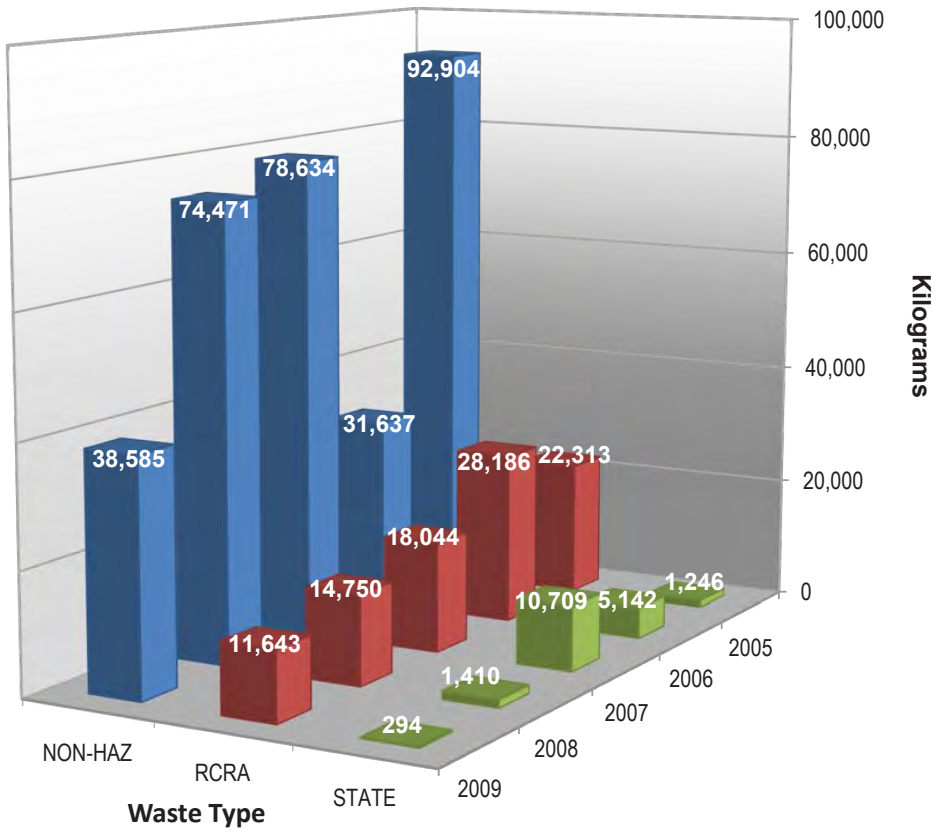


Figure 1-5. Kilograms of non-hazardous waste, RCRA-regulated waste, and NMED-regulated wastes generated at LANL for the past 5 years.

The Laboratory's P2 Program won four NNSA Pollution Prevention Awards for projects completed in 2009. The awards are based on an NNSA-wide competition and recognize major contributions in pollution prevention, recycling, and procurement. The awards affirm the importance and benefits of integrating pollution prevention into all NNSA sites' operations through environmental management systems. The actual award ceremony will be held in 2010. The NNSA Pollution Prevention Awards are summarized below.

- **RCRA-less Oxidation (NNSA Best in Class Award):** LANL developed the RCRA-less Oxidation approach to replace toxic RCRA-listed salts with non-toxic reagents for actinide separation schemes. RCRA-less Oxidation enables a 140-fold decrease in cost for waste treatment and disposal relative to other, standard oxidation methods. The process generates low level radioactive waste rather than mixed low-level radioactive hazardous waste. There is a three-fold decrease in cost of raw starting materials because silver salts are more expensive than their copper analogues.

- **Radiological Laboratory/Utility/Office Building (RLUOB) Integrated Planning, Design, Procurement, and Construction (NNSA Best in Class Award):** LANL uses the LEED® third-party rating system to document high performance sustainable design considerations and measure the level of sustainability that the RLUOB building achieves. Green design and implementation elements include sustainable site selection and development adjacent to programmatic facilities it will serve, construction with highly reflective roofing material to minimize the heat island effect, water efficiency, optimized energy performance, an indoor air quality management plan, and reduced environmental impact of materials and resources. Through September 2009, approximately 85% (by weight) of RLUOB construction waste including concrete, metal, corrugated cardboard, wood, and asphalt were recycled or reused and thereby diverted from disposal in landfills.

- **LANL's Electronic Recycling Program (NNSA Environmental Stewardship Award):** In the past, LANL disposed of computers by removing the hard drives and shredding and disposing of them through an out-of-state electronic recycler. The computer shell was then was released for sale to the public. LANL was concerned about management of materials sold to the public, especially in light of rising concerns about electronics recycling in third-world countries and associated pollution and public health issues. In addition, new memory device security requirements greatly expanded the types of electronic memory devices to include digital cameras, two-way radios, cell phones, and pagers, copiers, faxes, printers, PDAs, iPods, phones, thumb drives, as well as circuit boards, computers, and laptops. Property management staff improved the electronics disposal process to enhance security and closed the loop on all of LANL's salvaged memory devices, ensure proper cradle-to-grave management of LANL property through a zero-waste system and reduce the operation's overall carbon footprint. In 2009, LANL shipped 93,554 lbs of e-waste to a company at Terrell, Texas, where the electronics are crushed and recycled. The estimated savings for one year is $172,000. All of LANL's e-waste is recycled appropriately through this process.
- **Alternative Fuel Use at LANL (NNSA Environmental Stewardship Award):** In fiscal year 2009, a third of the LANL fleet could use E-85 fuel, an alcohol fuel mixture that typically contains up to 85% denatured fuel ethanol. At the end of 2009, one-half of LANL's fleet of vehicles was flex-fuel and 75% of the security officers' fleet in Los Alamos was powered by E-85. Since no local vendors have E-85 fuel available, LANL procured a mobile E-85 fuel transport truck that meets drivers of flex-fuel vehicles at a specified location for fueling. By using alternative fuels, LANL is meeting the intent of Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management, which led to DOE Order 430.2B.

4. Environmental Restoration Programs

The environmental restoration and cleanup work at LANL is organized into several projects that have responsibility for different aspects of environmental restoration:

- Corrective Actions Program (includes investigations and remediations in canyons)
- TA-21 Closure Project
- TA-54 Closure Project

The goal of these programs is to ensure that residual contaminants from past Laboratory operations do not threaten human or environmental health and safety. To achieve this goal, the Laboratory is investigating and, as necessary, remediating sites contaminated by past Laboratory operations. In calendar year 2009, fieldwork at several sites was either implemented, ongoing, or completed. Much of the work under these projects is subject to the requirements in the New Mexico Environment Department's (NMED's) Compliance Order on Consent (Consent Order), described in Chapter 2, Section B.1h. Most environmental sample analyses (78%) were for characterization or assessment of sites being investigated or cleaned up at LANL (Table 1-2). Chapter 9 summarizes the cleanup work conducted or completed in calendar year 2009.

After sites have been remediated, long-term monitoring may be required as part of the chosen remedy solution. Such monitoring will eventually become part of the existing environmental surveillance programs and will fulfill DOE requirements for a long-term environmental stewardship program.

Table 1-2
Approximate Numbers of Environmental Samples, Locations, and Analytes Collected in 2009

Sample Type or Media	Locations	Samples	Analytes or Measurements
Ambient Air*	65	2,969	9,792
Stack Monitoring	28	2,761	22,266
Biota	79	168	5,242
Soil	80	156	8,028
Sediment	60	69	8,743
Foodstuffs	22	34	3,246
Groundwater	200	1,6057	162,153
NPDES Outfalls	14	168	2,176
Surface Water Base Flow	30	123	16,394
Surface Water Storm Runoff	22	83	9,749
Neutron Radiation	47	188	188
Gamma Radiation	89	356	356
Environmental Restoration	2,849	4,882	766,499
Subsurface Vapor Monitoring	65	1,381	104,186
Totals:	**3,650**	**15,640**	**1,119,308**

Note: Not all the data counted in the table above are reported in this document. Totals include duplicate samples but do not include additional samples and results from extensive quality assurance/quality control program, which are normally 10% to 20% more but can be over 60% more, depending on the media.

* Does not include particulate (in air) measurements made by four Tapered Element Oscillating Microbalance instruments that calculated particulate concentrations every half hour.

5. Compliance and Surveillance Programs

LANL's environmental compliance and surveillance programs identify possible environmental hazards and impacts by regularly collecting samples and comparing results with previous results and applicable regulatory standards. The Laboratory routinely collects samples of air particles and gases, water, soil, sediment, foodstuffs, and associated biota from over 3,650 locations (Table 1-2).

All monitoring data collected at LANL is available through the RACER Data Analysis Tool (http://racernm.com/). This tool was developed to provide public access to the same data that NMED and LANL use in making remediation and other environmental management decisions.

In 2008, LANL and the local DOE office re-initiated the effort to pursue a natural resources damages assessment (NRDA) for LANL. The goal of the NRDA is to assess and recover monetary damages for injuries to natural resources (including air, surface water, groundwater, soils, and biota) that have resulted from the release of hazardous substances to the environment from the area of LANL. In 2009, the Trustee Council determined that the pre-assessment screen criteria have been met and it is appropriate to pursue a full scale assessment. See Chapter 2 of this document for more information.

Monitoring can detect and identify environmental impacts from hazardous and radioactive materials and data from monitoring can be used to help with mitigation of any impacts. To this end, each pathway by which an individual could be exposed is monitored. The sensitivity of environmental surveillance measurements allows for the detection of contaminants during cleanup or normal operations. Additional monitoring may be conducted in places where there is an increased potential for environmental releases. In some cases, immediate actions are warranted because of monitoring results. The various environmental monitoring programs are discussed below.

a. Air Quality Monitoring

The Laboratory maintains a rigorous ambient air surveillance and air quality compliance program for the emissions of both radionuclide and nonradionuclide air pollutants. The air monitoring and compliance efforts consist of three main parts: compliance and permitting, stack monitoring, and ambient air monitoring (AIRNET).

The Laboratory also works with and assists neighboring communities and pueblos in performing ambient air, direct penetrating radiation, and meteorological monitoring.

i. Compliance and Permitting

The Laboratory operates under a number of air emissions permits issued by the NMED and approvals for construction of new facilities or operations by the US Environmental Protection Agency (EPA). These permits and approvals require pollution control devices, stack emissions monitoring, and routine reporting.

LANS is authorized to operate applicable air emission sources at LANL per the terms and conditions as defined in Operating Permit No. P100 M2. As part of the Title V Operating Permit program, the Laboratory reports emissions from sources included in the Operating Permit twice a year. In 2008, the Laboratory submitted its new Title V permit application for a five-year renewal; the new permit was issued in 2009.

In addition, the Laboratory maintains compliance with Title VI of the Clean Air Act, which regulates the use of ozone-depleting substances, such as halons and refrigerants. The Laboratory maintains records on all work that involves refrigerants and the purchase, usage, and disposal of refrigerants.

To ensure compliance with the National Emission Standard for Hazardous Air Pollutants (NESHAP) for asbestos, the Laboratory conducted internal inspections of job sites and asbestos packaging approximately monthly. During 2009, the Laboratory had 17 major renovation or demolition projects that involved removal of asbestos. LANL also reports emissions from chemical use associated with research and permitted beryllium activities.

Chapter 2 of this report describes in greater detail these permits and the status of compliance; this information is also available online at http://www.lanl.gov/environment/air/.

ii. Stack Monitoring

As described in greater detail in Chapters 2 and 4, LANL rigorously controls and monitors stack emissions of radioactivity, as required by the Clean Air Act. Members of the Rad-NESHAP team at LANL evaluate these operations to determine potential impacts of the stack emissions on the public and the environment. This team continuously sampled 26 stacks at LANL for the emission of radioactive material to the ambient air. LANL categorizes its radioactive stack emissions into one of four types: (1) particulate matter, (2) vaporous activation products, (3) tritium, and (4) gaseous mixed activation products (GMAP).

During 2009, the off-site dose impact from LANL stack emissions was about 5.5% of the Clean Air Act standard for radionuclide emissions.

iii. Ambient Air Monitoring

The Laboratory operates an extensive network of ambient air quality monitoring stations (AIRNET) to detect other possible radioactive emissions (see Chapter 4). The network includes stations located on site, in adjacent communities, and in regional locations. These stations are operated to ensure that air quality meets EPA and DOE standards. These data are published in this report (see Chapter 4) and online at http://www.lanl.gov/environment/air/. During 2009, the AIRNET system did not detect any radionuclide concentrations of concern.

b. Water Resources Monitoring

The water resources monitoring and compliance efforts consist of three main parts: compliance and permitting, groundwater monitoring, and surface water monitoring.

i. Compliance and Permitting

The Laboratory's Water Quality and RCRA Group is responsible for all compliance and permitting functions related to the state Water Quality Act and federal Clean Water Act requirements. The group provides institutional expertise and implementation assistance for obtaining regulatory permits and maintaining compliance with all permit requirements. These functions include sampling, processing, and analyzing water and wastewater from treatment facilities; institutional coordination, integration, and communication of all wastewater resource-related monitoring and reporting activities; submitting permit applications, notices of intent to discharge, analytical data, and compliance documentation; interpretation of compliance with state and federal water quality laws and regulations; development of institutional standards and policy regarding water and wastewater with line organizations; and interaction with regulatory agencies, stakeholders, the public, and Native American pueblos on water quality or water resource management issues.

ii. Groundwater Monitoring

The LANL Water Stewardship Program manages and protects groundwater and surface water resources (see Chapters 5 and 6). The Laboratory conducts several activities to comply with the requirements of DOE orders, state and federal regulations, and the Consent Order.

Groundwater resource management and protection efforts at the Laboratory focus on (1) the regional aquifer underlying the plateau, (2) the shallow perched groundwater found within canyon alluvium, and (3) the perched groundwater at intermediate depths above the regional aquifer. The objectives of the Laboratory's groundwater programs are to determine compliance with liquid waste discharge requirements and to evaluate any impact from Laboratory activities on groundwater resources. This program includes environmental monitoring, resource management, aquifer protection, and hydrogeologic investigations.

The Los Alamos County water supply system contains no detected LANL-derived contaminants. At present, the major thrust of the water-monitoring program, being developed under the Consent Order with NMED, is directed toward estimating the prospective risk from contamination that may enter the drinking water in the future. One such activity is modeling to estimate the possibility of contaminants migrating from the surface through the vadose zone to the aquifer. Data show that plutonium, uranium, cesium, and strontium are tightly bound to the soil matrix and so will not migrate in measurable amounts. Tritium is more mobile, but due to dilution and long travel times to the regional aquifer compared with its approximately 12-year radioactive half-life, the activity of tritium in the regional aquifer is far below the drinking water standard. Thus, migration of radionuclides is not likely to be a problem, so attention is focused on migration of chemicals such as perchlorate, chromium, solvents, and high explosive residues.

LANL has drilled numerous monitoring wells over the past several years, and several more wells were drilled in 2009. These new wells will provide a better picture of the location and movement of contamination in the groundwater. Details of the new wells are provided in Chapter 2.



iii. Surface Water Monitoring

LANL's surface water protection efforts focus on monitoring surface water and stream sediment in northern New Mexico. The objectives of the surface water program are to address water pollution control compliance, environmental surveillance, watershed management, surface and ground water protection, drinking water quality protection, pesticide protection obligations, and public assurance needs. Samplers at more than 290 sites are set to collect samples when sufficient water is present during storm runoff events. The Laboratory analyzes samples for radionuclides, high explosives, metals, a wide range of organic compounds, and general chemistry.

c. Biological Monitoring

The LANL biological resources program focuses on assisting Laboratory projects and programs to comply with federal and state laws and regulations, DOE Orders, and LANL directives related to biological resources. LANL adopted a Biological Resources Management Plan in 2007. This document, along with LANL's 2005 revision of its Threatened and Endangered Species Habitat Management Plan, provides guidance for biological resources protection at LANL. The presence of federally listed species is monitored annually. In addition, the biological resources program is currently conducting an inventory of riparian habitats at LANL and is continuing a project to monitor state-listed species such as the Gray Vireo and Jemez Mountains Salamander.

LANL's Emergency Management and Response Division manages wildland fire, including fuels monitoring and treatment on LANL property. One of the lasting results of past wildfires in and around LANL has been a significant increase in a regional, multi-agency approach to managing wildland fire. In September 2007, the Laboratory adopted the Wildland Fire Management Plan, which provides a strategic program to manage risk associated with wildland fires (LANL 2007).

d. Soil, Foodstuffs, and Non-foodstuff Biota Monitoring

The Laboratory collects surface soil, foodstuffs, and non-foodstuffs biota from the Laboratory, perimeter communities (Los Alamos, White Rock, and surrounding pueblos), and regional (background) areas to determine whether Laboratory operations impact human health via the food chain and the environment. The Laboratory conducts these programs to comply with the requirements of DOE Orders and state and federal regulations. Samples of the various media are collected on a three-year rotating schedule and analyzed for radionuclides, heavy metals, and organic chemicals to determine concentrations and distribution in soil and potential uptake by plants, animals, and humans. Radiation doses to humans and biota (see Chapter 3) and changes in concentrations over time are also measured and analyzed. These data are published in Chapters 7 and 8 of this report and other Laboratory publications.

e. Radiation Monitoring

Gamma and neutron radiation is monitored by the direct penetrating radiation monitoring network (DPRNET) described in Chapter 4.

The largest source of direct radiation is TA-54, Area G, which is monitored at 33 DPRNET stations, all of which measure above-background intensities of neutron radiation. As discussed in Chapter 3, the all-pathway maximally exposed individual (MEI) is at the northern boundary of TA-54 and results primarily from neutrons. The neutron radiation is being reduced by removing the sources from Area G.

Though high radiation levels are not expected from TA-21 during the cleanup at that site, several new DPRNET stations were installed in 2006 along DP Road and State Road 502, between the potential sources at TA-21 and the public areas to the north and west.

Though not required for compliance purposes, the Laboratory operates 11 Neighborhood Environmental Monitoring Network (NEWNET) stations that measure gamma radiation levels at 15-minute intervals and post these data to the NEWNET website in near real time (http://newnet.lanl.gov/). Stations are located near the Laboratory boundary and in the nearby communities of Los Alamos, Pueblo de San Ildefonso, and Santa Clara Pueblo. The stations at East Gate and Mortandad Canyon are used to check the dose from LANSCE emissions. During 2009, the dose measured by NEWNET was 0.0 ±0.3 mrem. The data from these stations are available in real time on the NEWNET website and are not discussed further in this report.

f. Cultural Resources Protection

The Laboratory manages the diverse cultural resources according to the requirements of the National Historic Preservation Act and other federal laws and regulations concerned with cultural resources protection. Cultural resources include archaeological sites and associated artifacts, historic buildings and associated artifacts, and traditional cultural places of importance to Native American and other ethnic groups. Section 106 of the act requires federal agencies to take into account the effects of projects on historic properties and to allow review and comment by the State Historic Preservation Office and the Advisory Council on Historic Preservation. The Section 106 regulations outline a project review process that is conducted on a project-by-project basis.

The Laboratory has adopted a Cultural Resources Management Plan (LANL 2005b) as an institutional comprehensive plan that defines the responsibilities, requirements, and methods for managing its cultural properties. The plan provides an overview of the cultural resources program, establishes a set of procedures for effective compliance with applicable historic preservation laws, addresses land-use conflicts and opportunities, ensures public awareness of DOE's cultural heritage stewardship actions at LANL, and provides a 10-year road map that summarizes and prioritizes the steps necessary to manage these resources.

E. RISK AND HAZARD REDUCTION

The Laboratory is committed to reducing hazards and the associated risk to people and the environment. In some cases the risk is directly related to dose, which results from actual exposure to a radiological or chemical hazard. In this case, the risk is reduced by keeping the dose as low as reasonably achievable (ALARA). In other cases the risk depends on the probability of exposure in the future. For example, buried hazardous material may have little or no exposure under current conditions but may have an increased probability of exposure if the material is brought to the surface.

1. Estimation of Risk

Current risk is the risk of harm that might result from present-day conditions, whereas prospective risk is defined by the EPA as "the future risks of a stressor not yet released into the environment or of future conditions resulting from an existing stressor." The stressor or hazard could be a radionuclide or a chemical for which the potential risk is evaluated based on a reasonable exposure scenario.

An "acceptable" risk is determined by target levels defined by the regulatory authorities (EPA, NMED or DOE). These "acceptable" risks are less than a 10^{-5} (1 in 100,000) probability of cancer; a hazard index equal to 1.0 or less for noncancer-causing chemicals; and a dose of 15 mrem/yr or less for radionuclides. In keeping with the policy of maintaining all dose and risk as low as reasonably achievable, the Laboratory strives to reduce risk/dose to below these target levels whenever possible. For the MEI reported in Chapter 3 of this report, the calculated cancer risk from the estimated dose in 2009 was approximately 3×10^{-7} (a 3 in 10,000,000 chance of cancer).

To analyze risk, LANL uses environmental data, computer evaluation tools, and computer models. To evaluate potential risk based on material inventory buried or stored at a site, the Laboratory uses models such as the residual radioactivity (RESRAD) model (http://web.ead.anl.gov/resrad/), Hotspot (http://www.llnl.gov/nhi/hotspot/), and CAP88 (http://www.epa.gov/radiation/assessment/CAP88/index.html).

Prospective risk is also used in the evaluation of remediation and corrective measure options. Probabilistic models account for uncertainties. Prospective risk methods can also identify the additional data needed to determine the optimal decision, thus guiding data collection operations.

2. Examples of Risk Reduction

The following are examples of where the Laboratory is working to reduce risks.

a. TA-54, Area G, and MDA G

The transuranic waste disposition program expedites the disposal of legacy transuranic waste to WIPP in Carlsbad, NM. Area G stores radioactively contaminated waste and other contaminated materials in aboveground storage. MDA G is a subsurface disposal site containing potentially hazardous and radioactive

wastes from operational activities and from environmental restoration. Most of the waste will eventually be transported to permanent storage at WIPP in southern New Mexico.

As discussed in Chapter 3, the dose to the all-pathway MEI was about 1 mrem/yr in 2009. The primary method used to reduce both the current and prospective risk at Area G is to steadily reduce the inventory of transuranic waste by transporting drums of radioactive material to WIPP. Of the approximately 100,000 plutonium equivalent curies (PE-Ci) of radioactive materials in secure above-ground storage at Area G, the Laboratory shipped approximately 15,000 PE-Ci in 2,000 drums to WIPP in 2009. Additionally, the Laboratory disposed of approximately 100 drums of radioactive sealed sources, recovered by the Off-site Source Recovery Program, at WIPP.

b. TA-21

TA-21 is the site of the Laboratory's original plutonium processing facility, a tritium processing and handling facility, and several MDAs. The inventories of hazardous and radioactive material at the MDAs are not well characterized because there are few records of waste disposal during the 1940s and the Manhattan Project. MDAs V and U have been remediated; MDAs A and T have or will undergo corrective measures evaluations to determine the appropriate corrective actions; and MDA B is scheduled to be remediated. In addition, the other sites at TA-21 are being characterized or remediated as part of the DP Site Aggregate Area investigation.

c. Groundwater

As discussed in Chapter 5, Groundwater Monitoring, Laboratory-derived impacts to groundwater have been detected in some monitoring wells. At present, there is no measurable LANL-derived contamination in the Los Alamos County drinking water system, but there may be a prospective risk because of the potential for contamination to migrate to the drinking water supply wells. For the past several years, efforts have been underway to evaluate groundwater quality and augment the current monitoring network to ensure monitoring activities will detect contamination in groundwater before it can affect the drinking water. These investigations will help determine the actions to reduce the prospective risk.

d. Environmental Characterization and Restoration

The objective of the environmental investigation and cleanup activities at the Laboratory is to identify and characterize the nature of the contamination, the location and extent of the contamination, whether it requires remediation, and what type of remediation is appropriate. Over the past few years, the Laboratory has been conducting corrective action activities under the Consent Order.

In the past several years, the Laboratory has determined where contamination is present and in many cases has reduced the legacy contamination. Where contamination is present, the risk is quantified to determine whether it is unacceptable with respect to human health and the environment. Chapter 9 provides information about environmental investigation and cleanup activities in 2009.

F. REFERENCES

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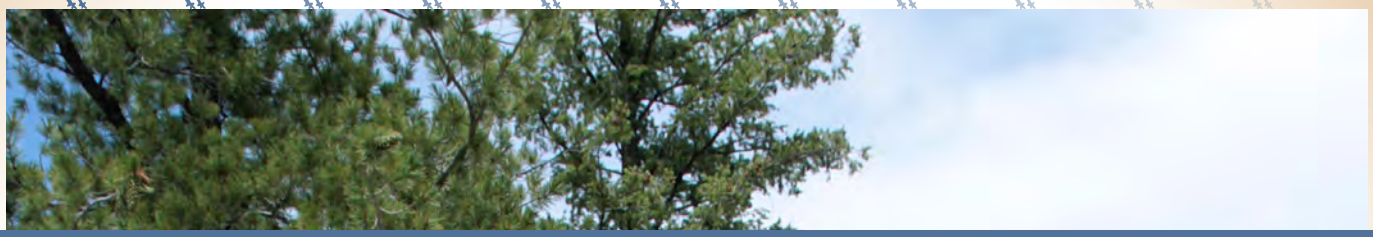
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2. Compliance Summary



contributing authors:
Debra Archuleta, Gian Bacigalupa, Marc Bailey, Bob Beers, Davis Christensen, Michelle Coriz, Albert Dye, Joe English, Greg Erpenbeck, David Fuehne, Kari Garcia, Gil Gonzales, Kathleen Gorman-Bates, Mark Haagenstad, Leslie Hansen, John Isaacson, David Keller, Terrill Lemke, Ellen Louderbough, Jake Meadows, Geri Martinez, Jennifer Nisengard, David Paulson, Peggy Powers, Sonja Salzman, Steve Story, Leonard Trujillo, Steven Veenis, Luciana Vigil-Holterman, Walter Whetham, Tim Zimmerly

To Read About **Turn to Page**

Introduction 49
Compliance Status 49
Unplanned Releases 74
References 76

A. INTRODUCTION

Many activities and operations at Los Alamos National Laboratory (LANL or the Laboratory) use or produce liquids, solids, and gases that may contain non-radioactive hazardous and/or radioactive materials. Laboratory policy implements US Department of Energy (DOE) requirements by directing employees to protect the environment and comply with all applicable federal and state environmental regulations. Federal and state environmental laws address: (1) handling, transporting, releasing, and disposing of contaminants and wastes; (2) protecting ecological, archaeological, historic, atmospheric, soil, and water resources; and (3) conducting environmental impact analyses. Regulations provide specific requirements and standards to ensure maintenance of environmental quality. The US Environmental Protection Agency (EPA) and the New Mexico Environment Department (NMED) are the principal administrative authorities for these laws. Los Alamos National Security (LANS), LLC, operates LANL for the National Nuclear Security Administration (NNSA), an agency of DOE, and is a co-permittee, with DOE and/or NNSA, on all EPA- or NMED-administered permits. LANL/LANS and its subcontractors are also subject to DOE-administered requirements for control of radionuclides.

Table 2-1 presents the environmental permits or approvals the Laboratory operated under in 2009 and the specific operations and/or sites affected. Table 2-2 lists the various environmental inspections and audits conducted at the Laboratory during 2009. The following sections summarize the Laboratory's regulatory compliance performance during 2009.

B. COMPLIANCE STATUS

The Laboratory continues to meet requirements under the Clean Water Act (CWA). The year 2009 was the second complete year the Laboratory operated under the current National Pollutant Discharge Elimination System (NPDES) permit for industrial and sanitary waste water discharges (effective August 1, 2007). During 2009, none of the 76 samples collected from the Sanitary Wastewater Systems (SWWS) Plant's outfall exceeded CWA effluent limits. Only seven of the 1,361 samples collected from industrial outfalls exceeded effluent limits: three chlorine exceedances, two pH exceedances, one total suspended solids (TSS) exceedence, and one PCB exceedence. The overall inspection compliance rate for NPDES-permitted construction sites in 2009 was 99.2%, but the rate was 100% during the summer precipitation season.

The Laboratory was issued a renewed Clean Air Act (CAA) Title V Operating Permit on August 7, 2009. The new permit includes updates to information and language found in the previous permit. The permit is valid for a term of five years. The Laboratory continues to operate well below all CAA permit limits for emissions to the air.

Table 2-1
Environmental Permits or Approvals under which the Laboratory Operated during 2009

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
RCRA[a] Permit	Hazardous Waste Facility Permit: Permitted hazardous waste storage units: Technical Areas (TA)-50 and TA-54	November 1989	November 1999*	NMED[b]
	40 CFR 265 Standards: Interim Status hazardous waste storage and treatment facilities: TAs-3, -14, -16, -36, -39, -50, -54, and -55. Permit applications submitted to NMED.	Post-1980 hazardous waste units; Post-1991 mixed waste units	Inclusion in Hazardous Waste Facility Permit or closure	NMED
HSWA[c]	RCRA corrective activities	March 1990	December 1999*	NMED
Consent Order	Legacy and contaminated waste site investigations, corrective actions, and monitoring; revised to establish new notification and reporting requirements for groundwater monitoring data	March 1, 2005; revised June 18, 2008	September 20, 2015	NMED
CWA[d]/NPDES[e]	Outfall permit for the discharge of industrial and sanitary liquid effluents	August 1, 2007	July 31, 2012	EPA[f]
	MSGP[g] for the discharge of storm water from industrial activities	September 29, 2008	September 29, 2013	EPA
	Federal Facility Compliance Agreement for storm water discharges from Solid Waste Management Units (SWMUs)	February 5, 2005	Upon issuance of the Individual Permit (issued April 1, 2009)	EPA
	Construction General Permits (17) for the discharge of storm water from construction activities	June 30, 2008	July 31, 2011	EPA
CWA Sections 404/401	COE[h] Nationwide Permits (six)	NA	NA	COE/NMED
Groundwater Discharge Plan, TA-46 SWWS Plant[i]	Discharge to groundwater	July 20, 1992 Renewed January 7, 1998	January 7, 2003*	NMED
Groundwater Discharge Plan, TA-50, Radioactive Liquid-Waste Treatment Facility	Discharge to groundwater	Submitted August 20, 1996	Approval pending	NMED
Groundwater Discharge Plan, Domestic Septic Systems	Discharge to groundwater	Submitted April 27, 2006	Approval pending	NMED

Table 2-1 (continued)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
Air Quality Operating Permit (20.2.70 NMAC[j])	LANL air emissions Renewal 1	August 7, 2009	August 7, 2014	NMED
Air Quality Construction Permits (20.2.72 NMAC)	Portable rock crusher	June 16, 1999	None	NMED
	Retired and removed from operating permit	June 15, 2006		
	Permit number will remain active to track exempt sources at LANL			
	TA-3 Power Plant	September 27, 2000	None	NMED
	Permit revision	November 26, 2003		
	Permit modification 1, Revision 1	July 30, 2004		
	Permit modification 1, Revision 2	March 5, 2009		
	1600-kW Generator at TA-33	October 10, 2002	None	NMED
	Permit revision	May 28, 2008	None	NMED
	Two 20-kW Generators and one 225-kW generator at TA-33	August 8, 2007	None	NMED
	Asphalt Plant at TA-60	October 29, 2002	None	NMED
	Permit revision	September 12, 2006	None	NMED
	Data disintegrator	October 22, 2003	None	NMED
	Chemistry and Metallurgy Research Replacement (CMRR), Radiological Laboratory, Utility, Office Building	September 16, 2005	None	NMED
Air Quality (NESHAP[k])	Beryllium machining at TA-3-141	October 30, 1998	None	NMED
	Beryllium machining at TA-35-213	December 26, 1985	None	NMED
	Beryllium machining at TA-55-4	February 11, 2000	None	NMED

[a] Resource Conservation and Recovery Act
[b] New Mexico Environment Department
[c] Hazardous and Solid Waste Amendments
[d] Clean Water Act
[e] National Pollutant Discharge Elimination System
[f] Environmental Protection Agency
[g] Multi-Sector General Permit
[h] US Army Corps of Engineers
[l] Sanitary Wastewater Systems Plant
[j] New Mexico Administrative Code
[k] National Emission Standards for Hazardous Air Pollutants

* Permit was administratively continued for all of 2009.
NA = Not applicable

Table 2-2
Environmental Inspections and Audits Conducted at the Laboratory during 2009

Date	Purpose	Performing Agency
07/13/09–07/15/09	NPDES Industrial Point Source Permit compliance evaluation Inspection	EPA
06/15/09–06/22/09	Hazardous waste compliance inspection	NMED
01/21/09–12/10/09	Hazardous waste compliance inspection	NMED
04/07/09–04/08/09	Toxic Substances Control Act PCB* Facility Compliance inspection	EPA
09/30/09	Title V Operating Permit compliance inspection	NMED

Note: No Federal Insecticide, Fungicide, and Rodenticide Act; Section 401/404; Construction General Permit; or Groundwater Discharge Plan compliance inspections were conducted in 2009.

* Polychlorinated biphenyls

The Laboratory continued to conduct corrective actions in accordance with the March 2005 Compliance Order on Consent (Consent Order). The NMED issued LANS and DOE a Notice of Violation (NOV) identifying two alleged violations noted during the 2009 RCRA compliance inspection, though a penalty was not assessed for these findings because the violations were adequately addressed during the inspection.

Self-inspections of RCRA hazardous and mixed waste compliance found a nonconformance rate of 3.07% (compared with 2.82% in 2008).

1. Resource Conservation and Recovery Act

a. Introduction

Laboratory operations produce a wide variety of hazardous wastes as a research facility. Wastes are generated primarily from research and development activities, processing and recovery operations, decontamination and decommissioning projects, and environmental restoration activities. Most of these waste streams are in small quantities compared with industrial facilities of comparable size because of the relatively diverse activities and the many research projects at the Laboratory.

RCRA, as amended by the Hazardous and Solid Waste Amendments (HSWA) of 1984, establishes a comprehensive program to regulate hazardous wastes from generation to ultimate disposal. The EPA has authorized the State of New Mexico to implement the requirements of the program, which it does through the New Mexico Hazardous Waste Act and regulations found in the New Mexico Administrative Code (NMAC) Title 20, Chapter 4, Part 1, as revised October 1, 2003.

The federal and state laws regulate management of hazardous wastes based on a combination of the facility's status, the quantities of waste generated, and the types of waste management conducted by the facility. Certain operations require a hazardous waste facility permit, often called a RCRA permit. The LANL hazardous waste facility permit was initially granted in 1989 for storage and treatment operations. It expired in 1999 but was administratively continued beyond the expiration date as allowed by 20.4.1.900 NMAC.

The Laboratory has submitted various permit applications for NMED review since 1996 to renew the hazardous waste facility permit. Permit modification packages have also been submitted to revise and update the waste management conditions and facilities contained in the original permit.

b. RCRA Permitting Activities

In 2007, NMED issued a draft for public comment on the renewal of the LANL hazardous waste facility permit. NMED received extensive comments from the Northern New Mexico Citizens' Advisory Board, the Embudo Valley Environment Monitoring Group, the Southwest Research and Information Center, the Natural Resources Defense Council, the Concerned Citizens for Nuclear Safety, Nuclear Watch New Mexico, the Pueblos de San Ildefonso and Santa Clara, the EPA, several private citizens, and the Laboratory. These comments were extensive and addressed many subjects contained in the draft permit including emergency

procedures, information availability, seismic considerations, financial assurance, open burning operations, and hazardous waste management unit decontamination, among others. All commenters who requested a hearing were invited to participate in NMED-mediated permit negotiations to resolve comments.

The negotiations were started in August 2008 and extended through 2009. The negotiations included information presentations, discussions and comment resolution that supported the development of a second revised draft permit. NMED issued the revised draft permit on July 6, 2009. Another public comment period for review of this draft remained open through the end of 2009. A public hearing regarding the draft permit was scheduled for early 2010.

On June 30, 2009, the Laboratory submitted a Class 1 permit modification transmittal for changes to the Contingency Plan in the original hazardous waste facility permit. The changes involved updating the list of emergency coordinators with new names, addresses, and phone numbers.

On September 30, 2009, the Laboratory submitted a Class 1 permit modification transmittal for additional changes to the Contingency Plan. These changes included updates for organization names and editorial revisions.

No hazardous waste management units at the Laboratory underwent full closure activities in 2009. Dome 226 was removed from the Pad 1 storage unit at TA-54 Area G in September of 2009 with notification to NMED. Storage activities will otherwise continue at the pad. In April and May 2009, the Laboratory submitted to NMED the new closure plans for all the hazardous waste management units that will be included in the renewed hazardous waste facility permit.

c. Other RCRA Activities

The compliance assurance program performed Laboratory self-assessments to determine whether hazardous waste and mixed waste are managed to meet the requirements of federal and state regulations, DOE orders, and Laboratory policy. The program communicated findings from these self-assessments to waste generators, waste-management coordinators, and waste managers who help line managers implement appropriate actions to ensure continual improvement in LANL's hazardous waste program. In 2009, the Laboratory completed 1,467 self-assessments with a nonconformance rate of 3.07%.

d. RCRA Compliance Inspection

From June 15, 2009, to June 22, 2009, NMED conducted a hazardous waste compliance inspection at the Laboratory (see Table 2-2). The Laboratory received two violations from this inspection. From December 1, 2009 to December 10, 2009, NMED conducted a hazardous waste compliance inspection at the Laboratory. The Laboratory received three potential findings from this inspection.

e. Site Treatment Plan

In October 1995, the State of New Mexico issued a Federal Facility Compliance Order to the DOE and the University of California, requiring compliance with the Site Treatment Plan (STP). On June 1, 2006, Los Alamos National Security, LLC (LANS) replaced UC as the operating contractor at LANL, and LANS assumed responsibility for compliance with the order. The plan documents the use of off-site facilities for treating and disposing of mixed waste generated at LANL and stored for more than one year. In 2009, the Laboratory shipped approximately 217 m^3 of STP-covered low-level mixed waste and approximately 300 m^3 of covered mixed transuranic waste for treatment and disposal.

f. Solid Waste Disposal

LANL sends sanitary solid waste (trash) and construction and demolition debris for transfer through the Los Alamos County Eco-Station on East Jemez Road. The DOE owns the property and leases it to Los Alamos County under a special-use permit. Los Alamos County operates this transfer station and is responsible for obtaining all related permits for this activity from the state. The transfer station is registered with the NMED Solid Waste Bureau. Laboratory trash sent to the transfer station in 2009 included 2,191 metric tons of trash and 554 metric tons of construction and demolition debris. Through LANL's recycling efforts in 2009, 3,242 metric tons of material was recycled and did not go to a landfill.

g. Hazardous Waste Report

The Hazardous Waste Report covers hazardous and mixed waste generation, treatment, and storage activities performed at LANL during calendar year 2009 as required by RCRA, under 40 CFR §262.41, Biennial Report. In 2009, the Laboratory generated about 357,000 kg of RCRA hazardous waste, approximately 66,135 kg of which was generated by corrective action activities at the Laboratory. The waste was recorded for more than 10,000 waste movements, treatment, or storage actions resulting in 471 Waste Generation and Management forms in the Hazardous Waste Report. The entire report is available on the Web at http://www.lanl.gov/environment/waste/docs/reports/2009_biennial_hwr_LA-UR-10-01462.pdf.

h. Compliance Order on Consent (Consent Order)

The Consent Order is an enforcement document that prescribes the requirements for corrective action at the Laboratory. The purposes of the Consent Order are (1) to define the nature and extent of releases of contaminants at, or from, the facility; (2) to identify and evaluate, where needed, alternatives for corrective measures to remediate contaminants in the environment and prevent or mitigate the migration of contaminants at, or from, the facility; and (3) to implement such corrective measures. The Consent Order supersedes the corrective action requirements previously specified in Module VIII of the Laboratory's Hazardous Waste Facility Permit and applies to Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) subject to RCRA and HSWA requirements, but not to sites that are regulated by DOE under the Atomic Energy Act, such as those containing or releasing radionuclides. The Consent Order does not apply to those SWMUs and AOCs that received "no further action" decisions from EPA when it had primary regulatory authority. A description of the Consent Order work done in 2009 is presented in Chapter 9 of this report.

In 2009, the Laboratory submitted 181 deliverables (plans and reports) required by the Consent Order on time to NMED (see Tables 9-1 and 9-2 in Chapter 9 of this report).

Figure 2-1 shows each aggregate area, as defined by the Consent Order, and indicates the status of LANL work in these aggregate areas as (1) scheduled activities complete, (2) scheduled activities in progress, or (3) scheduled activities pending. For those aggregate areas presented as scheduled activities complete in Figure 2-1, there are currently no scheduled field sampling campaigns, investigation reports, or corrective measures activities (as of June 2010). Aggregate areas listed as scheduled activities in progress include sites or areas where field sampling campaigns or corrective measure activities are currently being conducted, or investigation reports are being prepared or finalized. Aggregate areas listed as scheduled activities pending include sites or areas where field sampling campaigns have not yet started. Scheduled activities for four aggregate areas are complete, are in progress at nine aggregate areas, and are pending for 13 aggregate areas as of June 2010.

i. Notices of Violation

In October 2009, the NMED Hazardous Waste Bureau issued LANS and DOE an NOV identifying two alleged violations noted during the 2009 RCRA compliance inspection. A penalty was not assessed for these findings because it was determined that the violations were adequately addressed during the inspection, and no further action was required.

In May 2009, the NMED Hazardous Waste Bureau issued a demand for payment of stipulated penalties for the LANL report entitled Periodic Monitoring Report for Vapor-Sampling Activities at Material Disposal Area T. Penalties were assessed by NMED because the report did not contain all the monitoring data required by NMED and, therefore, was not in substantial compliance with the Consent Order. DOE and LANS paid stipulated penalties to NMED of $126,000 to settle the issue.

In May 2009, the NMED Hazardous Waste Bureau issued an NOV to DOE and LANS for failing to implement the requirements in the LANL report entitled Work Plan to Plug and Abandon Mortandad Canyon Wells Test Well 8 and MCOBT-4.4. The NOV was issued because DOE and LANS did not plug and abandon well MCOBT-4.4 by the date specified in the work plan. A settlement was reached and DOE paid NMED $1,300,000 to settle this issue.

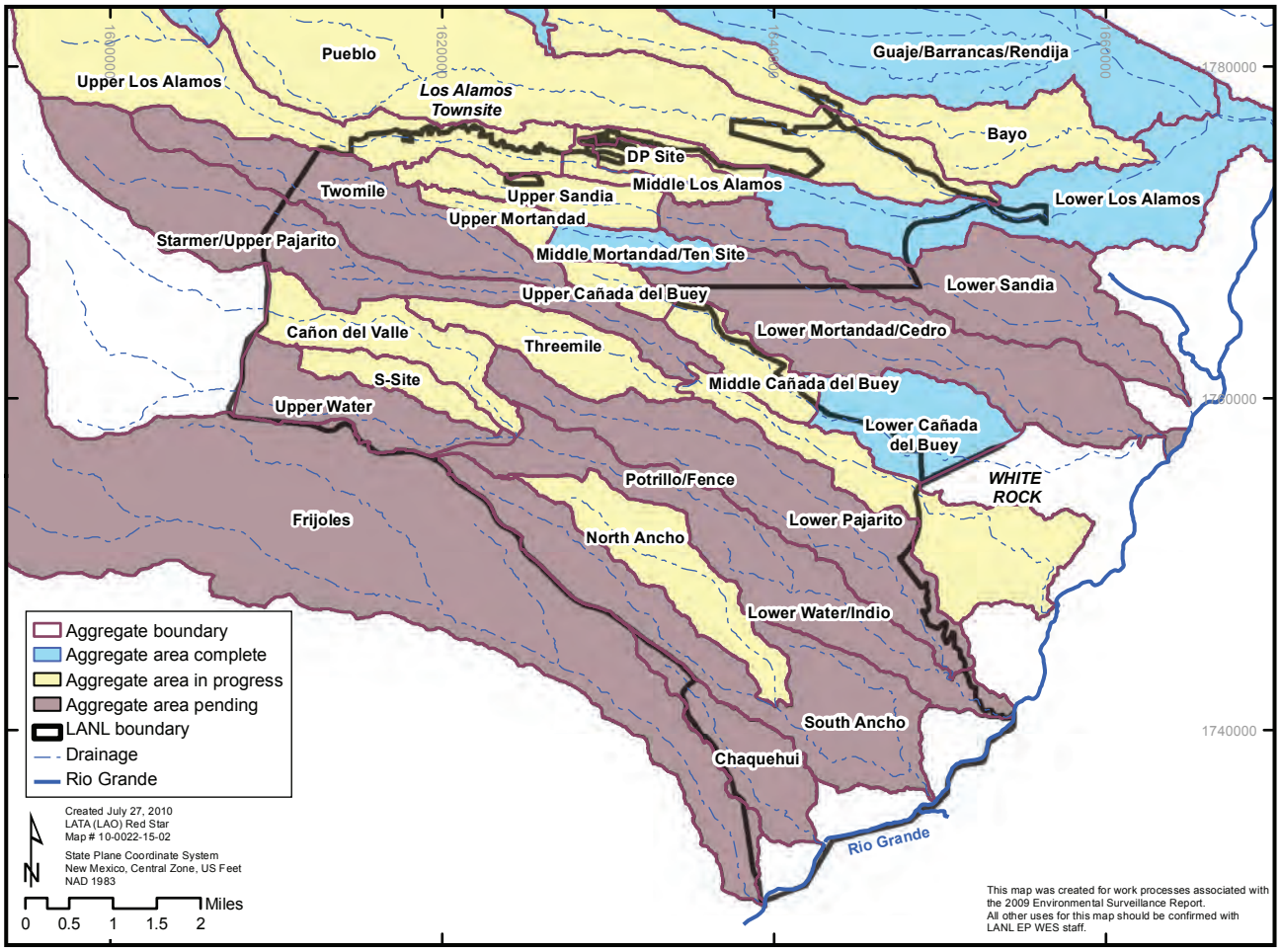


Figure 2-1. Aggregate areas as defined for the NMED Consent Order and their status. Status is shown as aggregrate area activities complete, activities in progress, or activities pending.

j. Other RCRA Non-compliances

The following waste storage or transportation violations were found during waste processing operations at LANL:

- Hazardous waste transferred from an accumulation area into storage at TA-54 was returned to the accumulation area and then back to TA-54 due to characterization issues.
- At TA-50-69, a waste drum failed a receipt inspection because of a small hole in the bottom of the drum. The drum was overpacked and processed through the facility.
- During repackaging processes at TA-54, Area G, an 85 gallon overpack drum was found to have a non-hazardous waste label while the drum within the overpack contained a hazardous waste label. The correct label was placed on the new container after repackaging.

There were no actual or potential hazards to the environment and human health outside the facility, and no material was lost or had to be recovered resulting from any of these incidents. None of these incidents required other reporting to the NMED under the LANL Hazardous Waste Facility Permit.

2. Comprehensive Environmental Response, Compensation, and Liability Act

a. Land Transfer

No properties were conveyed under Public Law 105-119 in 2009. The Environmental Baseline Survey Reports for A-13, the LASO Site; Tracts B-3, the Little Otowi Site; and A-10, DP Canyon were transmitted to and accepted by LASO in fiscal year 2009. These reports satisfy the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) 120(h) requirements for environmental disclosure in federal real property transfers.

b. Natural Resource Damage Assessment

Under a memorandum of agreement established in 2008, the DOE and several other federal, state, and tribal entities in the region continued to work towards completing a natural resources damages assessment (NRDA) for LANL. Participating entities include the DOE, the Department of Interior, the Department of Agriculture, the State of New Mexico, and the Pueblo de San Ildefonso (collectively known as Trustees). The governing regulations include the CWA, the Oil Pollution Act of 1990, the DOE Organization Act, CERCLA, and the New Mexico Natural Resources Trustee Act.

The Trustees may assess and recover monetary damages for injuries to natural resources (including air, surface water, groundwater, soils, and biota) that have resulted from the release of hazardous substances to the environment from the area of LANL. Damages may include the cost of restoring the injured resources to their baseline condition (i.e., the condition that would have existed but for the release) as well as the value of interim losses pending restoration. Damages are used to restore, rehabilitate, replace, or acquire the equivalent of services provided by injured natural resources.

Using Department of Interior guidance for cooperative implementation of NRDA, the LANL Natural Resource Trustee Council completed a pre-assessment screen in November 2009. The pre-assessment screen is the initial step in the NRDA process and provides a rapid review of readily available information on hazardous substance releases and the potential impacts of those releases on natural resources. The pre-assessment screen has been used to determine whether there is a reasonable probability of making a successful claim before efforts are expended in carrying out a full-scale assessment. The Trustee Council determined that the pre-assessment screen criteria have been met and it is appropriate to pursue a full-scale assessment. In December 2009, the Trustee Council began developing a statement of work for a DOE contract that will be used to develop an assessment plan for the full-scale assessment.

3. Emergency Planning and Community Right-to-Know Act

a. Introduction

The Laboratory is required to comply with the Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 and Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management.

b. Compliance Activities

For 2009, the Laboratory submitted reports to fulfill its requirements under EPCRA, as shown in Table 2-3 and described below.

i. Emergency Planning Notification

Title III, Sections 302–303, of EPCRA require the preparation of emergency plans for more than 360 extremely hazardous substances if stored in amounts above threshold limits. The Laboratory is required to notify state and local emergency planning committees (1) if any changes at the Laboratory might affect the local emergency plan or (2) if the Laboratory's emergency planning coordinator changes. No updates to this notification were made in 2009.

Table 2-3
Compliance with Emergency Planning and Community Right-to-Know Act during 2009

Statute	Brief Description	Compliance
EPCRA Sections 302–303 Planning Notification	Requires emergency planning notification to state and local emergency planning committees.	No changes to the notification have been made since the July 30, 1999, notification and an update in 2000.
EPCRA Section 304 Release Notification	Requires reporting of releases of certain hazardous substances over specified thresholds to state and local emergency planning committees and to the National Response Center.	No leaks, spills, or other releases of chemicals into the environment required EPCRA Section 304 reporting during 2009.
EPCRA Sections 311–312 Material Safety Data Sheets and Chemical Inventories	Requires facilities to provide appropriate emergency response personnel with an annual inventory and other specific information for any hazardous materials present at the facility over specified thresholds.	The presence of 20 hazardous materials stored at LANL over specified quantities in 2009 required submittal of a hazardous chemical inventory to the State Emergency Response Commission and the Los Alamos County Fire and Police Department.
EPCRA Section 313 Annual Toxic Release Inventory	Requires all federal facilities to report total annual releases of listed toxic chemicals used in quantities above reportable thresholds.	Laboratory use of lead exceeded the reporting thresholds in 2009, requiring submittal of Toxic Chemical Release Inventory Reporting Forms (Form Rs) to the EPA and the State Emergency Response Commission.

ii. Emergency Release Notification

Title III, Section 304, of EPCRA requires facilities to provide emergency release notification of leaks, spills, and other releases of listed chemicals into the environment if these chemicals exceed specified reporting quantities. Releases must be reported immediately to the state and local emergency planning committees and to the National Response Center. No leaks, spills, or other releases of chemicals into the environment required EPCRA Section 304 reporting during 2009.

iii. Material Safety Data Sheet/Chemical Inventory Reporting

Title III, Sections 311–312, of EPCRA require facilities to provide an annual inventory of the quantity and location of hazardous chemicals above specified thresholds present at the facility. The inventory includes hazard information and the storage location for each chemical. The Laboratory submitted a report to the State Emergency Response Commission and the Los Alamos County Fire and Police Departments listing 20 chemicals and explosives at the Laboratory stored on site in quantities that exceeded reporting threshold limits during 2009.

iv. Toxic Release Inventory Reporting

Executive Order 13423 requires all federal facilities to comply with Title III, Section 313, of EPCRA. This section requires reporting of total annual releases to the environment of listed toxic chemicals that exceed activity thresholds. Beginning with reporting year 2000, new and lower chemical-activity thresholds were put in place for certain persistent, bioaccumulative, and toxic chemicals and chemical categories. The thresholds for these chemicals range from 0.1 g to 100 lb. Until this change went into effect, the lowest threshold was 10,000 lb. LANL operations exceeded the threshold for use of lead in 2009 and therefore was required to report the uses and releases of this chemical. The largest use of reportable lead is at the on-site firing range where security personnel conduct firearms training. Table 2-4 summarizes the reported releases in 2009.

Table 2-4
Summary of 2009 Reported Releases under EPCRA Section 313

	Lead (lb)
Air Emissions	5.42
Water Discharges	0.065
On-Site Land Disposal	5.001
Off-Site Waste Transfers	9,779

4. Toxic Substances Control Act

Because the Laboratory's activities are research and development (R&D) rather than the manufacture of commercial chemicals, the Laboratory's main concerns under the Toxic Substances Control Act (TSCA) are the regulations covering polychlorinated biphenyls (PCBs) and the import/export of R&D chemical substances. The PCB regulations govern substances including, but not limited to, dielectric fluids, contaminated solvents, oils, waste oils, heat-transfer fluids, hydraulic fluids, slurries, soil, and materials contaminated by spills.

During 2009, the Laboratory shipped 263 containers of PCB waste off site for disposal or recycling. The quantities of waste disposed of included 1,941 lb (880.5 kg) of capacitors and 2,605 lb (1,181.6 kg) of fluorescent light ballasts. The Laboratory manages all wastes in accordance with 40 Code of Federal Regulations (CFR) 761 manifesting, record keeping, and disposal requirements. PCB wastes go to EPA-permitted disposal and treatment facilities. Light ballasts go off-site for recycling. The primary compliance document related to 40 CFR 761.180 is the annual PCB document log that the Laboratory maintains on file for possible inspection by EPA Region 6. The renewal request for the Area G PCB disposal authorization was withdrawn in 2006. During 2009, EPA did not perform a PCB site inspection. Approximately 23 TSCA reviews were conducted on imports and exports of chemical substances for the Laboratory's Property Management Group Customs Office. One TSCA Section 12b export notification letter was sent to EPA for the export of a TSCA-regulated substance to the Federal Republic of Germany.

5. Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulates the manufacturing of pesticides and protection of workers who use these chemicals. Sections of this act that apply to the Laboratory include requirements for certification of workers who apply pesticides. The New Mexico Department of Agriculture has the primary responsibility to enforce pesticide use under the act. The New Mexico Pesticide Control Act applies to the licensing and certification of pesticide workers, record keeping, equipment inspection, as well as application, storage, and disposal of pesticides.

The New Mexico Department of Agriculture did not conduct assessments or inspections of the Laboratory's pesticide application program in 2009. The Laboratory conducted four quarterly inspections of the pesticide storage area in 2009 and found that the storage area was maintained in accordance with FIFRA regulations.

Table 2-5 shows the amounts of pesticides and herbicides the Laboratory used in 2009.



Table 2-5
Herbicides and Pesticides Used at LANL in 2009

Herbicides	Amount
Velpar L (Liquid)	127.5 gal
Roundup (PRO liquid)	12 oz
Insecticides	**Amount**
Advion ANT Bait granular	16.75 oz
Advion ANT Bait (Gel)	7 oz
Prescription Treatment (PT) P.I. Contact	2 oz
Prescription Treatment (PT) Wasp Freeze	24 oz
Maxforce Ant Bait (granular)	6 oz
Tempo 20 WP	6 oz
Tempo WP Ultra	15 oz
Fertilizers	**Amount**
16-8-8 all season	100 lbs
18-5-9 w/herbicide	500 lbs
Color Marker	**Amount**
Blazon (Liquid)	5 gal
Water Treatment Chemicals	**Amount**
Fresh Airs	34.4 lbs
Garrat-Callahan 314T	3,285 lbs
Garrat-Callahan 315	5.5 gal
Garrat-Callahan 316	20 packs
Sump Buddy	99.5 lbs

6. Clean Air Act

Through the federal Clean Air Act Amendments and NMAC 20.2.70 Operating Permits, LANS is authorized to operate applicable air emission sources at LANL. The Laboratory was issued Operating Permit No. P100 in April 2004. The term of this permit was five years, so an application to renew the permit was submitted to NMED in April 2008. The renewed permit, P100R1, was issued in August 2009. This permit provides the terms and conditions that must be followed in order to operate the applicable air emission sources. The operating permit conditions are a collection of existing source-specific permit conditions that address operation, record keeping, monitoring, and reporting. By complying with the conditions of the Title V Operating Permit, the Laboratory is deemed to be in compliance with all applicable air requirements existing at the date of permit issuance.

As part of the Title V Operating Permit program, LANL reports the emissions from sources included in the Operating Permit to NMED twice a year. These sources include multiple boilers and electric generators, a power plant, a combustion turbine generator, a data disintegrator, two carpenter shops, a degreaser, and an asphalt plant. LANL also reports emissions from chemical use associated with R&D and permitted beryllium activities.

The Title V Operating Permit requires the Laboratory to submit an Annual Compliance Certification to NMED. In the 2009 Compliance Certification, the Laboratory reported one permit deviation. The deviation involved a new permit condition in the renewed Title-V Operating Permit. The condition required the use of a data logger to monitor the differential pressure across the baghouse filters and the time period the rotary dryer drum operates on the asphalt plant. The data logger was in the process of being installed when the permit was issued in August 2009. Due to the need for custom chart paper and availability of electricians to install the unit, the data logger was not fully installed and operational until September 2009.

LANL demonstrated full compliance with all other applicable air permit terms and conditions and met all required reporting deadlines during 2009.

In 2009, LANL requested and received a revision to New Source Review (NSR) permit 2195B. The revision replaced a combustion turbine monitoring requirement to perform periodic emission calculations with an annual emissions test using a portable analyzer. This permit revision was issued on March 5, 2009.

In 2009, LANL provided the first greenhouse gas emissions report to NMED, as required by NMAC 20.2.87. The 2008 emissions of CO2 (reported in 2009) were approximately 57,430 metric tons of carbon dioxide equivalents from the combustion of fossil fuels. For the 2009 reporting year, LANL will include methane emissions to the annual report. For 2010 and beyond, all listed greenhouse gasses will be reported. The State of New Mexico and the DOE have set aggressive goals to reduce greenhouse gas emissions; the data submitted in the annual emission reports will be used to track progress made towards these goals.

Under the Title V Operating Permit program, LANL is considered a major source of pollutants, based on the potential to emit NOX, CO, and volatile organic compounds (VOCs). In 2009, the TA-3 power plant and boilers located across the Laboratory were the major contributors of NOX, CO, and particulate matter (PM). R&D activities were responsible for most of the VOC and hazardous air pollutant emissions. Table 2-6 summarizes these data.

Table 2-6
Calculated Emissions of Regulated Air Pollutants Reported to NMED in 2009

	Pollutants[a], tons					
Emission Units	**NO_x**	**SO_x**	**PM**	**CO**	**VOC**	**HAPs**
Asphalt Plant	0.03	0.003	0.02	1.01	0.005	0.005
TA-3 Power Plant (3 Boilers)	14.2	0.15	1.9	9.8	1.35	0.46
TA-3 Power Plant (Combustion Turbine)	0.35	0.02	0.05		0.02	0.01
Regulated Boilers	5.8	0.04	0.5	3.9	0.33	0.11
R&D Chemical Use	NA[b]	NA	NA	NA	10.4	4.4
Degreaser	NA	NA	NA	NA	0.02	0.02
Data Disintegrator	NA	NA	0.05	NA	NA	NA
Carpenter Shops	NA	NA	0.06	NA	NA	NA
Stationary Standby Generators[c]	5.1	0.17	0.22	1.2	0.22	0.002
Miscellaneous Small Boilers[c]	19.7	0.12	1.50	16.6	1.10	0.37
TA-33 Generators (4 units)	1.39	0.18	0.06	0.93	0.04	<0.001
TOTAL	46.57	0.68	4.36	33.51	13.49	5.38

[a] NOx = nitrogen oxides; SOx = Sulfur oxides; PM = particulate matter; CO = carbon monoxide; VOC = volatile organic compounds; HAPs = hazardous air pollutants.
[b] NA = Not applicable.

LANL staff calculates air emissions using emission factors from source tests, manufacturer's data, and EPA documents. Calculated emissions are based on actual production rates, fuel usage, and/or material throughput. To satisfy requirements found in NMAC 20.2.73, Notice of Intent and Emissions Inventory Requirements, and the Title V Operating Permit, LANL submits an annual Emissions Inventory Report and semi-annual Emissions Reports, respectively, to NMED. Figure 2-2 depicts a five-year history of criteria pollutant emissions. Emissions from 2005 through 2009 are very similar and remain relatively constant.

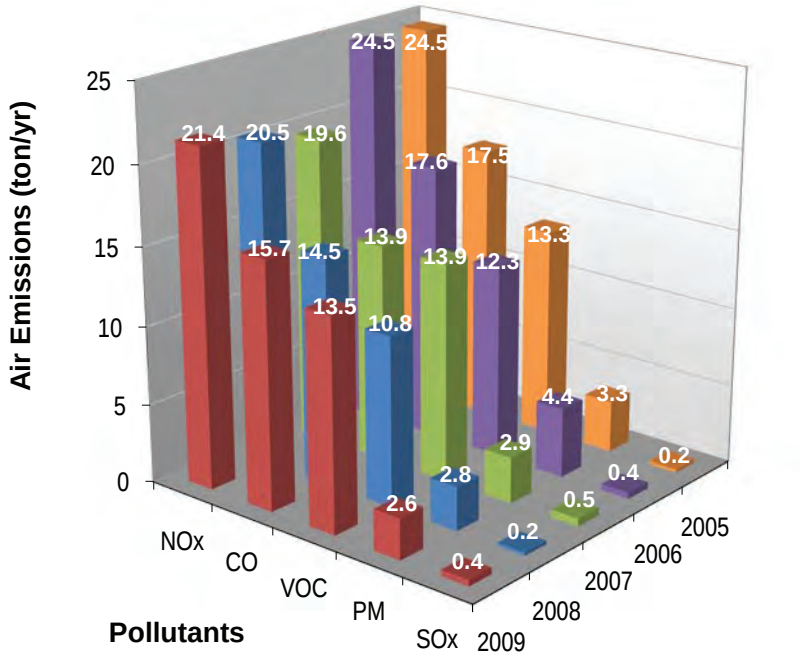


Figure 2-2. LANL criteria pollutant emissions from 2005 through 2009 for annual emissions inventory reporting. Totals from the emissions inventory report do not include small boilers or standby generators.

a. New Mexico Air Quality Control Act

i. Permits

LANL reviews plans for new and modified projects, activities, and operations to identify all applicable air quality requirements including the need to apply for construction permits or to submit notifications to NMED. During 2009, the Laboratory received an NSR air quality permit revision for the combustion turbine located at TA-3. No NSR permit applications were submitted in 2009. The Title V Operating Permit was renewed and issued by NMED in August 2009. The Laboratory operated under the existing Title V permit P100-M2 until the new permit was issued. LANL submitted two exemption notifications to NMED during 2009. The exemptions were for small boilers and small generators. During 2009, LANL operated under the air permits listed in Table 2-1.

ii. Open Burning

LANL may perform open burning under 20.2.60 NMAC (Open Burning) or 20.2.65 NMAC (Smoke Management) to thin vegetation and reduce the threat of fire. LANL did not perform any open burning during 2009.

iii. Asbestos

The National Emission Standard for Hazardous Air Pollutants (NESHAP) for Asbestos requires that LANL provide advance notice to NMED for large renovation jobs that involve asbestos and for all demolition projects. The asbestos NESHAP further requires that all activities involving asbestos be conducted in a manner that mitigates visible airborne emissions and that all asbestos-containing wastes be packaged and disposed of properly.

LANL continued to perform renovation and demolition projects in accordance with the requirements of the asbestos NESHAP. In 2009, 17 large renovation and demolition projects were completed. NMED was provided advance notice on each of these projects. These projects, combined with other smaller activities, generated approximately 73 m^3 of asbestos waste that was properly packaged and disposed of at approved landfills.

To ensure compliance, the Laboratory conducted internal inspections of job sites and asbestos packaging approximately monthly.

b. Federal Clean Air Act.

i. Ozone-Depleting Substances

Title VI of the CAA contains specific sections that establish regulations and requirements for ozone-depleting substances (ODS), such as halons and refrigerants. The main sections applicable to the Laboratory prohibit individuals from knowingly venting or otherwise releasing into the environment any refrigerant or refrigerant substitute during maintenance, repair, service, or disposal of halon fire-suppression systems and air-conditioning or refrigeration equipment. All technicians who work on refrigerant systems must be EPA-certified and must use certified recovery equipment. The Laboratory is required to maintain records on all work that involves refrigerants and the purchase, usage, and disposal of refrigerants. The Laboratory's standards for refrigeration work are covered under Criterion 408, "EPA Compliance for Refrigeration Equipment," of the LANL Operations and Maintenance Manual.

The Laboratory continued eliminating the use of Class I and Class II ODS. Class I and Class II ODS are the refrigerants that have high ozone-depleting potentials. In 2008, the Laboratory removed approximately 817 pounds of Class II ODS from the active inventory.

ii. Radionuclides

Under the NESHAP regulations, which regulate the air emissions of radionuclides other than radon from facilities owned or operated by the DOE, the EPA limits to 10 mrem/yr the effective dose equivalent of airborne releases of radioactive material from a DOE facility, such as LANL, to any member of the public. The 2009 annual dose to the maximally exposed individual (MEI) (as calculated using EPA-approved methods) was 0.55 mrem. The location of the highest dose was the East Gate area near the eastern edge of Los Alamos County. Emissions of radioactive gases from the Los Alamos Neutron Science Center (LANSCE) accelerator facility contributed over half of this dose; the remainder came from other Laboratory stack emissions and environmental cleanup work. See Chapter 4 for more information about these emissions.

7. Clean Water Act

a. NPDES Industrial Point Source Outfall Self-Monitoring Program

The primary goal of the CWA is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The act established the requirements for NPDES permits for point-source effluent discharges to the nation's waters. The NPDES outfall permit establishes specific chemical, physical, and biological criteria that the Laboratory's effluent must meet before it is discharged.

LANS and DOE/NNSA are co-permittees of the NPDES permit covering Laboratory operations. EPA Region 6 in Dallas, Texas, issues and enforces the permit. NMED certifies the EPA-issued permit and performs some compliance-evaluation inspections and monitoring for the EPA. During 2009, the Laboratory's industrial point-source NPDES permit contained 15 permitted outfalls that include one sanitary outfall and 14 industrial outfalls (Table 2-7). To facilitate full compliance with the requirements in the current permit, the Laboratory is planning to eliminate outfalls and to add additional treatment technologies. The Laboratory's NPDES permit is available online at http://www.lanl.gov/environment/h2o/permits.shtml?1.



Table 2-7
Volume of Effluent Discharge from NPDES Permitted Outfalls in 2009

Outfall Number	TA-Bldg	Description	Watershed (Canyon)	2009 Discharge (gal.)
02A129	21-357	TA-21 Steam Plant	Los Alamos	0
03A048	53-963/978	LANSCE Cooling Tower	Los Alamos	17,448,500
051	50-1	TA-50 Radioactive Liquid Waste Treatment Facility	Mortandad	1144,565
03A021	3-29	CMR Building Air Washers	Mortandad	0
03A022	3-2238	Sigma Cooling Tower	Mortandad	589,298
03A160	35-124	National High Magnetic Field Laboratory Cooling Tower	Mortandad	101,496
03A181	55-6	Plutonium Facility Cooling Tower	Mortandad	1,208,507
13S	46-347	Sanitary Wastewater Treatment Plant	Sandia	85,289,000
001	3-22	Power Plant (includes treated effluent from Outfall 13S)	Sandia	85,351,581
03A027	3-2327	Strategic Computing Complex Cooling Tower	Sandia	16,146,800
03A113	53-293/952	LANSCE Cooling Tower	Sandia	342,085
03A199	3-1837	Laboratory Data Communications Center	Sandia	10,079,880
03A130	11-30	TA-11 Cooling Tower	Water	3,021
03A185	15-312	DARHT Cooling Tower	Water	876,318
05A055	16-1508	High Explosives Wastewater Treatment Facility	Water	0
			2009 Total:	**133,292,051**

The Laboratory's current NPDES outfall permit requires weekly, monthly, quarterly, and yearly sampling to demonstrate compliance with effluent quality limits. The Laboratory reports analytical results to EPA and NMED at the end of the monitoring period for each respective outfall category. During 2009, none of the 76 samples collected from the SWWS Plant's outfall exceeded effluent limits; however, seven of the 1,361 samples collected from industrial outfalls exceeded effluent limits (described below). Monitoring data obtained from sampling at NPDES permitted outfalls are in Supplemental Data Table S2-1 and S2-2 (on included compact disc) and available online at http://racernm.com/.

The following is a summary of the corrective actions the Laboratory has taken during 2009 to address the NPDES outfall permit noncompliance cited above.

- **TA-50 RLWTF Outfall 051.** On February 4, 2009, during a discharge, a pH measurement of 5.7 standard units (su) was outside the acceptable range of 6.0–9.0 su. The pH meter at the sample sink (used as a final pH check of effluent tank contents prior to starting the discharge pump) had not been calibrated in approximately six weeks. The pH reading from this meter was 6.38 su, which met operational requirements for start of the discharge pump. While the discharge was in progress, a grab sample was collected to be analyzed for pH and total residual chlorine (using properly calibrated instruments) for NPDES compliance reporting. The pH of the compliance sample was 5.7 su. pH measurements must now be taken with the meter used for compliance monitoring which is calibrated at a minimum once each week. The procedure revision changes acceptable pH limits to 6.9 to 8.1 for treated water prior to discharge.
- **TA-3 LDCC Outfall 03A199.** During a discharge on February 4, 2009, pH was measured at 8.9 su, which is outside the acceptable range of 6.6 to 8.8 su for Outfall 03A199. Investigations revealed that a plugged strainer on the conductivity meter resulted in the cooling tower not blowing down as anticipated. The strainer was cleaned and the cooling tower returned to normal operation.

- **TA-35 HMFL Outfall 03A160.** During a discharge on March 31, 2009, total suspended solids (TSS) were measured at 97.7 mg/L, exceeding the monthly average limit of 30 mg/L. The cooling tower had not been used in March and dirt/sediment partially clogged the flow meter at the end of the blowdown pipe. A back-up operator at the Facility initiated the blowdown so quarterly compliance samples could be collected. The Lead Operator will be present when the cooling tower blowdown is initiated.

- **TA-3 SCC Outfall 03A027.** On May 20, 2009, a total residual chlorine (TRC) concentration of 1,510 µg/L exceeded the NPDES daily maximum limit of 11 µg/L. During maintenance of the cooling tower water treatment system, the system was set to the "No Blowdown" mode and the valve that introduces the chlorine neutralizer into the blowdown was placed in the closed position. After the maintenance was performed, the system was set back to the "Blowdown" mode. However the neutralizer valve was left in the closed position. An additional checklist has been implemented allowing facility personnel to verify that all components of the water treatment system are placed back in normal operation after routine maintenance has been performed.

- **TA-15 DARHT Outfall 03A185.** On November 3, 2009, a TRC concentration of >2,200 µg/L exceeded the NPDES daily maximum limit of 11 µg/L. The check valve on the chlorine neutralizer pump became stuck in the nearly closed position, not allowing sufficient neutralizer to mix with the blowdown. The check valve was cleaned and verification performed that it was working properly. The neutralizer pump, tubing, and valves will be inspected for crystallization each week and cleaned as necessary.

- **TA-3 Power Plant Outfall 001.** On December 17, 2009, a PCB concentration of 0.0131 µg/L was measured during compliance sampling. This result exceeded the monthly average permit limit of 0.009 µg/L. As part of the on-going investigation for the source of the elevated level of PCBs, corrective actions have included plugging the drains in the basement, discontinuing use of one basement sump, sealing caulked areas in basement, cleaning of tank sumps, and additional sampling (results pending).

- **TA-15 DARHT Outfall 03A185.** On December 28, 2009, a TRC concentration of 240 µg/L exceeded the NPDES daily maximum limit of 11 µg/L. The make-up valve on the north cooling tower cell was stuck in the open position (frozen) causing potable water to constantly enter the cooling tower. This resulted in the over-flowing condition. Excess potable water flows through a drain directly to Outfall 03A185 without being dechlorinated. The heat tape around the make-up valve failed because the solenoid controlling the blowdown valve was clogged with solids found in the cooling tower basin. The blowdown valve remained in the open position, draining the tower, which caused the heat tape to fail. The cooling tower has been placed on a yearly cleaning schedule to keep down the amount of solids in the basin.

b. NPDES Sanitary Sewage Sludge Management Program

The Laboratory's TA-46 SWWS Plant is an extended-aeration, activated-sludge sanitary wastewater treatment plant. The activated-sludge treatment process requires periodic disposing of excess sludge (waste-activated sludge) from the plant's clarifiers to synthetically lined drying beds. After air-drying for a minimum of 90 days to reduce pathogens, the dry sludge is characterized and disposed of as a New Mexico Special Waste. During 2009, the SWWS Plant generated approximately 25.8 dry tons (51,561 dry lbs) of sewage sludge. All of this sludge was disposed of as a New Mexico Special Waste at a landfill authorized to accept this material..

c. NPDES Industrial Point Source Permit Compliance Evaluation Inspection

A Compliance Evaluation Inspection was performed from July 13 to 15, 2009. The inspection consisted of separate evaluations for the sanitary and industrial outfalls. The Laboratory received a rating of four for the industrial outfalls evaluation and a rating of four for the sanitary outfall evaluation. A rating of five indicates very reliable self-monitoring programs, three is for satisfactory, and one is for very unreliable programs.

d. NPDES Storm Water Construction General Permit Program

The NPDES Construction General Permit (CGP) Program regulates storm water discharges from construction activities disturbing one or more acres, including those construction activities that are part of a larger common plan of development collectively disturbing one or more acres.

LANL and the general contractor apply individually for NPDES CGP coverage and are co-permittees at most construction sites. Compliance with the NPDES CGP includes developing and implementing a Storm Water Pollution Prevention Plan (SWPPP) before soil disturbance can begin and conducting site inspections once soil disturbance has commenced. A SWPPP describes the project activities, site conditions, best management practices (erosion control measures), and permanent control measures required for reducing pollution in storm water discharges and protecting endangered or threatened species and critical habitat. Compliance with the NPDES CGP is demonstrated through periodic inspections that document the condition of the site and also identify corrective actions required to keep pollutants from moving off the construction site. Data collected from these inspections are tabulated weekly, monthly, and annually in the form of Site Inspection Compliance Reports.

During 2009, the Laboratory implemented and maintained 52 construction site SWPPPs and addendums to SWPPPs and performed 471 storm water inspections. The Laboratory uses a geographic information system to manage project information and generate status reports that facilitate reporting under the Director's Portfolio Reviews. The overall CGP inspection compliance record in 2009 was 99.2%. During the summer months, when most high-intensity precipitation events occur, all 467 of the inspections were compliant.

The LANL storm water team continued to use relatively new methods to assist with storm water compliance. Improvements in accounting for non-uniform distribution of precipitation were made by using a network of rain gages in association with the Thiessen polygon method. This method associated 13 precipitation gauges across the Laboratory with LANL construction projects to ensure refined data were used for triggering storm water inspections. The gauges were equipped with 5-minute tipping buckets connected to existing stations with data loggers. The team incorporated solutions for preventing non-compliances in its Quality Improvement Performance Report. To further reduce future CGP non-compliances and to increase awareness of CGP requirements, the storm water team briefed subcontractors on CGP requirements at pre-bid and pre-construction meetings. Storm water requirements were put into subcontract requirements, so each bidder who responds to or bids on a subcontract for a Laboratory project is given project-specific environmental requirements. The team also gave presentations to multiple LANL organizations to increase awareness of CGP requirements and continued to hold a standing weekly meeting with LANL Project Management personnel to review the storm water compliance status of projects.

e. NPDES Industrial Storm Water Program

The NPDES Industrial Storm Water Permit Program regulates storm water discharges from identified regulated industrial activities (including SWMUs) and their associated facilities. These activities include metal fabrication; hazardous waste treatment, storage, and disposal; landfill operations; vehicle and equipment maintenance; recycling activities; electricity generation; warehousing activities; and asphalt manufacturing.

LANS and the DOE are co-permittees under the EPA 2008 NPDES Storm Water Multi-Sector General Permit for Industrial Activities (MSGP-2008). MSGP-2008 requires the development and implementation of site-specific SWPPPs, which must include identifying potential pollutants and activities and installing erosion control measures. Permit requirements also include monitoring storm water discharges from permitted sites. In 2009, LANL implemented and maintained 15 SWPPPs under the MSGP-2008 requirements, covering 19 facilities. Compliance with the requirements for these sites is achieved primarily by implementing the following activities:

- Identifying potential contaminants and activities that may impact surface water quality and identifying and providing structural and nonstructural controls to limit the impact of those contaminants.
- Developing and implementing facility-specific SWPPPs.

- Monitoring storm water runoff at facility gauging stations and stand-alone samplers for industrial sector-specific benchmark parameters, impaired water constituents, and effluent limitations, and visually inspecting storm water runoff to assess color; odor; floating, settled, or suspended solids; foam; oil sheen; and other indicators of storm water pollution.

f. Federal Facility Compliance Agreement/Administrative Order

In February 2005, DOE and EPA Region 6 entered into the FFCA with the purpose of establishing an interim compliance program for the regulation of storm water discharges from listed sites and to allow adequate time to submit an Individual Storm Water Permit Application. The March 2005 Individual Storm Water Permit application was intended to separate the sites regulated under the MSGP into an Individual Storm Water Permit (IP) focused primarily on imposing more stringent requirements for storm water discharge from Sites.

The IP was issued in February 2009 and became effective on April 1, 2009 (NPDES Permit No. NM0030759). The IP was subsequently appealed by a coalition of regional citizens' groups. Since that time, the final conditions of the IP continue to be negotiated under a proposed settlement agreement between LANS, DOE, EPA and the citizens' groups. As a result of the permit appeal negotiations, it is expected that issuance of a modified IP will have requirements different from the original 2009 permit.

In 2009, the Laboratory completed the following tasks:

1. Completed the annual modification of the SWPPP for SWMU/AOCs that describes watershed-scale monitoring, site-specific monitoring, and the erosion control program at SWMU/AOCs;
2. Continued negotiations with EPA and NMED on the development of an individual permit for storm water discharges from SWMUs/AOCs;
3. Completed the following fieldwork:
   - Installed 52 new site-specific samplers for IP sampling;
   - Maintained 60 gage stations for storm event sampling;
   - Collected 85 filtered and unfiltered storm water samples;
   - Installed 150 new erosion control measures at IP sites;
   - Conducted 1012 inspections at IP sites;
   - Completed maintenance of control measures at 25 IP sites;
   - Conducted Annual Comprehensive Site Compliance Evaluation inspections.

Qualified personnel, as required under the MSGP, conducted the Annual Comprehensive Site Compliance Evaluation inspections to assess the presence of existing industrial materials, leaks and spills, off-site tracking of sediment, tracking/blowing of industrial materials, and evidence of pollutants entering into receiving waters. The annual inspections also included an evaluation of the existing structural control measures at each site and corrective actions when needed.

The Laboratory completed supplemental information submittals in support of the Individual Permit application for storm water discharges from certain SWMUs/AOCs. EPA issued a draft permit in early 2008 for public comment. The final Individual Permit was issued in April 2009.

g. Aboveground Storage Tank Compliance Program

The Laboratory's Aboveground Storage Tank (AST) Compliance Program is responsible for ensuring compliance with the requirements established by EPA (Clean Water Act 40 CFR, Part 112) and NMED's Petroleum Storage Tank Bureau (PSTB) Regulations (20.5 NMAC). During 2009, the Laboratory was in full compliance with both EPA and NMED requirements.

Spill Prevention Control and Countermeasures (SPCC) Plans fulfill the federal requirements for the AST Compliance Program, as required by the CWA (40 CFR, Part 112, Oil Pollution Prevention Regulations). Comprehensive SPCC Plans are developed to meet EPA requirements that regulate water pollution from oil spills.

EPA proposed additional extensions to compliance deadlines for meeting new regulatory requirements under the federal Clean Water Act (40 CFR, Part 112). Proposed new regulations will require the Laboratory to modify and implement its SPCC Plans by November 10, 2010. Primary modifications address AST storage capacity, inspection frequency, integrity testing requirements, and equipment. The Laboratory completed 18 out of 20 modifications to existing and new SPCC Plans and implementation of those modifications is in process. Updates to two remaining SPCC Plans will be completed in early 2010.

The Laboratory continues to maintain and operate ASTs in compliance with 20.5 NMAC of the NMED-PSTB Regulations. The Laboratory paid annual AST registration fees of $100 per AST. The Laboratory has three tank systems that are operational pursuant to 20.5 NMAC. The remaining four tanks systems are under temporary closure status pursuant to 20.5 NMAC.

During 2009, the Laboratory continued to work on removing and decommissioning ASTs that are no longer in service. Three AST systems were officially closed out with NMED-PSTB pursuant to 20.5 NMAC. These AST system were located at TA-53-645 (near LANSCE), TA 53-1071(a, b, and c), and TA-3-316.

On February 21, 2002, the Laboratory notified EPA, NMED, and the National Response Center of a discharge of approximately 48,000 gallons of diesel fuel released into the environment from a tank at TA-21-57. Soil removal and sampling were performed in accordance with Laboratory, state, and federal regulatory requirements to determine the extent of the leak. In 2009, the Laboratory completed additional characterization work at the site. A Tier 1 Assessment will be conducted in 2010 pursuant to 20.5 NMAC of the NMED-PSTB regulations. Additional corrective actions will be recommended pursuant to the Tier 1 Assessment findings.

h. Dredge and Fill Permit Program

Section 404 of the Clean Water Act requires the Laboratory to obtain permits from the US Army Corps of Engineers to perform work within perennial, intermittent, or ephemeral watercourses. Section 401 of the Clean Water Act requires states to certify that Section 404 permits issued by the Corps of Engineers will not prevent attainment of state-mandated stream standards. NMED reviews Section 404/401 joint permit applications and issues separate Section 401 certification letters, which may include additional permit requirements to meet state stream standards for individual Laboratory projects. In addition, the Laboratory must comply with 10 CFR 1022, which specifies how DOE sites comply with Executive Order 11988, Floodplain Management, and Executive Order 11990, *Protection of Wetlands*.

During 2009, six Section 404/401 permits were issued to the Laboratory:

- Removal of Abandoned Sewer Line, North Ancho Canyon (Nationwide Permit No. 18, Minor Discharges)
- Installation of a Carbon Filtration System at SWSC Spring, Cañon de Valle (Nationwide Permit No. 18, Minor Discharges)
- Upgrades to the Existing Carbon Filtration System at Martin Spring, Martin Spring Canyon (Nationwide Permit No. 18, Minor Discharges)
- Installation of a Pilot Permeable Reactive Barrier, Cañon de Valle (Nationwide Permit No. 3, Maintenance)
- Installation of a Carbon Filtration System at Burning Ground Spring, Cañon de Valle (Nationwide Permit No. 18, Minor Discharges)
- Installation of Three Cross Vane Structures to Control Sediment Transport, Pueblo Canyon (Nationwide Permit No. 18, Minor Discharges)

During 2009, one Section 404/401 permit was issued to the NNSA, Los Alamos Site Office:

- Installation of Grade Control Structures in DP and Pueblo Canyons to Control Sediment Transport (Nationwide Permit No. 43, Stormwater Management Facilities)

In addition, LANL reviewed 608 excavation permits and 61 project profiles for potential impacts to watercourses, floodplains, or wetlands. No Floodplain/Wetland Assessments were prepared in 2009. No violations of the DOE Floodplains/Wetlands Environmental Review Requirements were recorded. NMED and the Corps of Engineers did not inspect any sites permitted under the Section 404/401 regulations during 2009.

8. Safe Drinking Water Act

Los Alamos County, as owner and operator of the Los Alamos water supply system, is responsible for compliance with the requirements of the federal Safe Drinking Water Act (SDWA) and the New Mexico Drinking Water Regulations (NMEIB 2007). The SDWA requires Los Alamos County to collect samples from various points in the water distribution systems at the Laboratory, Los Alamos County, and Bandelier National Monument to demonstrate compliance with SDWA maximum contaminant levels (MCLs). EPA has established MCLs for microbiological organisms, organic and inorganic constituents, and radioactivity in drinking water. The State of New Mexico has adopted these standards in the New Mexico Drinking Water Regulations. EPA has authorized NMED to administer and enforce federal drinking water regulations and standards in New Mexico. Information on the quality of the drinking water from the Los Alamos County water supply system is in the County's annual Consumer Confidence Report, available online at http://www.losalamosnm.us/.

In 2009, the Laboratory conducted additional confirmation monitoring of the Los Alamos County water supply system for quality assurance purposes. The data are available in Chapter 5 of this report and at the online RACER Data Analysis Tool (http://racernm.com/). Drinking water supplied by Los Alamos County has not been impacted by any LANL contaminants.

9. Groundwater

a. Groundwater Protection Regulations

New Mexico Water Quality Control Commission (NMWQCC) regulations control liquid discharges onto or below the ground surface to protect all groundwater in New Mexico. Under the regulations, when required by NMED, a facility must submit a groundwater discharge plan and obtain NMED approval (or approval from the New Mexico Oil Conservation Division for energy/mineral-extraction activities). Subsequent discharges must be consistent with the terms and conditions of the discharge plan. In 2009, the Laboratory had one approved groundwater discharge plan and two groundwater discharge plans pending NMED approval (see Table 2-1).

i. TA-46 SWWS Plant Discharge Plan DP-857

On July 20, 1992, the Laboratory was issued a discharge permit for the TA-46 SWWS Plant. The permit was renewed on January 7, 1998. The permit requires quarterly sampling of the SWWS Plant's effluent, NPDES Outfalls 001 and 03A027, and Cañada del Buey alluvial groundwater well CDBO-6 to demonstrate compliance with NMWQCC groundwater standards. The Laboratory reports the analytical results to the NMED quarterly. During 2009, none of samples collected exceeded NMWQCC groundwater standards. Monitoring data are available online at the RACER Data Analysis Tool (http://racernm.com/). On August 27, 2002, the Laboratory submitted a renewal application for the TA-46 SWWS Plant's discharge permit, and NMED approval was pending at the end of 2009.

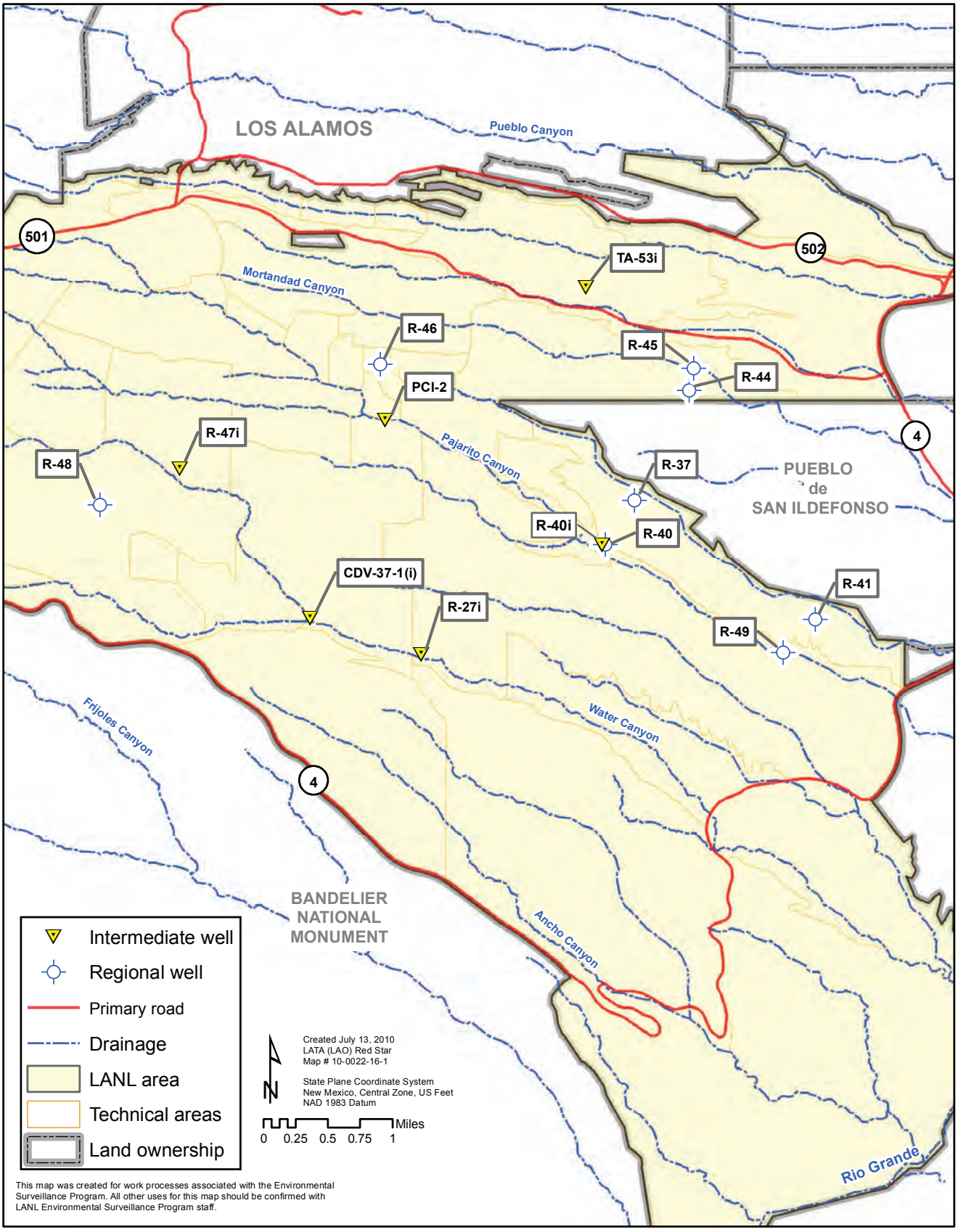


Figure 2-3. Characterization wells in the intermediate and regional aquifers installed during 2009.

ii. TA-50 RLWTF Discharge Plan DP-1132

On August 20, 1996, at the NMED's request, the Laboratory submitted a discharge plan application for the RLWTF at TA-50; NMED approval was pending at the end of 2009. Since 1999, the Laboratory has conducted voluntary quarterly sampling of the RLWTF's effluent and alluvial groundwater monitoring wells MCO-3, MCO-4B, MCO-6, and MCO-7 in Mortandad Canyon for nitrate (as N), fluoride, and total dissolved solids (TDS). The Laboratory reports the analytical results to the NMED quarterly. During 2009, none of the quarterly discharge plan samples exceeded NMWQCC groundwater standards with the exception of two effluent results in October and November 2009; nitrate (as nitrogen) concentrations in two samples—11.8 mg/L and 11.2 mg/L—exceeded the NMWQCC groundwater standard of 10 mg/L. Monitoring data are available online at the RACER Data Analysis Tool (http://racernm.com/).

iii. Septic Tanks Discharge Plan

On April 27, 2006, at the NMED's request, the Laboratory submitted a discharge plan application for the discharge of domestic wastewater from 21 septic systems. These septic systems (a combined septic tank and leach field) are located in remote areas of the Laboratory where access to the SWWS Plant's collection system is not practicable. The Laboratory regularly pumps and maintains these tanks. The NMED has declared the Laboratory's application to be administratively complete, but approval was still pending at the end of 2009.

b. Groundwater Monitoring Activities

The Laboratory performed significant groundwater compliance work in 2009 pursuant to the Consent Order. These activities included groundwater monitoring, groundwater investigations, and groundwater well construction.

Sample analytical and other groundwater data can be reviewed online on the RACER Data Analysis Tool (http://racernm.com/). Periodic monitoring reports and water-level and well construction data can be found on the Laboratory's Environment Website at http://www.lanl.gov/environment/h2o/reports.shtml.

In 2009, LANL installed six perched-intermediate monitoring wells and eight regional monitoring wells (Table 2-8). Figure 2-3 shows the locations of the new wells; maps of all monitoring well locations can be found in Chapter 5. Intermediate well TA-53i was installed south of Los Alamos Canyon to assess the southern extent of perched water identified in the canyon bottom. Regional wells R-44 and R-45 were installed as part of the ongoing chromium contamination investigation. Regional well R-46 was installed in support of the MDA C investigation. Six wells were installed to supplement the groundwater monitoring network around TA-54. Wells R-37, R-40, R-41, and R-49 were installed in the regional aquifer. Wells PCI-2 and R-40i were installed in the intermediate depth perched zone. Four wells were installed to monitor groundwater associated with historical TA-16 activities. Wells R-27i, CdV-37-1i, and R-47i were installed to intermediate depths. Well R-48 was installed to the regional aquifer by advancing the previously drilled CdV-16-3(i) borehole.

10. DOE Order 435.1 Radioactive Waste Management

Institutional Requirements

DOE Order 435.1 "Radioactive Waste Management" and the associated DOE Manual 345.1-1 give requirements for management and handling of radioactive waste. In 2005, LANL submitted a compliance plan to DOE which was approved in 2007. Since 2007, major operational facilities at LANL that contain or manage radioactive waste must prepare a Radioactive Waste Management Basis (RWMB) for the generating facility. LANL submits compliance reporting for the RWMB to the local DOE office for approval. Any facility at LANL that generates radioactive waste must comply with three internal requirement documents that cover waste acceptance criteria, the radioactive waste certification requirements, and off-site shipment of chemical, hazardous, or radioactive waste. At the end of 2009, 11 organizations had prepared and submitted RWMBs for approval by DOE and seven had been approved. Four approvals were granted by DOE and three extensions for radioactive waste stored over one year were approved.

Table 2-8
Wells and Boreholes Installed in 2009

Type[a]	Identifier	Watershed (Canyon)	Total Completed depth[b] (ft bgs)	Screened interval(s) (ft bgs)	Initial Water level (ft bgs)	Comments
I	TA-53i	Los Alamos	620.8	600.0–610.0	599.8	Monitors for potential southward migration of contaminants from sources in Los Alamos Canyon
R	R-37	Pajarito	1068.8	929.3–950.0 1026.0–1046.6	909.6 1009.6	Monitors groundwater downgradient of MDA H at TA-54
R	R-40	Pajarito	895	751.6–785.0 849.3–870.0	761.3 852.0	Monitors TA-54 and potential sources in Pajarito Canyon
I	R-40i	Pajarito	674.6	649.7–669.0	640.4	Monitors TA-54 and potential sources in Pajarito Canyon
I	PCI-2	Pajarito	533.3	512.0–522.0	508.0	Intermediate depth well adjacent to regional aquifer well R-17. Provides baseline data for areas upgradient of TA-54
R	R-44	Mortandad	1016.0	895.0–905.0 985.3–995.2	878.0 879.0	Monitors for nature and extent of contaminants from sources in Sandia Canyon
R	R-45	Mortandad	1016.0	880.0–890.0 974.9–994.9	868.2 868.3	Monitors for nature and extent of contaminants from sources in Sandia Canyon
R	R-46	Mortandad	1382.2	1340.0–1360.7	1327.9	Monitors groundwater quality downgradient of MDA C at TA-50
R	R-41	Pajarito	997.1	928.0–937.7 965.3–975.0	Dry 960.4	Monitors groundwater northeast of MDA G at TA-54
R	R-49	Pajarito	949.3	845.0–855.0 905.6–926.4	809.9 833.3	Monitors groundwater south of MDA G at TA-54
R	R-48	Water	1542.4	1500.0–1520.6	1352.7	Deepening and completion of borehole CdV-16-3(i) at TA-16. Monitors historical TA-16 sources
I	R-47i	Water	865.5	840.0–860.6	832.2	Originally intended to be a regional aquifer well, but completed as an intermediate aquifer well. Provides data in support of 260 Outfall CME.
I	R-27i	Water	630.2	619.0–629.0	616.4	Intermediate depth well adjacent to regional aquifer well R-27. Monitors groundwater downgradient of historical TA-16 sources
I	CdV-37-1i	Water	657.8	632.0–652.5	627.9	Sited to monitor intermediate depth groundwater at the confluence of Water Canyon and Canon de Valle downgradient from historical TA-16 sources

[a] Perched intermediate aquifer well; R = regional aquifer well.
[b] Total depth refers to the completed well; bgs = below ground surface.

The Laboratory has required registration of on-site radioactive waste storage and staging areas since July 24, 2007. The on-site Waste Certification Program also calls for self-assessments to ensure radioactive waste is managed in accordance with the approved RWMB and DOE requirements. Registration, facility self-inspections, and surveillance of radioactive staging and storage areas ensure LANL radioactive waste management practices are consistent with the requirements in DOE Order 435.1. The WCP assures compliance from the generators through storage and transport to the receiving facility. In calendar year 2009, 142 inspections were conducted and 17 findings were documented.

11. National Environmental Policy Act

Under the National Environmental Policy Act (NEPA) (42 U.S.C. 4331 et seq.), federal agencies such as DOE/NNSA must consider the environmental impacts of proposed projects and ensure public participation as part of the decision-making process. The Laboratory's Environmental Stewardship Group devotes considerable resources to assist NNSA in compliance with NEPA, pursuant to DOE Order 451.1B. Proposed projects and actions at LANL are reviewed to determine potential resource impacts and the appropriate coverage under NEPA, and these recommendations are provided to NNSA. The NEPA analysis in the new LANL Site-Wide Environmental Impact Statement (SWEIS) was prepared in 2007.

The DOE NEPA implementing regulations (10 CFR Part 1021.330[d]) require a SWEIS to be reviewed at least every five years and a Supplemental Analysis be performed to examine whether the SWEIS still adequately covers site operations. In August 2005, a memo was issued to LANL from DOE/NNSA to prepare a new SWEIS. The final SWEIS was issued in May 2008 (DOE 2008a). A limited Record of Decision (ROD) was issued in September 2008 (DOE 2008b) in which DOE decided to implement the No Action Alternative with the addition of some elements of the Expanded Operations Alternative.

The second ROD for the 2008 SWEIS was issued in July 2009. The ROD was based on the information and analyses contained in the SWEIS and other factors, including comments received on the SWEIS, costs, technical and security considerations, and the missions of NNSA. The following elements of the Expanded Operations Alternative were approved:

- Complete the environmental remediation and closure of TA-18 Pajarito Site;
- Complete the environmental remediation and closure of TA-21 (also referred to as the Delta Prime or DP Site);
- Refurbish the Plutonium Facility Complex at TA-55;
- Construct and operate a new Radioactive Liquid Waste Treatment Facility Complex in TA-50 and operate a zero liquid discharge facility in TA-52 as an auxiliary action;
- Install additional processors and equipment to further expand the capabilities and operation level of the Nicholas C. Metropolis for Modeling and Simulation in TA-3; and
- Construct and operate a new Science and Engineering Complex at TA-62.

The first Supplement Analysis to the 2008 SWEIS was issued in October 2009. This analysis was prepared to determine if the 2008 SWEIS adequately bounded off-site transportation of low specific activity and low level waste by a combination of truck and rail to EnergySolutions in Clive, Utah. DOE/NNSA concluded that the proposed shipment of waste to EnergySolutions by truck and rail are bounded by 2008 SWEIS transportation analysis.

12. Endangered Species Act

The Endangered Species Act requires federal agencies to protect populations and habitats of federally listed threatened or endangered species. The Laboratory contains potential habitat for two federally endangered species (Southwestern willow flycatcher, *Empidonax traillii extimus*, and black-footed ferret, *Mustela nigripes*), one federally threatened species (Mexican spotted owl, *Strix occidentalis lucida*), and two candidate species (yellow-billed cuckoo, *Coccyzus americanus*, and New Mexico meadow jumping mouse, *Zapus hudsonius luteus*).

The Southwestern willow flycatcher, black-footed ferret, and New Mexico meadow jumping mouse have not been observed on Laboratory property. In addition, several federal species of concern and state-listed species potentially occur within LANL (Table 2-9).

The Laboratory meets its requirements for threatened and endangered species protection through implementation of its Threatened and Endangered Species Habitat Management Plan and review of excavation permit requests and project profiles. During 2009, LANL reviewed 612 excavation permits, 115 project profiles, and seven storm water pollution prevention plans for potential impacts to threatened or endangered species. The Laboratory conducted annual surveys for the Mexican spotted owl, Southwestern willow flycatcher, Jemez Mountains salamander, and grey vireo.

Table 2-9
Threatened, Endangered, and Other Sensitive Species Occurring or Potentially Occurring at LANL

Scientific Name	Common Name	Protected Status[a]	Potential to Occur[b]
Empidonax traillii extimus	Southwestern Willow Flycatcher	E	Moderate
Mustela nigripes	Black-footed Ferret	E	Low
Strix occidentalis lucida	Mexican Spotted Owl	T	High
Coccyzus americanus	Yellow-billed Cuckoo	C, NMS	Moderate
Zapus hudsonius luteus	New Mexico meadow jumping mouse	C, NMS	Moderate
Haliaeetus leucocepahlus	Bald Eagle	NMT, S1	High
Gila pandora	Rio Grande Chub	NMS	Moderate
Plethodon neomexicanus	Jemez Mountains Salamander	NME, FSOC	High
Falco peregrinus anatum	American Peregrine Falcon	NMT, FSOC	High
Falco peregrinus tundrius	Arctic Peregrine Falcon	NMT, FSOC	Moderate
Accipiter gentiles	Northern Goshawk	NMS, FSOC	High
Lanius ludovicianus	Loggerhead Shrike	NMS	High
Vireo vicinior	Gray Vireo	NMT	Moderate
Plegadis chihi	White-faced Ibis	S1	Moderate
Myotis ciliolabrum melanorhinus	Western Small-footed Myotis Bat	NMS	High
Myotis volans interior	Long-legged Bat	NMS	High
Euderma maculatum	Spotted Bat	NMT	High
Plecotus townsendii pallescens	Townsend's Pale Big-eared Bat	NMS, FSOC	High
Nyctinomops macrotis	Big Free-tailed Bat	NMS	High
Myotis thysanodes thysanodes	Fringed Bat	NMS	High
Myotis yumanensis yumanensis	Yuma Bat	NMS	High
Myotis evotis evotis	Long-eared Bat	NMS	High
Bassariscus astutus	Ringtail	NMS	High
Vulpes vulpes	Red Fox	NMS	Moderate
Ochotona princeps nigrescens	Goat Peak Pika	NMS, FSOC	Low
Lilium philadelphicum var. andinum	Wood Lily	NME	High
Cypripedium calceolus var. pubescens	Greater Yellow Lady's Slipper	NME	Moderate
Speyeria Nokomis nitocris	New Mexico Silverspot Butterfly	FSOC	Moderate

[a] E = Federal Endangered; T = Federal Threatened; C = Federal Candidate Species; NMS = New Mexico Sensitive Taxa (informal); S1 = Heritage New Mexico: Critically Imperiled in New Mexico; NMT = New Mexico Threatened; NME = New Mexico Endangered; FSOC = Federal Species of Concern.

[b] Low = No known habitat exists on LANL; Moderate = Habitat exists, though the species has not been recorded recently; High = Habitat exists, and the species occurs at LANL.

13. Migratory Bird Treaty Act

Under the provisions of the Migratory Bird Treaty Act, it is unlawful "by any means or manner to pursue, hunt, take, capture [or] kill" any migratory birds except as permitted by regulations issued by the US Fish and Wildlife Service. In the project review process, LANL biologists provided specific comments for projects with the potential to impact migratory birds, their eggs, or nestlings if, for example, a project proposed an electrical power line or a project disturbed vegetation during the bird nesting season.

14. Cultural Resources

The goal of the National Historic Preservation Act (NHPA) of 1990 is to have federal agencies act as responsible stewards of the nation's resources when their actions affect historic properties. NHPA Section 106 requires federal agencies to take into account the effects projects may have on historic properties and to allow for comment by the Advisory Council on Historic Preservation. Section 106 regulations outline a project review process conducted on a project-by-project basis.

In 2009, the Laboratory conducted 40 projects that required some field verification of previous cultural surveys. Twenty-one new archaeological sites and seven new historical buildings were identified in 2009. Five historic buildings were determined eligible for the National Register of Historic Places.

The Laboratory began the eighth year of a multiyear program that included archaeological excavation in support of the Land Conveyance and Transfer Project. The DOE/NNSA is in the process of conveying to Los Alamos County approximately 2,000 acres of Laboratory lands. Thirty-nine archaeological sites were excavated during the 2002 to 2005 field seasons, with more than 200,000 artifacts and 2,000 samples collected. During 2009, the remaining artifacts stored at LANL were transferred for curation to the Museum of New Mexico. Together, these sites provide new insights into past activities on the Pajarito Plateau from 5000 B.C. to A.D. 1943. From a compliance perspective, these excavations resolve the anticipated adverse effects to archaeological sites from the future development of lands to be acquired by Los Alamos County. These sites are also ancestral places to the local Pueblo populations, and, as such, representatives from the Pueblos de San Ildefonso and Santa Clara acted as tribal consultants and monitors on the project. During fiscal year 2008, the final report was completed and submitted to the New Mexico State Historic Preservation Office in fulfillment of the Data Recovery Plan and the Programmatic Agreement between the DOE Los Alamos Site Office, the Advisory Council on Historic Preservation, and the State Historic Preservation Office.

In support of LANL's 2009 decontamination and decommissioning program, square footage reduction, and Laboratory consolidation, the Laboratory conducted historic building assessments and other documentation work related to three proposed projects as required under the provisions of the NHPA. Buildings included in these projects are located at TAs-8, -11, -15, -16, -22, -33, -37, -41, -46, and -49. This work included field visits to historic properties (including interior and exterior inspections), digital and archival photography, and architectural documentation (using standard LANL building recording forms). Additional documentation included the production of location maps for each of the evaluated projects. Historical research was also conducted using source materials from the LANL archives and records center, historical photography, the Laboratory's public reading room, and previously conducted oral interviews.

The Laboratory continues to consult with the Pueblos with respect to identifying and protecting traditional cultural properties, human remains, and sacred objects in compliance with the NHPA and Native American Graves Protection and Repatriation Act (NAGPRA). This work included ongoing consultations with the Pueblo de San Ildefonso regarding culturally affiliated human remains discovered in TA-36.

C. UNPLANNED RELEASES

1. Air Releases

No unplanned air releases occurred during 2009.

2. Liquid Releases

No unplanned releases of radioactive liquids occurred on Laboratory lands in 2009. There were 28 unplanned releases of non-radioactive liquids in 2009:

- Approximately 1,800 gallons of potable water into Los Alamos Canyon.
- Approximately 100,000 gallons of potable water into Twomile Canyon.
- Approximately 3 gallons of diesel fuel at the Pajarito Laydown Yard.
- Approximately 600,000 gallons of potable water into Twomile Canyon.
- Approximately 200 gallons of re-use water from an excavation.
- Approximately 5,000 gallons of potable water into Sandia Canyon.
- Approximately 14,000 gallons of potable water into DP Canyon.
- Approximately 24,000 gallons of potable water into Sandia Canyon.
- Approximately 1 gallon of Roof Guard mixed with storm water to a storm drain into Mortandad Canyon.
- Approximately 1 gallon of propylene glycol in storm water into a storm drain to Mortandad Canyon.
- Approximately 4 gallons of Roof Guard mixed with storm water into a storm drain to Twomile Canyon.
- Approximately 75 gallons of hydraulic fluid at TA-60 from a crane.
- Approximately 500 gallons of R-28 purge water.
- Approximately 20,000 gallons of potable water into Pajarito Canyon.
- Approximately 4,320 gallons of steam condensate into Sandia Canyon.
- Approximately 15,000 gallons of R-47 drilling fluid.
- Groundwater from R-20 Screen #1 communicated to Screen #2.
- Approximately 200,000 gallons of steam condensate into upper Twomile Canyon.
- Approximately 300 gallons of potable water to Pajarito Canyon.
- Approximately 1,000 gallons of potable water into Water Canyon.
- Approximately 20,000 gallons of R-37 well development drilling fluid.
- Packer systems in some wells may have become under inflated causing communication between perched aquifers and the regional aquifer.
- Approximately 2,800 gallons per day of steam condensate into Twomile Canyon.
- Approximately 6,500 gallons of potable water into Sandia Canyon.
- Approximately 10,000 gallons of potable water into Water Canyon.
- Approximately 3,600 gallons per day of steam condensate into Sandia Canyon.
- Approximately 25,000 gallons of potable water into DP Canyon.
- Approximately 6,000 gallons of potable water into Los Alamos Canyon.

The Laboratory investigated all unplanned releases of liquids as required by the NMWQCC Regulations 20.6.2.1203 NMAC. Upon cleanup, the NMED and the DOE Oversight Bureau inspected the unplanned release sites to ensure adequate cleanup. In 2009, the Laboratory was in the process of administratively closing all releases for 2009 with the NMED and the DOE Oversight Bureau and anticipates these unplanned release investigations will be closed out after final inspections.

D. REFERENCES

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LANL 2006: "Interim Measures Work Plan for Chromium Contamination in Groundwater," Los Alamos National Laboratory document LA-UR-06-1961, Los Alamos, New Mexico. (LANL 2006, 091987) (March 2006).

NMEIB 2007: New Mexico Environmental Improvement Board, State of New Mexico, "Drinking Water Regulations" (as amended through April 2007), found at 20.7.10 NMAC.



3. Radiological and Nonradiological Dose Assessment



contributing authors:
William Eisele, Michael McNaughton, and Jeffrey Whicker

To Read About **Turn to Page**

Introduction 79
Radiological Dose Assessment for Humans 79
Biota Dose Assessment 88
Nonradiological Risk Assessment 89
References 91

A. INTRODUCTION

This chapter presents the results of the calculation of radiological dose and non-radiological risk to the public and biota from Los Alamos National Laboratory (LANL or the Laboratory) operations in 2009 and reports whether the doses are below specified limits. This chapter also provides a measure of the significance of environmental radioactivity in the context of its potential risk to humans and biota. In this respect, the human dose assessment provides a different perspective from the biota dose assessment. The calculated human dose is received near the publicly accessible Laboratory boundaries, whereas the calculated biota dose is potentially received throughout the interior of Laboratory property, usually at locations rarely visited by humans. In addition, the potential risks from non-radiological materials detected during 2009 and previous years' sampling activities are summarized.

As defined by US Department of Energy (DOE) Standard 1153-2002 (DOE 2002), biota are divided into plants and animals. Plants receive the highest radiation dose because they grow and remain in one location. Most animals range over an area, which usually minimizes their dose. Humans receive the lowest radiation dose because they limit their time in areas with residual contamination and do not typically eat the vegetation or drink the water in these areas. Therefore, locations with no significant human radiation dose may have a higher biota radiation dose.

B. RADIOLOGICAL DOSE ASSESSMENT FOR HUMANS

1. Overview of Radiological Dose Equivalents

Radiological dose equivalents presented are calculated using standard methods specified in guidance documents (DOE 1988a, 1988b, 1991; EPA 1988, 1993, 1997, 1999; ICRP 1996; NRC 1977). The effective dose equivalent, referred to here as "dose," is calculated using radiation weighting factors and tissue weighting factors to adjust for the various types of radiation and the various tissues in the body. The final result, measured in millirem (mrem), is a measure of the overall dose to an individual, whether from external radiation or contact with radioactive material. For example, from a human health risk perspective, 1 mrem of direct gamma radiation is effectively equivalent to 1 mrem from inhalation of plutonium. In addition, the dose results within this chapter reflect potential dose to hypothetical people and biota and are not to be construed as a dose assessment for any specific individual or organism.

Federal government standards limit the dose that the public may receive from Laboratory operations. The DOE dose limit to a member of the public is 100 mrem/yr (DOE 1993) received from all pathways (i.e., all ways in which a person can be exposed to radiation, such as inhalation, ingestion, and direct radiation). Furthermore, doses to members of the public must be reduced to low levels consistent with a documented "as low as reasonably achievable" (ALARA) process (LANL 2008b) and generally should not exceed a dose constraint of one-quarter of the primary dose limit, or 25 mrem/yr (DOE 1999). The dose received from airborne emissions of radionuclides is further restricted by the US Environmental Protection Agency (EPA) dose standard of 10 mrem/yr (EPA 1986), also known as the National Emission Standards for Emissions of Radionuclides Other than Radon from DOE (Rad-NESHAP) dose limit. These doses are in addition to exposures from natural background, consumer products, and medical sources. Doses from community drinking water supplies are limited in accordance with the

Clean Water Act, either by established maximum contaminant levels (MCLs) for some radionuclides or by dose rate (4 mrem/yr for man-made radionuclides) (EPA 2000).

2. Public Dose Calculations

a. Scope

The objective of our public dose calculations is to report incremental (above-background) doses resulting from LANL operations. Therefore, we do not include dose contributions from radionuclides present in our natural environment or from radioactive fallout.

Annual radiation doses to the public are evaluated for three principal exposure pathways: inhalation, ingestion, and direct (or external) radiation. We calculate doses for the following cases:

1. The entire population within 80 km of the Laboratory
2. The maximally exposed individual (MEI) not on LANL property; for the airborne pathway dose only and compared with the EPA RAD-NESHAP dose limit of 10 mrem/yr
3. The MEI not on LANL property; for the all-pathways dose and compared with the DOE Order 5400.5 dose limit of 100 mrem/yr
4. Residents in Los Alamos and White Rock

b. General Considerations

As discussed in Section B.4, below, the dose rate from naturally occurring radioactivity is approximately 450 mrem/yr. Additional man-made sources of radiation, such as medical/dental uses of radiation and building products such as stone walls, raise the total background dose to about 700 mrem/yr on average (NCRP 1975, 1987a, 1987b, 2009). It is extremely difficult to measure doses from LANL that are less than 0.1% (one one-thousandth) of natural doses. As the dose rates become smaller, the estimates become less certain and less significant. Generally, we conclude that a dose rate less than 0.1 mrem/yr is essentially zero and cannot be distinguished from natural background radiation.

We begin with environmental measurements of radionuclides in air, water, soil, foodstuffs, sediment, and non-foodstuffs biota. We compare the concentrations of these radionuclides in the various media to pre-determined radionuclide-specific screening levels that are equivalent to 0.1 mrem/yr for specific exposure pathways such as ingestion of drinking water, ingestion of foodstuffs, and residing on contaminated soil (LANL 2003). If the concentrations do not exceed the screening levels, no further assessment is required and the doses are assumed to be essentially zero. If the concentrations do exceed the screening levels, further dose assessment is required and specific numerical dose values are reported in this chapter (LANL 2008a).

i. Direct Radiation Exposure

The Laboratory monitors direct radiation from gamma photons or neutrons at about 100 locations in and around LANL (see Chapter 4, Section C). Direct radiation doses above natural background are measured near Technical Area (TA) -54, but there are no other Laboratory sources of external radiation that can be measured at off-site areas.

To receive a measurable dose, a member of the public must be within a few hundred meters of the source of external radiation. At distances more than one kilometer, the decrease in radiation dose rate with increasing distance from the radiation source (inverse-square law), combined with scattering and attenuation or shielding in the air, reduces the dose to much less than 0.1 mrem/yr, which cannot be distinguished from natural background radiation. This means the only significant above-background doses from direct radiation are measured near TA-54 (see Section B.3.b of this chapter).

To estimate the dose to the public near TA-54, we multiply the measurements of neutron dose by an occupancy factor of 1/16 (NCRP 1976). The direct radiation measurements reported in Chapter 4 apply to an individual who is at a particular location continuously (i.e., 24 hours/day and 365 days/yr). We followed standard guidance and assumed continuous occupancy for residences and places of business. For all other locations, we multiplied the measured dose by the 1/16 occupancy factor.

ii. Airborne Radioactivity (Inhalation Pathway)

At distances of more than a few hundred meters from LANL sources, the dose to the public is almost entirely from airborne radioactive material. Whenever possible, we use the direct measurements of airborne radioactivity concentrations measured by the Ambient Air Sampling Network (AIRNET) and reported in Chapter 4, Section A. Where local concentrations are too small to measure, we calculate the doses using the CAP88 model (PC Version 3.0) (EPA 2007a), an atmospheric dispersion and dose calculation computer code that combines stack radionuclide emissions information with meteorological data to estimate where the released radioactive material may have gone and the dose from that radioactive material.

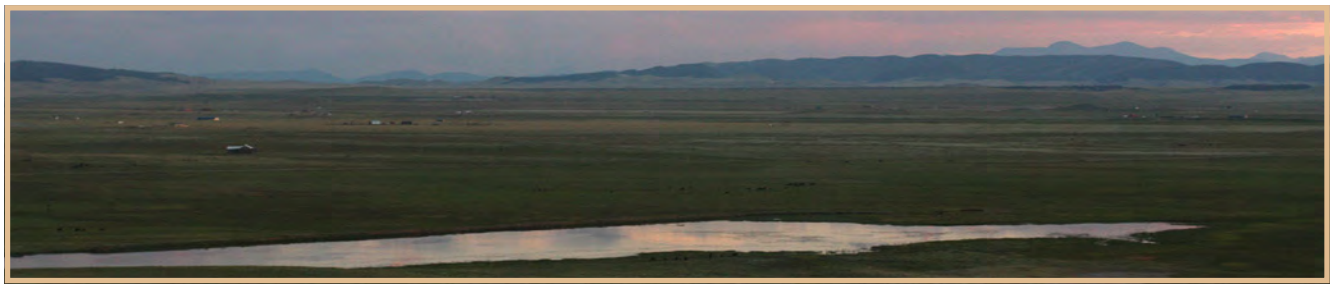
In particular, some of the radionuclide emissions from the Los Alamos Neutron Science Center (LANSCE) are not measured by AIRNET. These emissions are measured at the stacks (see Chapter 4, Section B), and the resulting doses are calculated with CAP88. These doses decrease substantially with distance from the stack because the radioactive half-lives are short (mostly 20 minutes or less).

iii. Water (Ingestion Pathway)

The majority of radionuclides detected in groundwater samples collected from known or potential drinking water sources (i.e., Los Alamos County drinking water supply wells, Buckman wells, and natural springs) in 2009 resulted from the presence of natural radioactivity in these sources. These radionuclides include natural uranium and its decay products, such as radium-226. Except for tritium, radionuclides attributable to Laboratory operations are not found in recognized drinking water sources. The highest concentration of tritium detected in a Los Alamos County drinking water supply well was 17 pCi/L in a sample collected from the Otowi-1 well located in Pueblo Canyon and is within the range of tritium concentrations found in rain water (16 to 35 pCi/L) (Holloway 1993). This concentration is far below the EPA MCL of 20,000 pCi/L and results in a dose of much less than 0.1 mrem/yr if this water were to be ingested for an entire year (assumes 730 L ingested for the year). However, Los Alamos County has not used this well as a drinking water source for several years. Tritium was also detected in water samples from Basalt Spring on Pueblo de San Ildefonso land at levels up to 67 pCi/L, somewhat above the highest level expected in rain water. The dose from ingesting this water for an entire year (730 L) would also be much less than 0.1 mrem/yr.

Surface water samples were obtained in 2009 from three locations along the Rio Grande. Radionuclide analysis of these samples indicated the presence of radium-226, radium-228, thorium-228, thorium-230, thorium-232, tritium, uranium-234, uranium-235/236, and uranium-238. The highest concentrations of radium-226, the thorium isotopes, and tritium were measured in samples taken from a location above LANL at Otowi Bridge, indicating non-LANL and naturally-occurring sources for these radionuclides. The maximum uranium isotope concentrations measured downriver from Otowi Bridge were between 1% and 13% of the maximum concentrations measured upriver, thus indicating minimal contribution from LANL operations. In no case did any concentration exceed the 0.1 mrem/yr screening levels specified in LANL (2003), which would trigger a dose assessment.

In conclusion, these water ingestion doses are very small relative to the 4-mrem/yr EPA community drinking water dose limit.



iv. Soil (Direct Exposure Pathway)

We report measurements of radionuclide concentrations in surface soil in Chapter 7. As described in Chapter 7, Section C.1, soil samples are collected on the perimeter of the Laboratory and at regional and on-site locations on a triennial basis (every three years). Routine soil samples were previously collected in 2006 and were collected again in 2009. No regional samples have had radionuclide concentrations detected above the regional statistical reference levels (RSRLs). RSRLs represent background radionuclide concentrations plus three standard deviations in media, such as soil, sediment, and crops, collected or harvested in regional areas far from the influence of the Laboratory averaged over a period of five years.

However, radionuclide concentrations measured in soil samples from 2009 were above the RSRL at some perimeter and LANL locations. For example, plutonium-239/240 was above the RSRL at perimeter locations near TA-8 (GT Site) and the east and west sides of the Los Alamos County airport. Tritium was above the RSRL at the Tsankawi/PM-1 perimeter location. Several on site LANL locations had transuranic and uranium soil concentrations in samples above the RSRL, including locations at TA-21's DP Site and TA-54. Screening of the perimeter soil concentrations indicate that annual doses from the soil exposure pathway would result in less than 0.1 mrem/yr to a member of the public residing in these areas.

Only six sample results, from locations on site in and around TA-54 and the Dual Axis Radiographic Hydrodynamic Test (DARHT) facility, exceeded the 0.1 mrem/yr screening criteria: two for transuranic radionuclides, one for tritium, and three for uranium-238. However, because these locations are not accessible to the public, no public dose impact through the soil exposure pathway would result.

In addition, soil samples were collected along the north side of East Jemez Road and analyzed for transuranic radionuclides and cesium-137 for a special monitoring study in order to eventually determine airborne emissions from historical operations at TA-1 and TA-21, DP West. These sampling locations are all on site, but some are accessible to the public. Most of the plutonium-239/240 results were above the RSRL, but all were below the 0.1 mrem/yr screening criteria.

A study was also performed where soil samples were collected from alfalfa fields irrigated with Rio Grande river water upstream and downstream of LANL. None of the analysis results exceeded the RSRL values, and none of these results exceeded the 0.1 mrem/yr screening values.

In summary, we conclude that the LANL contribution to the dose from soil around the perimeter of the Laboratory and off site is less than 0.1 mrem/yr, and the majority of the anthropogenic radionuclides detected are primarily due to worldwide fallout and historical operations at the Laboratory.

v. Food (Ingestion Pathway)

We report measurements of the radioactive content of food, mostly crops, fish, and native vegetation, in Chapter 8. The food is collected on a triennial basis, rotating with the collection of soils. This year, we focused our analysis on of road-killed deer from Pueblo de San Ildefonso and LANL, alfalfa forage irrigated from Rio Grande river water upstream and downstream of LANL, and crawfish sampled from the Rio Grande water upstream and downstream of LANL. While humans do not directly consume alfalfa forage, it does represent a means of transferring potential contaminants from irrigation water, soil, and the air to cattle and then on to humans, so it will be considered a foodstuff for purposes of this analysis.

None of the deer muscle and bone radionuclide concentrations exceeded the 0.1 mrem/yr screening levels. Consumption of these deer would, therefore, not result in a dose to the public above 0.1 mrem/year. The uranium-234 and uranium-238 concentrations in alfalfa forage at certain locations did exceed the 0.1 mrem/yr screening level. However, these concentrations were all well below the RSRL value and the ratios of uranium-234 to uranium-238 at these locations were indicative of naturally occurring uranium in river water being used for irrigation purposes. None of the crawfish from either the upstream or downstream reaches had radionuclide concentrations that exceeded the 0.1 mrem/yr screening levels. Therefore, consumption of crawfish either

upstream or downstream of LANL at an assumed ingestion rate of 10 pounds per year would result in less than 0.1 mrem/yr to a member of the public.

In conclusion, the food ingestion doses are very small relative to the all-pathways dose limit of 100 mrem/yr and the 25-mrem/yr dose constraint.

vi. Release of Items and Real Property

The Laboratory releases miscellaneous surplus items of salvageable office and scientific equipment to the general public, following Laboratory requirements for release of such items (LANL 2009). All items destined for release from known or potentially contaminated areas are screened for radioactive contamination in accordance with the procedures of LANL's Health Physics Operations Group. Any items with surface contamination or dose levels above the authorized release limits for uncontrolled use are not released to the public. Items from a known or potentially contaminated area that cannot be completely surveyed are also not released. The authorized release limits for items (LANL 2009) are the limits in Figure IV-1 of DOE requirements (DOE 1993, DOE 1995). In 2009, no items were released to the public with contamination or dose levels approaching the authorized release limits. Therefore, the dose to the public from this pathway is negligible.

The transfer of real property (land) from DOE to the public is allowed if the modeled dose is no greater than the authorized release limit of 15 mrem/yr and the modeled dose is ALARA. Several environmental ALARA analyses were performed in 2009, specifically for the future conveyance and transfer of land tracts A-13 (old DOE Los Alamos Area office location), B-3 (TA-74-4), C-1 (portion of State Route 4 in White Rock), C-2 (White Rock "Y" interchange), C-3 (portion of State Route 502 west of interchange), and C-4 (portion of State Route 4 south of interchange and north of White Rock). All calculated doses were found to be below the authorized release limit of 15 mrem/year. However, the calculated dose for land tract C-2 was above the 3 mrem/year quantitative ALARA analysis threshold. Therefore, a quantitative analysis was performed for land tract C-2. The analysis indicated that the cost of further remediation for this land tract far exceeded the benefit, and, therefore, no further remediation action was recommended.

3. Dose Calculations and Results

a. Collective dose to the population within 80 Kilometers

We used the local population distribution to calculate the dose from 2009 Laboratory operations to the population within 80 km (50 miles) of LANL. Approximately 280,000 persons live within an 80-km radius of the Laboratory. We used New Mexico county population estimates provided by the University of New Mexico Bureau of Business and Economic Research (available at http://www.unm.edu/~bber/).

The collective dose from Laboratory operations is the sum of the estimated doses for each member of the public within an 80-km radius of LANL. For example, if two persons each receive 3 mrem, the collective dose is 6 person-mrem. This collective dose results from airborne radioactive emissions. Other potential sources, such as direct radiation, are essentially zero. We calculated the collective dose by modeling the transport of radioactive air emissions using CAP88.

The 2009 collective population dose that may be attributable to Laboratory operations to persons living within 80 km of the Laboratory is 0.57 person-rem, which is less than the collective dose of 0.79 person-rem reported for 2008. Tritium contributed 9% of the dose, and short-lived air activation products such as carbon-11 from LANSCE contributed 88% of the dose. The decrease in the 2009 collective population dose compared with 2005 (2.46 person-rem) is primarily attributable to the repair of a leak at LANSCE in December 2005 and to an additional delay line installed at LANSCE in 2005. LANSCE has historically been the major contributor to the collective population dose. Collective population doses for the past 16 years have generally declined from a high of 4 person-rem in 1994 to less than 1 person-rem in 2009 (Figure 3-1). It is expected that future collective population doses will be less than 1 person-rem. No observable health effects in the local population are expected from this dose.

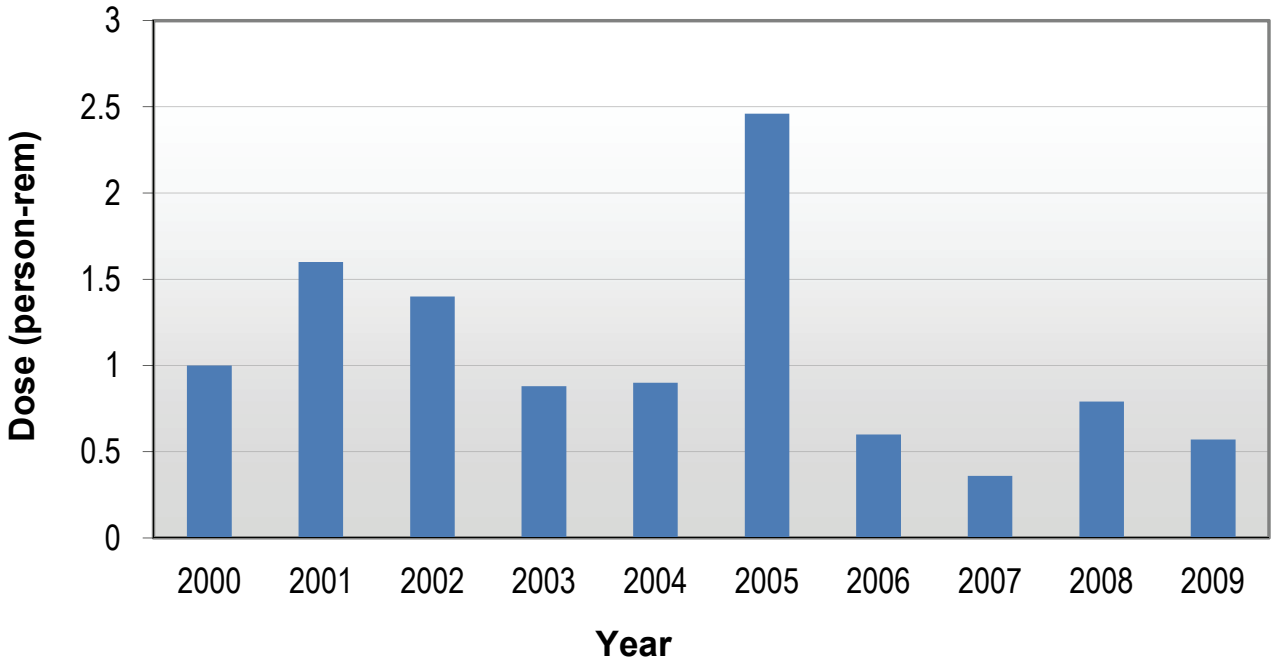


Figure 3-1. Annual collective dose (person-rem) to the population within 80 km of LANL over the past 10 years.

b. Dose to the Maximally Exposed Individual

The MEI is a hypothetical member of the public who, while not on DOE/LANL property, receives the greatest dose from LANL operations. For most of the past 15 years, the airborne pathway (RAD-NESHAP) MEI location has been at 2470 East Road, usually referred to as "East Gate." East Gate has normally been the location of greatest exposure because of its proximity to LANSCE and the prevailing wind direction. During LANSCE operations, short-lived positron emitters, such as carbon-11, nitrogen-13, and oxygen-15, are released from the stacks and diffuse from the buildings. These emitters release photon radiation as they decay, producing a potential radiation dose.

i. Airborne Pathway (RAD-NESHAP) MEI Dose

Because the LANSCE emissions after 2005 have been reduced to such low levels, the location of the MEI for 2009 was not as readily apparent as in the past and required more detailed evaluation, as follows.

We modeled the dose at East Gate from LANSCE and from the other LANL stacks using CAP88. The CAP88-modeled individual doses (Fuehne 2010) were 0.267 mrem/yr from LANSCE and 0.249 mrem/yr from other LANL stacks. We added 0.039 mrem/yr calculated from the airborne radionuclide concentrations measured at the East Gate AIRNET station, though this dose includes tritium, which was also in the CAP88 modeled doses (thus, tritium dose is conservatively included twice). Therefore, the total dose at East Gate was approximately 0.55 mrem/yr (Figure 3-2).

To ensure the East Gate location is the location with the highest potential dose (the actual MEI), we estimated the potential dose at two other locations that had relatively high AIRNET doses: station 32 at the Los Alamos County Landfill office and station 66 near the former Los Alamos Inn on Trinity Drive. Though the dose from LANSCE emissions is a significant contributor at the East Gate location, it is much less so at the other possible MEI locations. For each location, we determined the LANSCE facility (stack 53000702) annual gaseous mixed activation products (GMAP) emissions dose contribution and added the dose contribution from the AIRNET-measured radionuclides. The sums of these contributions at stations 32 and 66 were lower than the corresponding sum at East Gate. Therefore, the East Gate site was determined to be the MEI. See Section III of Fuehne (2010) for the details of how the MEI calculations were performed.

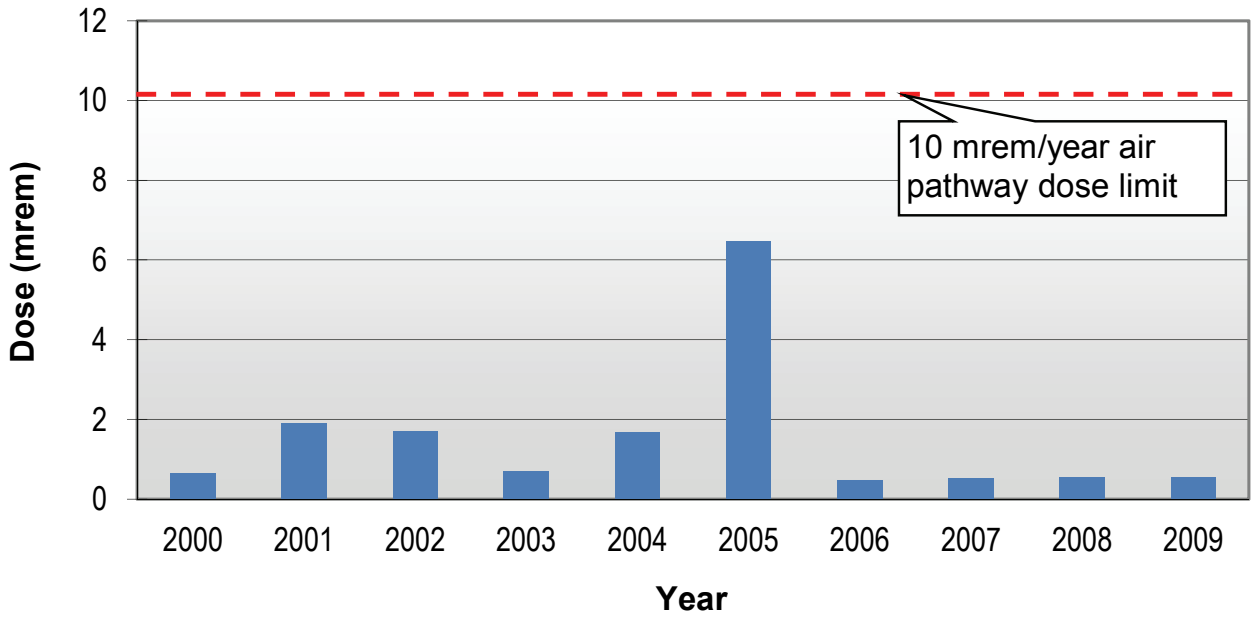


Figure 3-2. Annual airborne pathway (RAD-NESHAP) dose (mrem) to the MEI over the past 10 years.

ii. All-Pathways MEI Dose

The location evaluated in 2009 as the potential all-pathways MEI is the Laboratory boundary near the Pueblo de San Ildefonso sacred area north of TA-54, Area G. Transuranic waste at Area G awaiting shipment to the Waste Isolation Pilot Plant (WIPP) emits neutrons. The measured neutron dose at the boundary was 17 mrem/yr. After subtracting a 2-mrem/yr neutron background dose and applying the standard occupancy factor of 1/16 (NCRP 1976), the individual neutron dose is 15 mrem/16 = 0.9 mrem/yr. The gamma dose is calculated to be less than 0.01 mrem and is not included because it cannot be distinguished from the much larger gamma background measured at this and other nearby monitoring locations. To estimate the contributions from airborne radionuclides at this location, we used CAP88 to model the dose contribution from the LANL stacks as 0.02 mrem/16 = 0.001 mrem/yr. We added the dose derived from measurements at the highest-dose AIRNET station along the northern boundary of Area G (0.36 mrem/yr) close to where the neutron dose was measured and applied the occupancy factor of 1/16 to obtain a dose of 0.02 mrem/yr. This resulted in a total dose at this location of approximately 1 mrem/yr, which is greater than the airborne pathway MEI dose at East Gate.

iii. Dose Summary

The airborne pathway MEI dose of 0.55 mrem/yr at East Gate is below the 10 mrem/yr EPA airborne emissions dose limit for the public (EPA 1986), and, based on previous studies, we conclude it causes no observable health effects (BEIR 2006). The all-pathways MEI dose of 1 mrem/yr at the Laboratory boundary of the Pueblo de San Ildefonso sacred area north of Area G is below the 100 mrem/yr DOE limit for all pathways and the 25 mrem/yr dose constraint (DOE 1993, DOE 1999), and, again, we conclude it causes no observable health effects.

In most past years, LANSCE has been the major contributor to the MEI airborne pathway dose. Future operations of the facility and associated emissions are expected to stay consistent with 2009 levels. The 2009 and 2008 MEIs were located at East Gate and were primarily due to short-lived air activation emissions from LANSCE. The 2007 airborne pathway MEI was located on DP Road and was primarily due to the re-suspension of plutonium-239 in soil from Material Disposal Area (MDA) B. With increased remediation activities at MDA B and TA-21 DP West and East during 2010 and into the future, it is possible that the airborne pathway MEI may once again be located on DP Road in 2010 and in future years until completion of these projects.

c. Doses in Los Alamos and White Rock

We used background-corrected AIRNET data (reported in Chapter 4, Section A) and the factors in EPA guidance (EPA 1986) to calculate an annual dose at each of the two perimeter AIRNET stations that represent the Los Alamos resident and the White Rock resident. To these doses, we added the contributions from LANSCE and other stack emissions, calculated using CAP88 for two representative locations: 5 km northwest of LANSCE in Los Alamos and 6.8 km southeast of LANSCE in White Rock.

i. Los Alamos

During 2009, the Laboratory contributions to the dose at an average Los Alamos residence were 0.002 mrem/yr from tritium, 0.005 mrem/yr from transuranic radionuclides, 0.019 mrem/yr from uranium, and 0.008 mrem/yr from LANSCE. Other radionuclides contributed about 0.001 mrem/yr. This results in a total dose to an average Los Alamos resident of approximately 0.035 mrem/yr.

ii. White Rock

During 2009, the Laboratory contributions to the dose at an average White Rock residence were 0.008 mrem/yr from tritium, 0.001 mrem/yr from transuranic radionuclides, 0.008 mrem/yr from uranium, and 0.008 mrem/yr from LANSCE. Other radionuclides contributed less than 0.001 mrem/yr. This results in a total dose to an average White Rock resident of approximately 0.025 mrem/yr.

iii. Dose Summary

The contributions from direct radiation, food, water, and soil are discussed in Section B.2, above, in this chapter; each contribution is considered to be essentially a zero dose (i.e., <0.1 mrem/yr). In summary, the total annual dose in 2009 to an average White Rock/Los Alamos resident from all pathways was about 0.025 to 0.035 mrem and is well below the all-pathways dose limit of 100 mrem/yr and the 25 mrem/yr dose constraint. No observable health effects are expected from this dose.

4. Estimation of Radiation Dose Equivalents for Naturally Occurring Radiation

In this section, we discuss the potential LANL dose contribution relative to natural radiation and radioactive materials in the environment (NCRP 1975, 1987a, 1987b).

External radiation comes from two sources that are approximately equal: cosmic radiation from space and terrestrial gamma radiation from naturally occurring radionuclides. Doses due to cosmic radiation range from 50 mrem/yr at lower elevations near the Rio Grande to about 90 mrem/yr in the higher elevations west of Los Alamos (Bouville and Lowder 1988). In addition, background doses from terrestrial radiation range from about 50 to 150 mrem/yr.

The largest dose from radioactive material is from the inhalation of naturally occurring radon and its decay products. Nationwide, the average dose from radon is about 200 to 300 mrem/yr (NCRP 1987b.) In Los Alamos County, the average residential radon concentration results in a dose of 270 mrem/yr and is within the range of the national average (personal communication, J.J. Whicker 2010). An additional 40 mrem/yr results from naturally occurring radioactive materials in the body, primarily potassium-40, which is present in all food and living cells.

In addition, members of the US population receive an average dose of 300 mrem/yr from medical and dental uses of radiation. Compared to estimates used in previous years, this is a significant increase and is attributable to new information about the average medical dose received by members of the US population (NCRP 2009). About 10 mrem/yr comes from man-made products, such as stone or adobe walls, and less than 1 mrem/yr comes from global fallout from nuclear weapons tests. Therefore, the average total annual dose from sources other than LANL is approximately 700 mrem. Figure 3-3 compares the natural radiation background (and other sources) in Los Alamos to the average background dose in the United States. The estimated LANL-attributable 2009 all-pathways MEI dose, 1 mrem/yr, is about 0.1% of the average US dose.

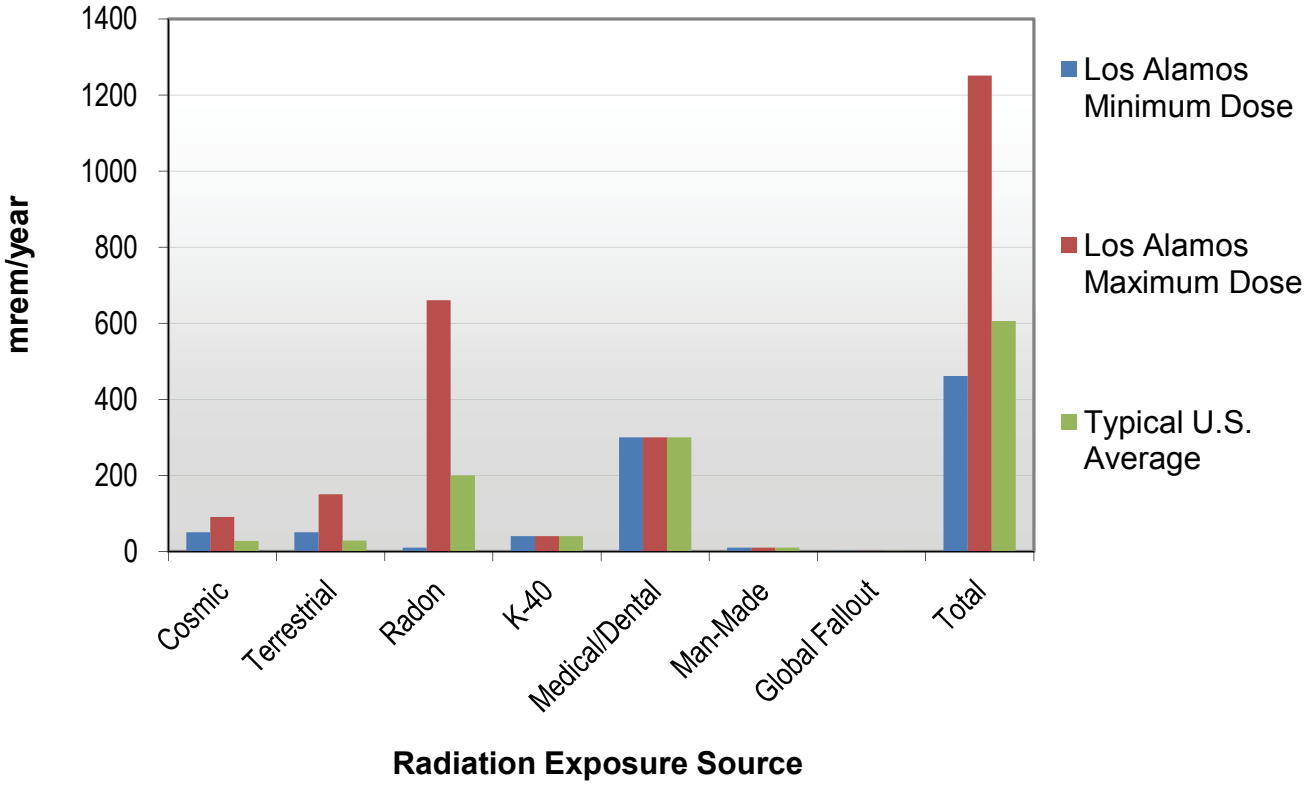


Figure 3-3. **Los Alamos County radiation background compared with average US background. Los Alamos County-specific background doses have not been determined for radon, potassium-40, medical/dental exposures, man-made radiation, and global fallout and are assumed to be the same as the US average in this figure.**

5. Effect to an Individual from Laboratory Operations

Health effects from radiation exposure have been observed in humans at doses in excess of 10 rem (10,000 mrem), and as low as 1 rem (1,000 mrem) for the in utero fetus (BEIR 2006). However, doses to the public from LANL operations are much smaller (Table 3-1). Therefore, the doses presented in this chapter are not expected to cause observable health effects. .

Table 3-1
LANL Radiological Dose for Calendar Year 2008

Pathway	Dose to Maximally Exposed Individual mrem/yr	% of DOE 100 mrem/yr Limit	Estimated Population Dose person-rem	Population within 80 km	Estimated Background Radiation Population Dose person-rem
Air	0.55[a]	0.55%	0.57	NA[b]	NA
Water	<0.1	<0.1%	0	NA	NA
Other Pathways (foodstuffs, soils, etc.)	<0.1	<0.1%	0	NA	NA
All Pathways	1[c]	1%	0.57	~280,000	~220,000[d]

[a] RAD-NESHAP MEI dose measured at 2470 East Road (East Gate).

[b] NA = Not applicable. Pathway-specific populations are not specified, and pathway-specific background doses have not been determined, as allowed by DOE guidance.

[c] All-pathways MEI dose at the boundary of the Pueblo de San Ildefonso sacred area north of Area G.

[d] Based on 270 mrem/yr from inhalation of radon and its decay products, 70 mrem/yr from cosmic radiation, 100 mrem/yr from terrestrial radiation, 40 mrem/yr from potassium-40, 300 mrem/yr from medical and dental uses of radiation, and 10 mrem/yr from man-made products (see Section B.4).

C. BIOTA DOSE ASSESSMENT

1. Biota Dose Assessment Approach

a. Overview

The biota dose assessment methods are described in detail in the DOE Standard 1153-2002 (DOE 2002) and in the computer program RESRAD-BIOTA (http://web.ead.anl.gov/resrad/home2/biota.cfm). Because the calculations apply to all types of biota and all types of ecosystems, the DOE methods are general in nature and allow specific parameters to be adjusted according to local conditions. The site-specific methods used at LANL are specified in the quality assurance project plan for Biota Dose Assessment (available at http://www.lanl.gov/environment/air/qa.shtml?2), and McNaughton 2005 describes in detail the application of these methods to specific locations at LANL.

We calculate the dose to selected plants and animals following the guidance of DOE Standard 1153-2002 (DOE 2002) and LANL (LANL 2004). Trees of the pine family (Pinaceae) are representative of terrestrial plants because they are radiosensitive (UNSCEAR 1996) and because their deep roots might tap into buried contamination (Foxx et al. 1984a, b; Tierney and Foxx 1987). Deer mice are representative of terrestrial animals because of their relatively small home range, which means the maximally exposed mouse might spend a large fraction of its time in the most contaminated location. These representative plants and animals are common and widespread within LANL and the surrounding area. Other plants and animals (including aquatic plants and animals) may be collected and analyzed to estimate biota dose depending on availability and locations of interest.

b. Biota Dose Limits

The biota dose limits (DOE 2002) are applied to representative biota populations rather than to the MEIs because it is DOE's goal to protect populations, especially with respect to preventing the impairment of reproductive capability within the population.

The DOE dose limits to biota populations are

- Terrestrial animals: 0.1 rad/day (100 mrad/day)
- Terrestrial plants: 1 rad/day (1,000 mrad/day)
- Aquatic animals: 1 rad/day (1,000 mrad/day)

c. Methods

To ensure that the assessment is comprehensive, we began with a level 1 initial screening (DOE 2002) comparing the maximum radionuclide concentrations in soil, sediment, and surface water with the DOE Biota Concentration Guides (BCGs). The DOE Standard (DOE 2002) states, "An important point is that exceeding the BCGs should not force a mandatory decision regarding remediation of the evaluation area, but rather is an indication that further investigation is likely necessary." If the BCGs are exceeded, a level 2 site-specific assessment (DOE 2002) is conducted that uses average concentrations and incorporates site-specific bioaccumulation factors. Following the guidance of the DOE Standard (DOE 2002), we did not include external-radiation dose from experimental facilities such as the DARHT facility and LANSCE.

2. Biota Dose Results

As reported in Chapters 5 through 8, we collected water, soil, sediment, vegetation, bees, and small mammals in 2009 from several locations. All radionuclide concentrations in vegetation sampled were far below the plant 0.1 rad/day biota dose screening level (10% of the 1 rad/day dose limit), and all radionuclide concentrations in terrestrial animals sampled were far below the terrestrial animal 0.01 rad/day biota dose screening level (10% of the 0.1 rad/day dose limit). As previously mentioned in the soil pathway section of this chapter (see Section B.2.b.iv.), certain perimeter and on-site sample locations had soil radionuclide concentrations above background. However, none of these concentrations exceeded the limiting terrestrial animal BCG screening levels.

As reported in Chapter 6, there were several locations where surface water concentrations were above the BCG screening levels. Twenty percent of surface water samples collected from the Pajarito Plateau in 2009 contained radium at concentrations that were above the DOE BCG for aquatic systems. Radium is a naturally occurring radionuclide and was found in all major watersheds and from releases upstream of LANL. The concentrations that exceed

the BCG are for storm water containing sediment and not from aquatic habitats, so we used the maximum concentrations detected for this location in terrestrial biota dose assessments. The worst-case dose rates were 6×10^{-4} rad/day for terrestrial animals and 5×10^{-6} rad/day for plants and thus are less than the terrestrial biota dose limits.

D. NONRADIOLOGICAL RISK ASSESSMENT

1. Overview

Dose to members of the public and the environment from LANL radiological hazards is well understood and extensively documented. We place equal emphasis on the risk to members of the public and the environment from non-radiological hazards present at LANL, such as heavy metals and organic compounds.

This section assesses the potential human health risk from non-radiological materials released from LANL either during 2009 or during the previous 65 years of operations at LANL. The Clean Air Act regulates non-radiological air pollutants, as discussed in Chapter 2, Section 6. The applicable standards for other media are summarized in Table 5-1, Table 6-1, Table 8-1, and Appendix A. Air emissions data are reported in Chapter 2, ambient air data are reported in Chapter 4, and the data for other environmental media are reported in Chapters 5 through 8. The resulting potential public health risks are summarized below.

2. Results

a. General Considerations

Off-site concentrations of non-radiological contaminants in air, water, soil, and food described elsewhere in this report are well below the applicable standards or risk-based concentrations (EPA 2007, NMED 2006). The results from LANL monitoring and their potential human health impacts are summarized below.

i. Air (Inhalation Pathway)

Assessments of ambient air quality of non-radiological constituents, as reported in Chapter 4 Section D, indicate that LANL operations are not adversely impacting public health. The assessment of the ambient air impacts of high explosives testing, reported in Chapter 4, Section D.4, indicates no adverse impacts to the public. The beryllium concentrations reported in Chapter 4, Section D.5 are less than 1% of the NESHAP recommended concentration of 10 ng/m^3, and the PM-10 and PM-2.5 concentrations are lower than EPA limits (Chapter 4, Section D.3).

ii. Groundwater (Ingestion)

Groundwater results are reported in Chapter 5. The only Laboratory impact on a potential drinking water supply is at well Otowi-1 in Pueblo Canyon. For 2009, groundwater samples from this well had perchlorate concentrations ranging from 1.3 to 2.3 µg/L and were consistent with the 2008 concentrations. However, Los Alamos County does not use this well for its drinking water supply, and these values are below the EPA interim health advisory of 15 µg/L for drinking water. These perchlorate levels, therefore, do not present a potential risk to human health.

Basalt Spring, on Pueblo de San Ildefonso land in lower Los Alamos Canyon, had nitrate results in 2009 ranging from 2.8 mg/L to 4.7 mg/L, slightly lower than 2008 results which approached the NMED groundwater standard of 10 mg/L. The elevated level of nitrate in the spring water is most likely due to past and present releases of treated effluent from the Los Alamos County sanitary treatment plant. This spring is not a recognized drinking water source and because of minimal water ingestion expected from this source, i.e., less than 730 liters per year, and levels of nitrate around one-half of the standard, no deleterious health effects would be expected from these levels. Pine Rock Spring, also on Pueblo de San Ildefonso land, also had nitrate concentrations just above the NMED standard at 10 mg/L in 2008 and was near the NMED standard at 8.2 mg/L in 2009. Again, these levels should not present a deleterious health effect.

LANL has detected hexavalent chromium in the Mortandad Canyon regional aquifer monitoring well samples at levels above the New Mexico groundwater standard and at about 40% of the standard (50 µg/L of any dissolved form of chromium) in a Sandia Canyon regional aquifer monitoring well. However, hexavalent chromium has not been detected in Los Alamos County and Santa Fe Buckman drinking water supply wells above natural levels, so there is no health risk from ingestion of water from the drinking water supply wells.

iii. Surface Water and Sediment

The concentrations of chemicals in surface water and sediment are reported in Chapter 6. No potentially hazardous chemicals of LANL origin were detected off-site. We conclude there is no current hazard to the public from surface water and sediment exposure due to LANL past and present environmental releases.

Polychlorinated biphenyls (PCBs) are present in the on-site surface water and sediment. However, there are no aquatic organisms within the LANL boundaries that are part of a food ingestion pathway to humans. Measurements of PCBs in sediment using the Aroclor method indicated that none of the results were greater than recreational or residential screening levels.

PCBs are carried in sediment by storm water runoff to the Rio Grande. In 2009, sediment samples from the Rio Grande and the Abiquiu and Cochiti Reservoirs were analyzed for PCBs using the Aroclor method. Results from upstream and downstream sampling locations show that sources for PCBs are primarily from non-LANL sources, and the PCB congener homolog data generally supports this conclusion. Looking at these data together, we conclude that there is no measurable contribution of PCBs from LANL to the Rio Grande and, therefore, no detrimental health impact to humans from PCBs of LANL origin.

iv. Soil

Soil concentrations are reported in Chapter 7. The concentrations are far below their soil screening levels and, therefore, do not pose a potential human health risk.

v. Foodstuffs (Ingestion)

The concentrations of non-radioactive materials in foodstuffs are reported in Chapter 8. Of particular interest are PCB levels in bottom-feeding and predator fish caught in the Rio Grande. Crayfish sampled upriver and downriver of LANL contained low levels of PCBs in concentrations significantly below consumption limits for fish with no significant differences between the upstream and downstream values (Chapter 8, Table S8-3A). Concentrations of target analyte list elements (TALs) in downstream crayfish were higher than upstream crayfish for several TALs (aluminum, barium, beryllium, chromium, magnesium, vanadium, and arsenic), but the edible portions of the crayfish are expected to have low concentrations and negligible contribution to human risk (Chapter 8, Section A.3.d.).

Concentrations of TALs and PCBs in road-killed deer from Pajarito Plateau were measured for the first time and are documented for discussion and future use (Chapter 8, Table S8-5, and Table S8-6). Concentrations of PCBs in the muscle and bone appear to be low though there is no literature data to compare against. Human risk from TALs and PCBs in deer is considered negligible.

vi. Biota Samplings

TALs concentrations were measured in several important indicator species to assess potential impacts of particular LANL operations. Specifically, deer mice, several species of birds, and honey bees were sampled near the DARHT facility (Chapter 8, Section B.4.b.). Results show that the concentrations of TALs were below the RSRL for most elements. Barium concentrations in field mice were higher than the RSRLs, and birds contained concentrations of barium, antimony, and silver greater than the RSRLs, though intake of these elements likely occurred during migration given the low soil concentrations in the area. Concentrations of barium and copper in bees were higher than the background statistical reference level (similar to RSRL), but the concentrations agree with past results. While there are no ecological screening levels for concentrations of TALs in field mice and birds, the concentrations of these elements in the soil near DARHT are below the ecological screening levels.

Additionally, overstory vegetation was sampled for TALs (Table S8-8). All regional TAL concentrations were less than the RSRLs. Perimeter concentrations of TALs were mostly below the RSRLs except for lead at the Sportsman Club in Rendija Canyon (likely due to the public shooting range which is not on or near Laboratory land) and for mercury, which was found in several sites. The concentrations of the mercury were below health standards for consumption.

vii. Potential Future Risks

The possibility of hexavalent chromium and perchlorate from LANL sources entering the drinking-water supply in the future is being evaluated. Our goal is to assess both present and future risk. Models to calculate future risks are being developed.

3. Conclusion

The environmental data collected in 2009 show that there is no potential public health risk from non-radiological materials released from LANL.

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4. Air Surveillance



contributing authors:
David Fuehne, Andrew Green, Scot Johnson, Michael McNaughton, Terrance Morgan, Doug Stavert

To Read About **Turn to Page**

Ambient Air Sampling 95
Stack Sampling for Radionuclides 109
Gamma and Neutron Radiation Monitoring Program 115
Nonradiological Ambient Air Monitoring 116
Meteorological Monitoring 118
Quality Assurance Program 123
References 127

A. AMBIENT AIR SAMPLING

1. Introduction

The radiological air sampling network, AIRNET, measures environmental levels of airborne radionuclides, such as plutonium, americium, uranium, tritium, and some activation products. Most regional airborne radioactivity is from fallout (from past nuclear weapons tests worldwide), natural radioactive constituents in particulate matter, terrestrial radon and its decay products, and cosmic radiation products. Table 4-1 summarizes regional levels of airborne radioactivity for the past five years.

Table 4-1
Average Background Concentrations of Radioactivity in the Regional[a] Atmosphere

			Annual Averages[c]				
Analyte	Units	EPA Concentration Limit[b]	2005	2006	2007	2008	2009
Alpha	fCi/m^3	No limit	0.9	1.0	1.0	0.9	1.0
Beta	fCi/m^3	No limit	16	17	19	17	19
Tritium[d]	pCi/m^3	1,500	0.1	-0.2	0.2	0.8	0.2
Am-241	aCi/m^3	1,900	0.1	0.2	-0.1	-0.3	-0.6
Pu-238	aCi/m^3	2,100	0.1	-0.3	-0.3	0.1	0.4
Pu-239	aCi/m^3	2,000	0.0	0.1	0.6	-0.1	1.0
U-234	aCi/m^3	7,700	12	17	15	18	17
U-235	aCi/m^3	7,100	1.2	0.8	0.8	1.3	0.7
U-238	aCi/m^3	8,300	13	16	15	17	16

[a] Regional air sampling stations operated by LANL (locations can vary by year).
[b] Each EPA Concentration Limit is from 10 CFR 40 and corresponds to 10 mrem/year.
[c] Alpha and beta values are gross air concentrations. All others are net air concentrations.
[d] Tritium values have been corrected for the tritium lost to bound water in the silica gel.

Particulate matter in the atmosphere is primarily caused by aerosolized soil. Windy, dry days increase soil entrainment; precipitation washes particulate matter out of the air. Meteorological conditions cause large daily and seasonal fluctuations in airborne radioactivity concentrations.

LANL staff compare ambient air concentrations and resulting off-site dose equivalents to the US Environmental Protection Agency (EPA) (EPA 1989) 10-mrem annual dose equivalent concentration limit, and on-site to those for a 100 mrem dose.

2. Air Monitoring Network

During 2009, LANL operated about 60 environmental air stations to sample radionuclides by collecting water vapor and particulate matter. AIRNET sampling locations (Figures 4-1 through 4-4) are categorized as regional, pueblo, perimeter, waste site (Technical Area [TA] –54), decontamination and decommissioning (D&D) at Material Disposal Area B (MDA-B), or other on-site locations.

3. Sampling Procedures, Data Management, and Quality Assurance

The AIRNET quality assurance project plan and implementing procedures provide details about sample collection, sample management, chemical analysis, and data management.

a. Sampling Procedures

A station collects a continuous two-week sample. Particulate matter is collected on 47-millimeter polypropylene filters at airflow rates of about 110 liters per minute. Cartridges containing about 135 grams of desiccant (silica gel) collect water vapor samples with an air flow rate of 0.2 liters per minute. The silica gel is dried in an oven to remove most residual water before use. After use in the field, the silica gel is removed from the cartridge and shipped to the analytical laboratory where the moisture is distilled and then analyzed for tritium.

b. Data Management

In the field, personnel record the sampling data on a palm-held microcomputer, including timer readings, volumetric flow rates at the beginning and end of the sampling period, and comments pertaining to these data. These data are later transferred to a database.

c. Analytical Chemistry

A commercial laboratory analyzes each filter for gross alpha and gross beta activities. These filters are also grouped by region into 'clumps' of four to nine filters and screened for gamma-emitting radionuclides. A quarterly composite for each station is made up of half-filters from six or seven sampling periods. Analysts at the laboratory dissolve these composites, separate them chemically, and analyze them for isotopes of americium, plutonium, and uranium using alpha spectroscopy. The analytical laboratory uses liquid scintillation spectrometry to analyze the distillate from the gel for tritium. All analytical procedures satisfy Title 40 Code of Federal Regulations (CFR) Part 61, Appendix B. The AIRNET quality assurance project plan specifies the target minimum detectable activities for all samples.

d. Laboratory Quality Control Samples

The sampling team and the analytical laboratory maintain a program of blank, spike, duplicate, and replicate analyses. This program provides information on the quality of the data received from the analytical laboratory. These data are reviewed to ensure they meet all quality assurance requirements.



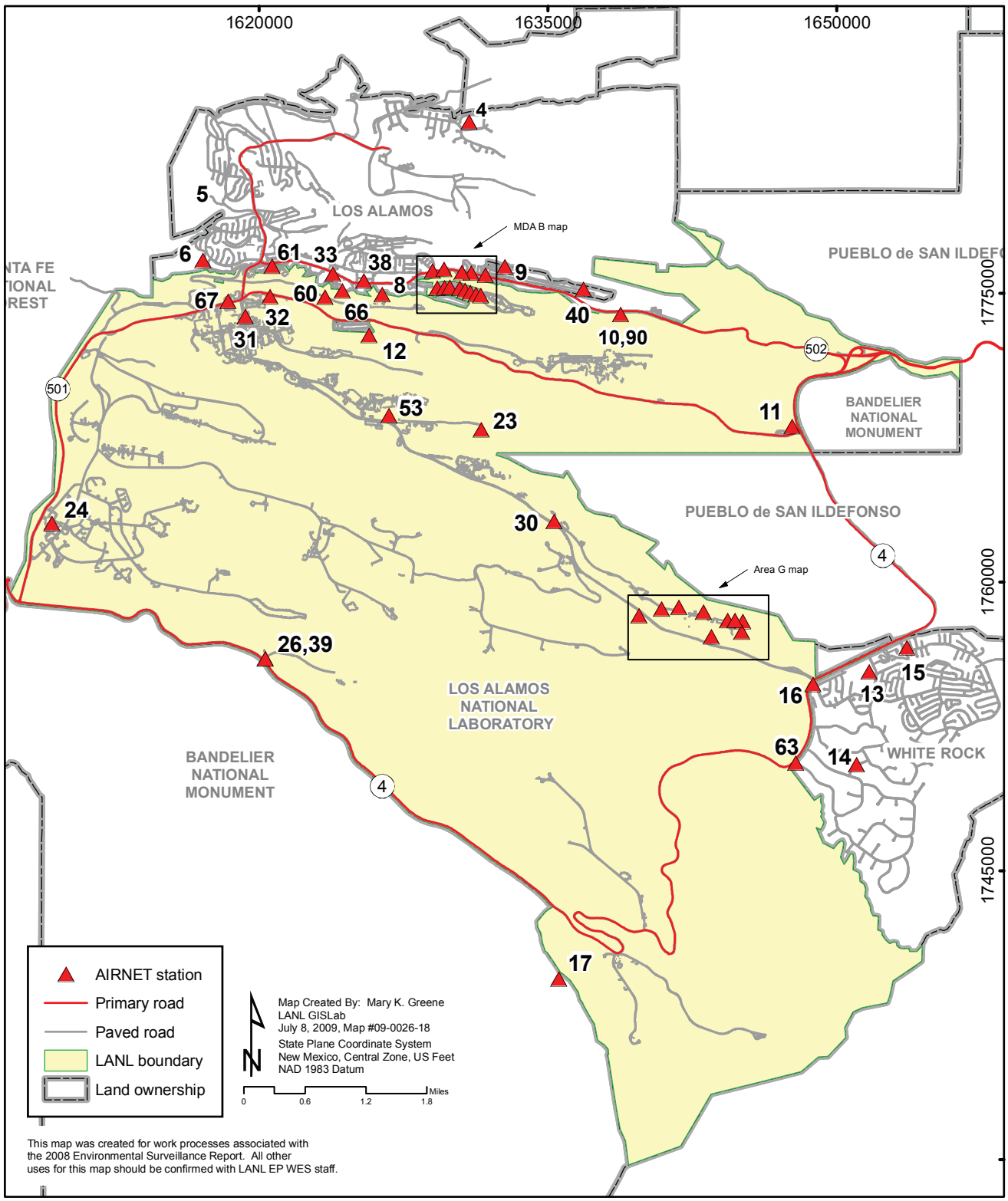


Figure 4-1. AIRNET locations at and near Los Alamos National Laboratory.

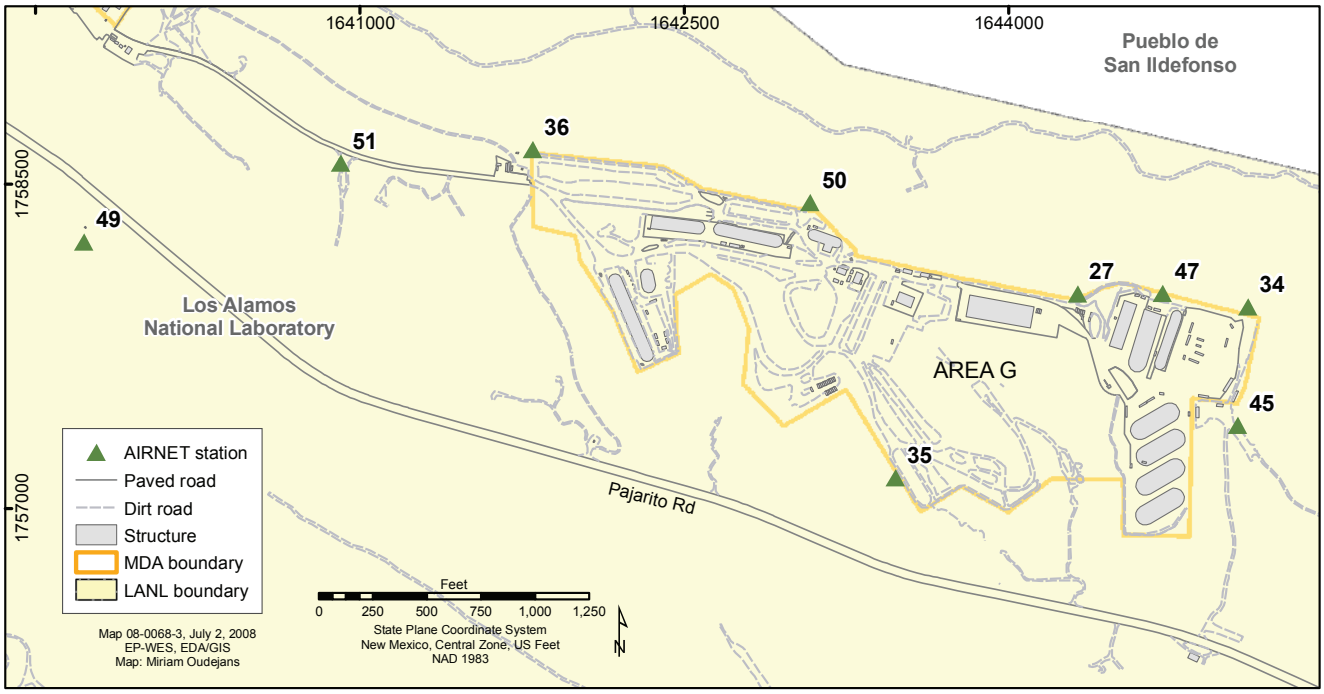


Figure 4-2. AIRNET station locations at Area G, TA-54, Los Alamos National Laboratory.

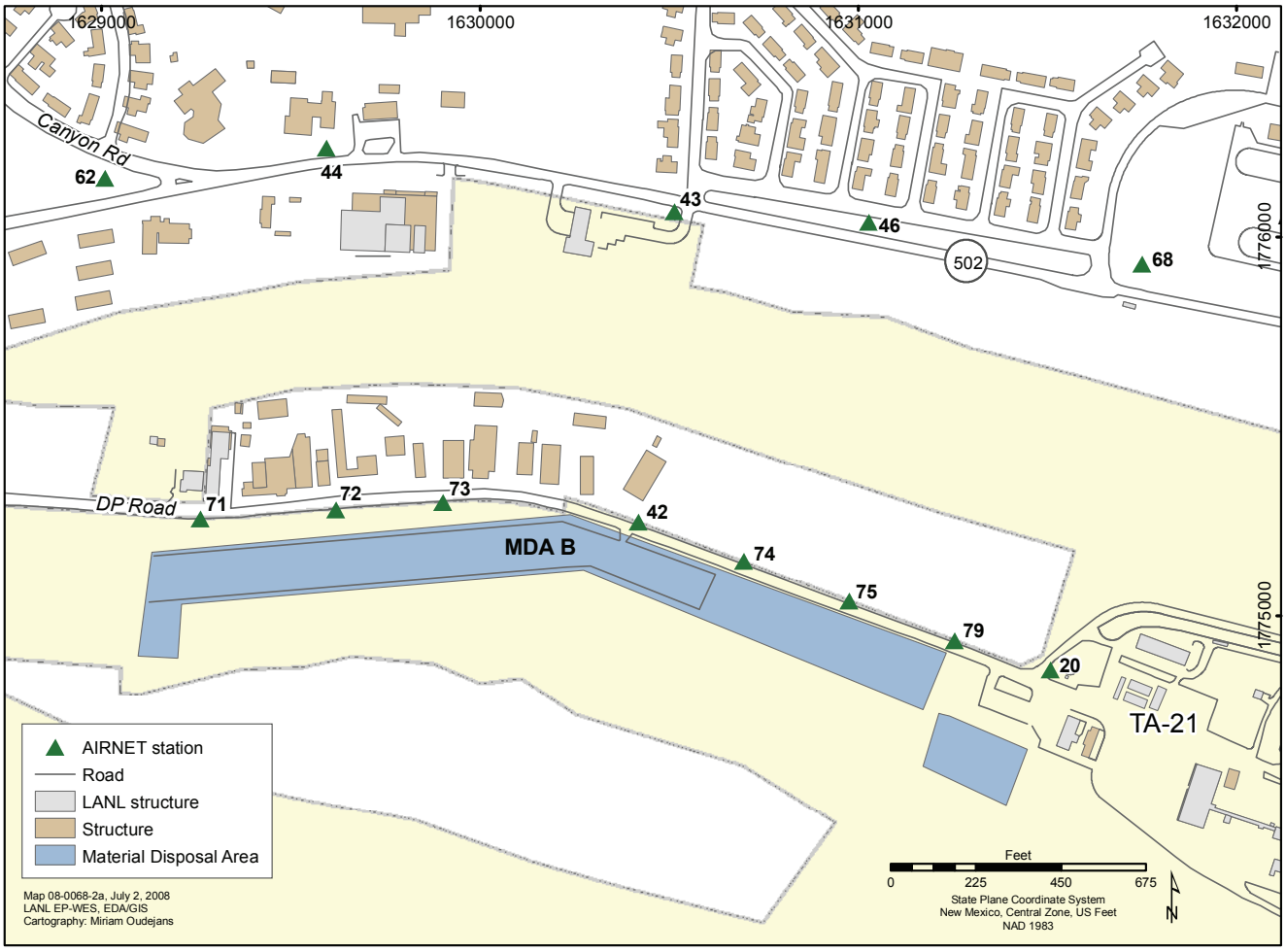


Figure 4-3. AIRNET station locations near TA-21, MDA B.

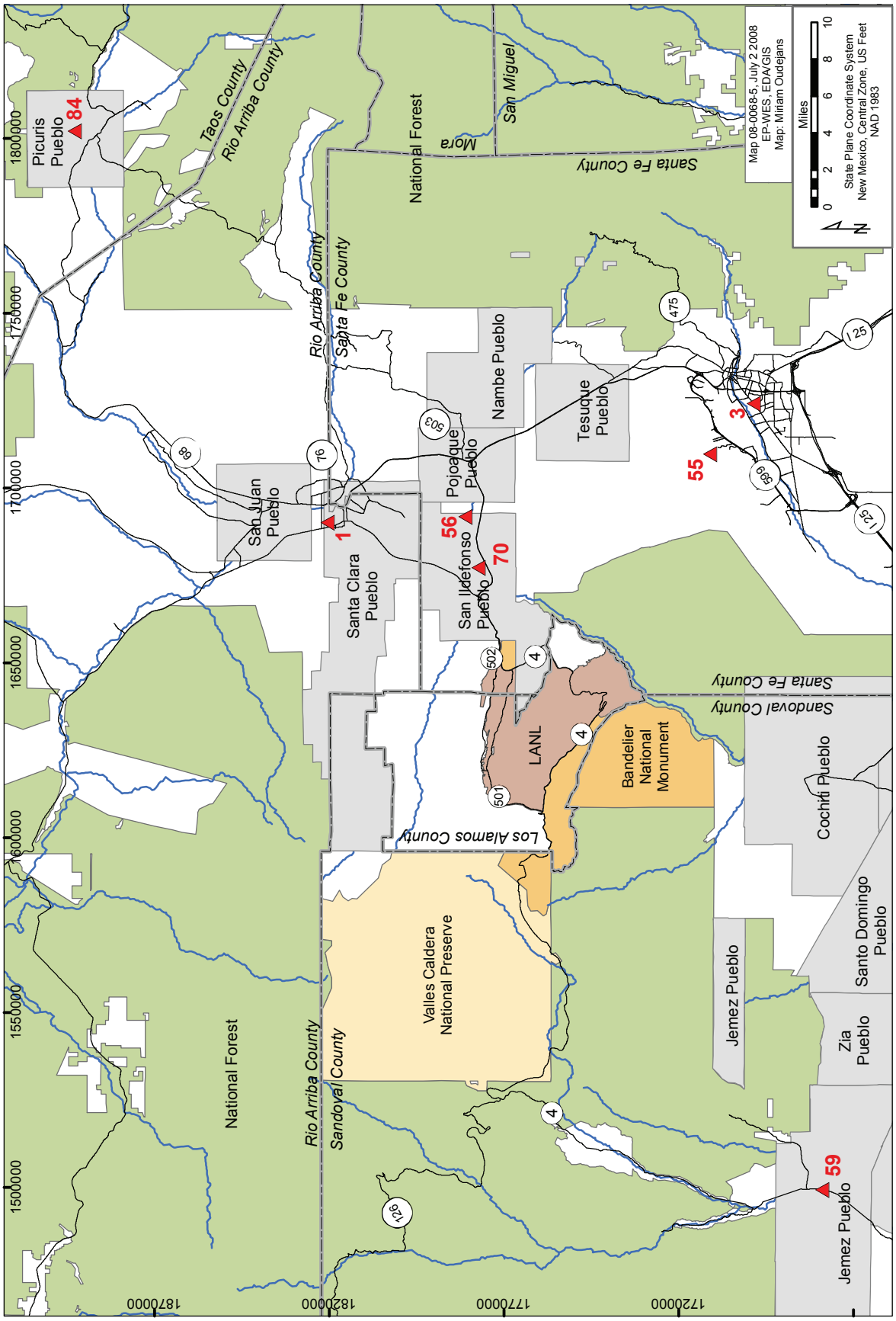


Figure 4-4. Regional and Pueblo AIRNET locations.

4. Ambient Air Concentrations

a. Explanation of Reported Concentrations

Tables 4-2 through 4-10 summarize the measured 2009 ambient air concentrations. The Supplemental data tables (on included compact disc) Tables S4-1 through S4-9 provide data from individual sites. AIRNET concentrations do not have any background subtraction, but do include blank corrections for radioactivity in the filter material, acids used to dissolve the filter, and tracers added to determine recovery efficiencies. The net uncertainties include the variation added by correcting for the blank measurements.

Uncertainties for all data in this ambient air sampling section represent a 95% confidence (2s) interval. Since confidence intervals are calculated with data from multiple sites and throughout the year, they include not only random measurements and analytical errors but also seasonal and spatial variations. The 95% confidence intervals are overestimated for the average concentrations and probably represent confidence intervals near 99%. Negative values are included in averages as their omission would bias averages upward.

Concentrations greater than their 3s uncertainties are used to identify samples of interest or detected concentrations. A control limit of 3s is widely used for statistical quality control charts (Duncan 1986, Gilbert 1987) since the rate of false positives or detections is 5% at 2s but only 0.3% at 3s.

Table 4-2
Airborne Long-Lived Gross Alpha Concentrations for 2009 — Group Summaries

Station Grouping	Number of Biweekly Samples	Fraction of Samples > 3s Uncertainty	Mean ± 99.7% Confidence Interval* (fCi/m^3)		Maximum Station Concentration (fCi/m^3)	
					Biweekly	Annual
Regional	104	100%	1.0	±0.1	2.3	1.1
Pueblo	71	100%	1.0	±0.2	3.5	1.1
Perimeter	769	100%	0.9	±0.03	2.8	1.1
Waste Site	208	99.5%	0.8	±0.06	2.2	0.9
Onsite	130	100%	0.7	±0.06	1.8	0.8
D and D	208	99.0%	0.8	±0.06	1.6	0.9

*Confidence intervals are calculated using all calculated sample concentrations from every site within the group.

Table 4-3
Airborne Long-Lived Gross Beta Concentrations for 2009 — Group Summaries

Station Grouping	Number of Biweekly Samples	Fraction of Samples > 3s Uncertainty	Mean ± 99.7% Confidence Interval* (fCi/m^3)		Maximum Station Concentration (fCi/m^3)	
					Biweekly	Annual
Regional	104	100%	19	±2	34	20
Pueblo	71	100%	18	±3	65	22
Perimeter	769	100%	18	±0.5	61	23
Waste Site	208	100%	17	±1	35	18
Onsite	130	100%	17	±1	33	17
D and D	208	100%	17	±1	29	18

*Confidence intervals are calculated using all calculated sample concentrations from every site within the group.

b. Investigation of Elevated Air Concentrations.

We have established two action levels to determine the potential impact of an unplanned release. The "investigation" action level is triggered when an air concentration exceeds a five-year average plus 3s at that location. "Alert" action levels are higher concentrations that are based on allowable EPA and DOE annual doses and require a more thorough and immediate follow-up.

When a measured air concentration exceeds an action level, we verify that the calculations were done correctly and that the sampled air concentrations are representative. If so, we work with operations personnel to assess potential sources and implement possible mitigation plans.

In 2009, no measurements of plutonium, americium, and uranium exceeded alert action levels. Tritium alert levels were not exceeded off-site, but elevated tritium levels were observed at Area G. Approximately 57 measurements were above the investigation levels but none exceeded 1% of the EPA dose limits.

c. Gross Alpha and Gross Beta Radioactivity

We use gross alpha and gross beta analyses for rapid evaluation of general radiological air quality, potential trends, and detection of sampling problems. Elevated gross results may cause additional investigative analyses.

The National Council on Radiation Protection and Measurements (NCRP) estimated the national average concentration of long-lived gross alpha activity in air to be 2 femtocuries per cubic meter (aCi/m^3). Polonium-210 and other naturally occurring radionuclides are the primary sources of alpha activity (NCRP 1975, NCRP 1987). The national average for long-lived gross beta activity in air is 20 aCi/m^3. Lead-210 and bismuth-210, decay products of radon, and other naturally occurring radionuclides are the primary sources of beta activity.

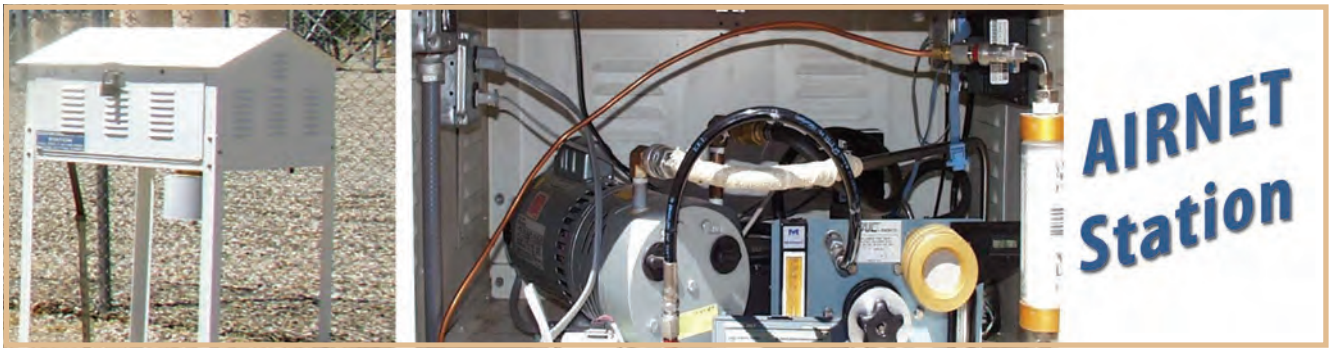
In 2009, we analyzed about 1,500 air samples for gross alpha and gross beta activity. The annual average for alpha at all stations (Table 4-2) is about half of the national average. At least two factors contribute: (1) the use of actual sampled air volumes instead of volumes at standard temperature and pressure and (2) the burial of alpha emitters in the filter that are missed by front-face counting. Gross alpha and beta activity depends on atmospheric pressure, atmospheric mixing, temperature, and soil moisture.

Table 4-3 shows gross beta concentrations at and around LANL. The variability is similar to that in the gross alpha concentrations. The annual average is slightly below the national average. Our gross beta measurements include little to no lead-210 due to its low-energy beta emission. We calculate the gross beta concentrations using actual sampled air volumes.

Figures 4-5 and 4-6 show the variability of gross alpha and gross beta activities. Geographical variability is usually much less than temporal variability and is often larger in winter than summer. In winter radon may be trapped below an inversion layer, resulting in higher count rates.

d. Tritium

Tritium is present in the environment primarily as the result of past nuclear weapons tests and natural production by cosmogenic processes (Eisenbud and Gesell 1997). We measure tritiated water (HTO) because the dose impact is about 25,000 times higher than from gaseous HT or T2 (ICRP 1978). We used water-vapor concentrations in the air and tritium concentrations in the water vapor to calculate ambient levels of tritium, including corrections for blanks, bound water in the silica gel, and isotopic distillation effects.



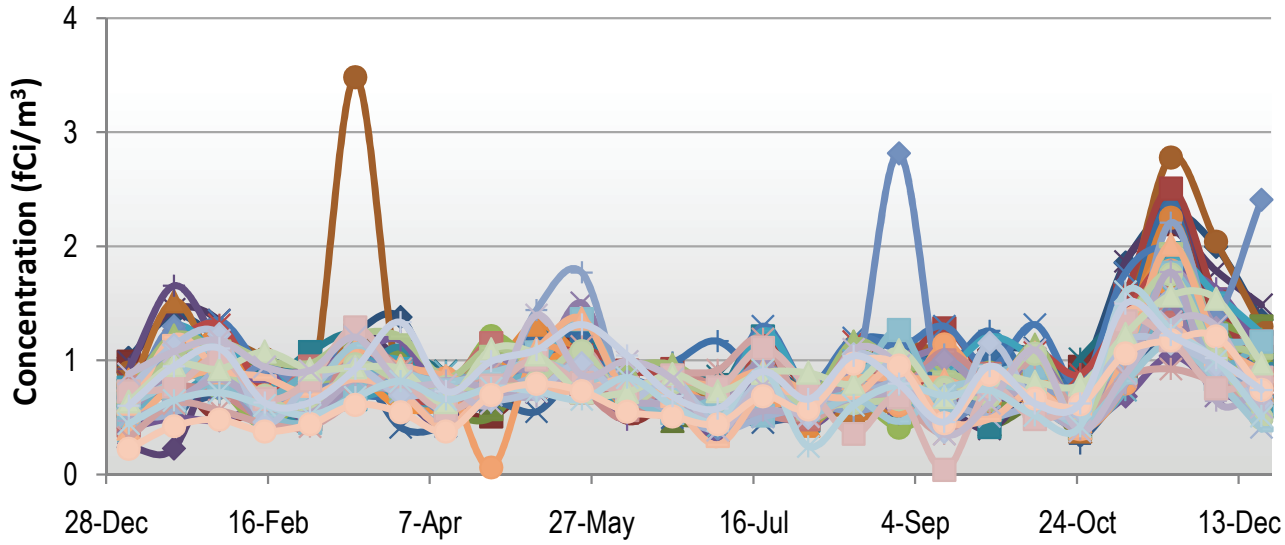


Figure 4-5. Gross alpha measurements for all sampling sites by date collected in 2009.

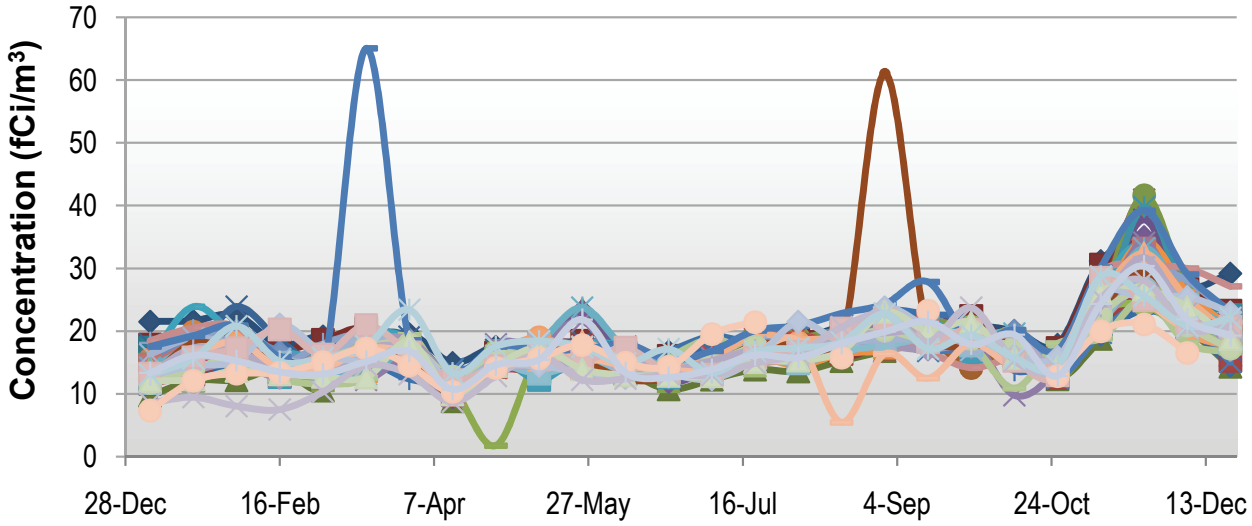


Figure 4-6. Gross beta measurements for all sampling sites by date collected in 2009.

During 2009, all annual mean concentrations were well below EPA and DOE guidelines (Table 4-4). The highest off-site annual tritium concentration is equivalent to about 0.25% of the EPA public dose limit. We measured elevated tritium concentrations at a number of on-site stations, with the highest annual mean concentration near a known source at TA-54 but at less than 3% of the on-site worker exposure limit.

Tritium concentrations reflect current operations and show no distinctive trends (Figure 4-7). In 2006, tritiated waste at Area G raised the annual average. This waste was moved to tritium shafts at Area G and levels decreased.

Table 4-4
Airborne Tritium as Tritiated Water Concentrations for 2009 — Group Summaries

Station Grouping	Number of Biweekly Samples	Fraction of Samples > 3s Uncertainty	Mean ± 99.7% Confidence Interval[a] (pCi/m³)		Maximum Station Concentration (pCi/m³)	
					Biweekly	Annual
Regional[b]	104	1%	0.2	±0.3	6	0.5
Pueblo[b]	72	1%	0.3	±0.6	7	0.3
Perimeter[b]	761	6%	0.6	±0.2	8	4
Waste Site[c]	205	78%	60	±53	2,200	430
On-Site[c]	130	16%	4	±3	67	17
D&D[b]	207	4%	0.7	±0.3	6	2

[a] Confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40, CFR Part 61, Appendix E, concentration limit is 1,500 pCi/m³.
[c] Ten times public limit in b.

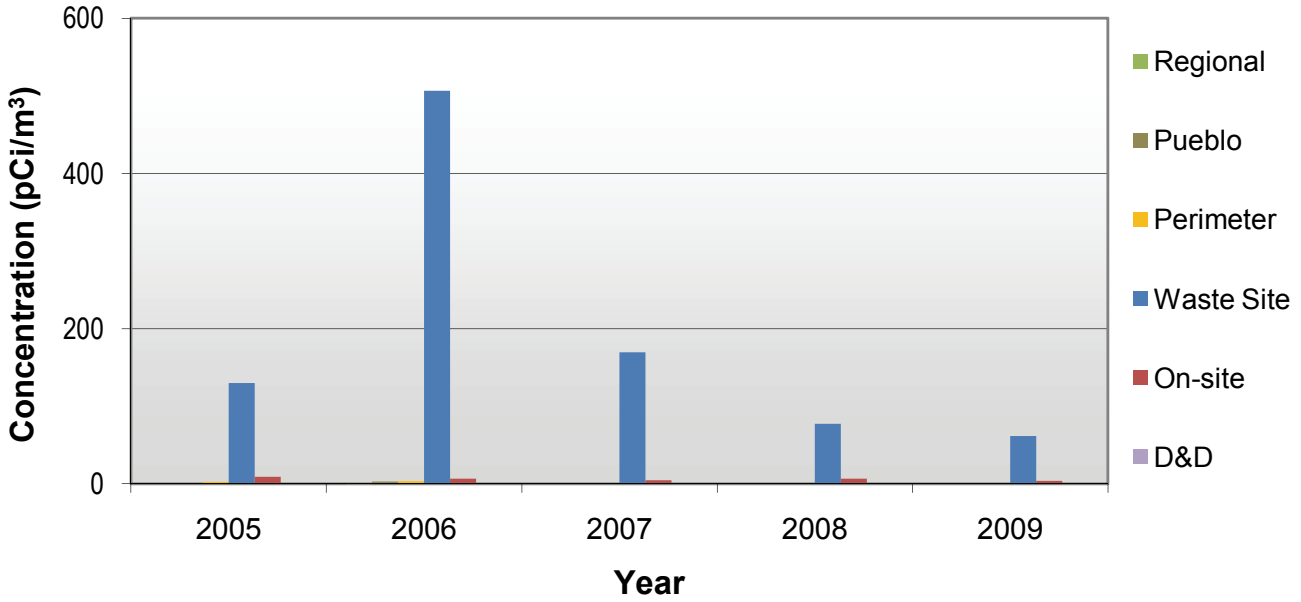


Figure 4-7. Annual average concentrations of tritium by group.

e. Plutonium

While plutonium occurs naturally at extremely low concentrations from cosmic radiation and spontaneous fission (Eisenbud and Gesell 1997), it is not naturally present in measurable quantities in the ambient air. Measurable sources in air are usually plutonium research activities, nuclear weapons production and testing, the nuclear fuel cycle, and other related activities. With few exceptions, fallout from atmospheric testing of nuclear weapons is the primary source of plutonium in ambient air.

Table 4-5 summarizes the plutonium-238 data for 2009. The highest annual average concentration was recorded off-site but was only 2.9 ± 7aCi/m³, about 0.15% of the EPA public limit and consistent with zero. Four quarterly concentrations above 3s were measured near MDA-B, and two others elsewhere off-site.

Table 4-6 summarizes the plutonium-239/240 data. All quarterly concentrations at Station 66 (on the canyon edge south of Ashley Pond) were above their 3s uncertainties. The annual mean concentration here was the highest at 26 ± 9 aCi/m³, about 1.3% of the EPA public dose limit. These higher ambient concentrations are from legacy deposits on the hillside to the south. Eleven quarterly concentrations above 3s were measured near the MDA-B clean-up site, and seven others elsewhere off-site. Twelve on-site quarterly concentrations exceeded 3s, all but one being at or near Area G.

Table 4-5
Airborne Plutonium-238 Concentrations for 2009 — Group Summaries

Station Grouping	Number of Biweekly Samples	Fraction of Samples > 3s Uncertainty	Mean ± 99.7% Confidence Interval[a] (aCi/m³)		Maximum Station Concentration (aCi/m³)	
					Biweekly	Annual
Regional[b]	16	0%	0.4	±0.7	2	1
Pueblo[b]	11	0%	0.5	±0.8	2	1
Perimeter[b]	120	5%	0.6	±0.3	8	3
Waste Site[c]	32	3%	0.7	±0.4	2	1
On-Site[c]	20	0%	0.6	±0.7	3	2
D&D[b]	32	0%	0.9	±0.4	2	1

[a] Confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40, CFR Part 61, Appendix E, concentration limit is 2,100 aCi/m³.
[c] Ten times public limit in b.

Table 4-6
Airborne Plutonium-239/240 Concentrations for 2009 — Group Summaries

Station Grouping	Number of Biweekly Samples	Fraction of Samples > 3s Uncertainty	Mean ± 99.7% Confidence Interval[a] (aCi/m³)		Maximum Station Concentration (aCi/m³)	
					Biweekly	Annual
Regional[b]	16	13%	1.0	±0.9	3	1
Pueblo[b]	11	0%	1.1	±1.4	4	2
Perimeter[b]	120	8%	1.4	±1.3	32	26
Waste Site[c]	32	31%	3.4	±2.9	26	14
On-Site[c]	20	10%	1.1	±1.5	9	3
D&D[b]	32	34%	2.7	±1.3	10	5

[a] Confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40, CFR Part 61, Appendix E, concentration limit is 2,000 aCi/m³.
[c] Ten times public limit in b.

Concentrations of plutonium show no distinctive trends over the past five years. In 2007 and 2008, remediation activities at TA-21 increased plutonium averages near that location. Figures 4-8 and 4-9 show the annual grouping average concentrations, except Area G which is shown separately in Figure 4-10. The increased concentration of plutonium-239 in 2006 was due to operations involving cleanup of waste.



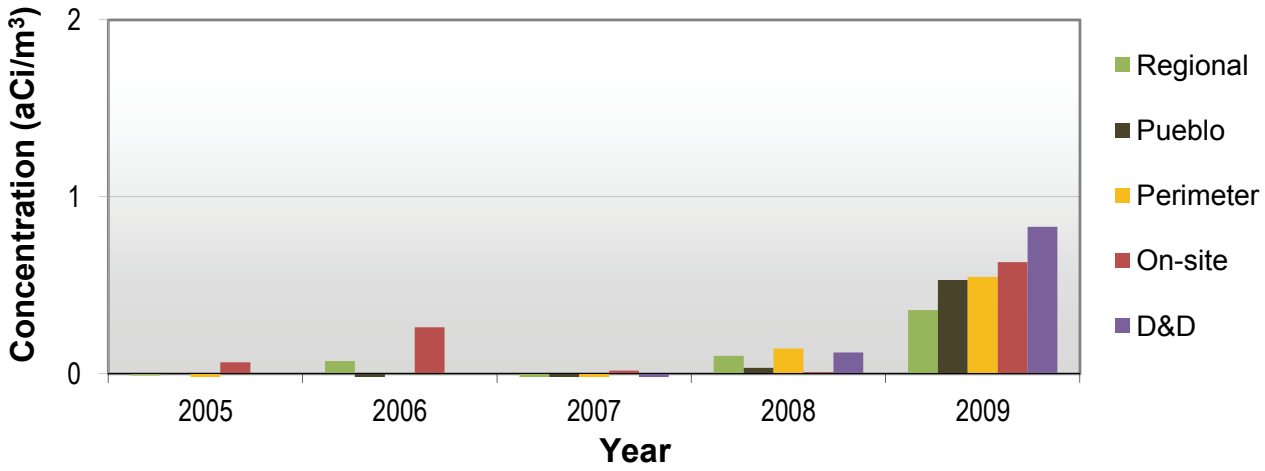


Figure 4-8. Annual average concentrations of plutonium-238 by group.

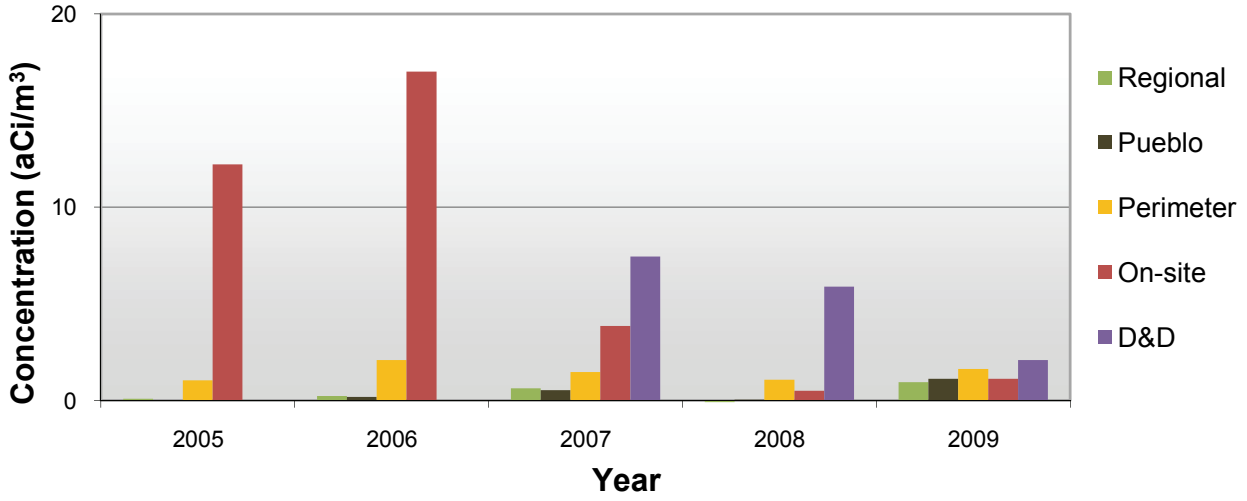


Figure 4-9. Annual average concentrations of plutonium-239/240 by group.

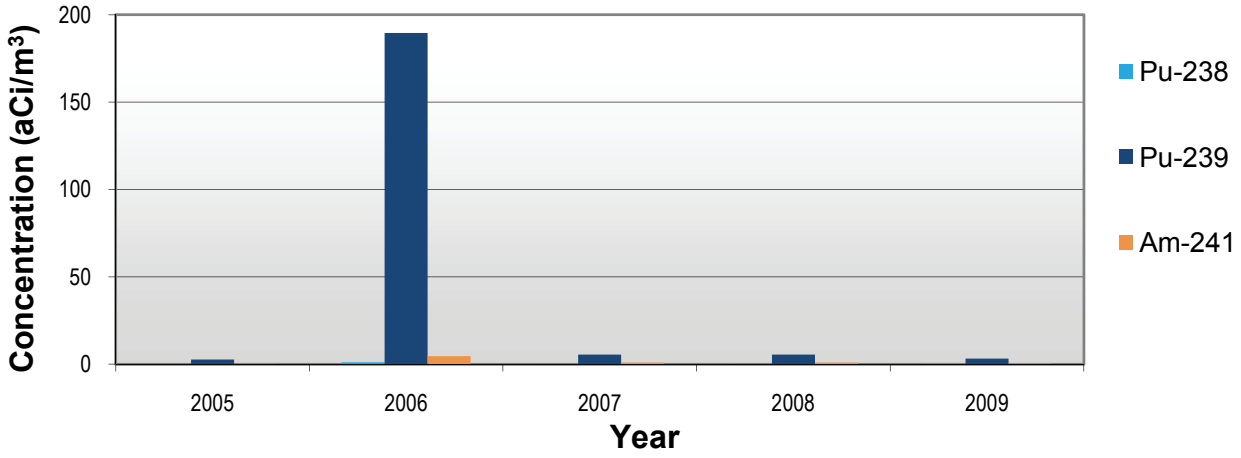


Figure 4-10. Americium and plutonium concentrations at TA-54, Area G.

f. Americium-241

Americium is present in very low concentrations in the environment. Table 4-7 summarizes the americium-241 data. Seven off-site quarterly samples with a concentration greater than 3s were measured. Six on-site quarterly samples (five at Area G) were measured with concentrations greater than 3s. The highest quarterly off-site and on-site concentrations were 0.1% and 0.01% of the public and worker limits, respectively.

Table 4-7
Airborne Americium-241 Concentrations for 2009 — Group Summaries

Station Grouping	Number of Biweekly Samples	Fraction of Samples > 3s Uncertainty	Mean ± 99.7% Confidence Interval[a] (aCi/m³)		Maximum Station Concentration (aCi/m³)	
					Biweekly	Annual
Regional[b]	16	0%	-0.6	±0.8	1	0
Pueblo[b]	11	0%	-0.2	±0.9	1	0
Perimeter[b]	120	3%	-0.1	±0.4	9	2
Waste Site[c]	32	16%	0.4	±0.8	4	2
On-Site[c]	20	5%	0.0	±1.2	5	2
D&D[b]	32	9%	0.0	±0.7	5	2

[a] Confidence intervals are calculated using all calculated sample concentrations from every site within the group.

[b] EPA 40, CFR Part 61, Appendix E, concentration limit is 1,900 aCi/m³.

[c] Ten times public limit in b.

Americium concentrations show no distinctive trends over the past five years. In 2007 and 2008, remediation activities at TA-21 raised americium averages in that area. Figure 4-11 shows the annual group average concentrations, except Area G which is shown separately in Figure 4-10.

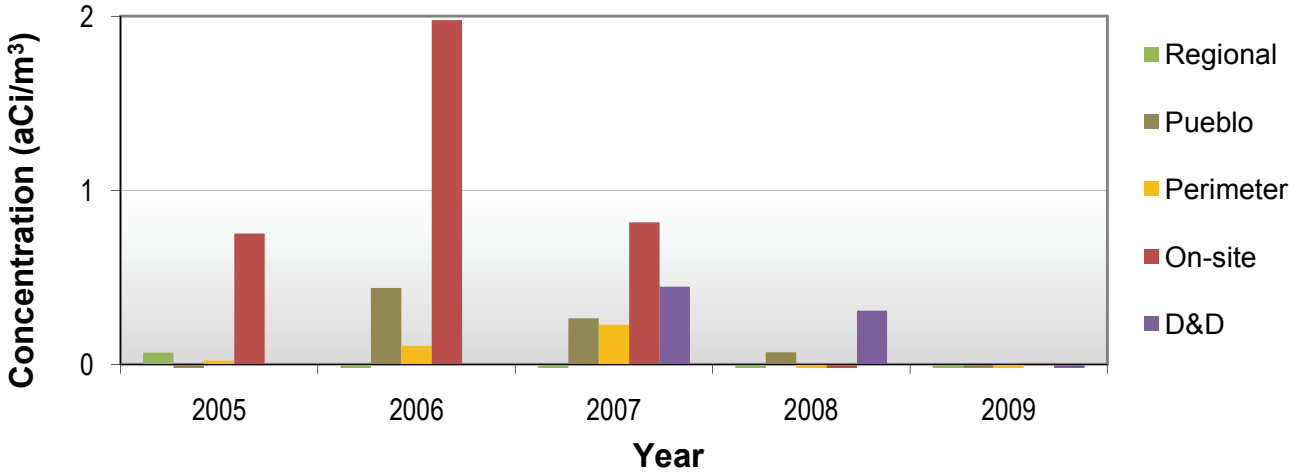


Figure 4-11. Annual average concentrations of Americium-241 by group.

g. Uranium

Three isotopes of uranium are normally found in nature: uranium-234, -235, and -238. In natural uranium, relative isotopic abundances are constant and known; the ratio of the activity of uranium-238 to that of uranium-234 is approximately 1 (Walker et al., 1989). LANL uses comparisons of isotopic concentrations to estimate its contributions because known Laboratory emissions in the past 50 years were not of natural uranium, but either enriched uranium (EU) (enriched in uranium-234 and -235) or depleted uranium (DU). EU and DU were identified by comparing uranium-234 and -238 concentrations. If they differed by more than 3s the sample was considered to have significant concentrations of EU or DU.

All annual mean concentrations of uranium isotopes (Tables 4-8 to 4-10) were below 0.5% of the EPA guidelines. The highest annual uranium concentrations are typically at dusty locations.

Table 4-8
Airborne Uranium-234 Concentrations for 2009 — Group Summaries

Station Grouping	Number of Biweekly Samples	Fraction of Samples > 3s Uncertainty	Mean ± 99.7% Confidence Interval[a] (aCi/m³)		Maximum Station Concentration (aCi/m³)	
					Biweekly	Annual
Regional[b]	16	94%	17	±5	38	4
Pueblo[b]	11	100%	20	±6	34	9
Perimeter[b]	120	97%	10	±1	50	0.3
Waste Site[c]	32	100%	17	±5	66	3
On-Site[c]	20	100%	9	±2	20	3
D&D[b]	32	94%	13	±4	71	4

[a] Confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40, CFR Part 61, Appendix E, concentration limit is 7,700 aCi/m³.
[c] Ten times public limit in b.

Table 4-9
Airborne Uranium-235 Concentrations for 2009 — Group Summaries

Station Grouping	Number of Biweekly Samples	Fraction of Samples > 3s Uncertainty	Mean ± 99.7% Confidence Interval[a] (aCi/m³)		Maximum Station Concentration (aCi/m³)	
					Biweekly	Annual
Regional[b]	16	6%	0.7	±1.2	4	2
Pueblo[b]	11	0%	0.9	±0.9	3	1
Perimeter[b]	120	3%	0.5	±0.3	3	3
Waste Site[c]	32	9%	1.1	±0.9	6	3
On-Site[c]	20	5%	0.9	±0.7	3	1
D&D[b]	32	9%	1.4	±1.0	9	3

[a] Confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40, CFR Part 61, Appendix E, concentration limit is 7,100 aCi/m³.
[c] Ten times public limit in b.

Table 4-10
Airborne Uranium-238 Concentrations for 2009 — Group Summaries

Station Grouping	Number of Biweekly Samples	Fraction of Samples > 3s Uncertainty	Mean ± 99.7% Confidence Interval[a] (aCi/m³)		Maximum Station Concentration (aCi/m³)	
					Biweekly	Annual
Regional[b]	16	100%	16	±4	32	23
Pueblo[b]	11	100%	18	±7	39	28
Perimeter[b]	120	98%	12	±2	51	37
Waste Site[c]	32	100%	16	±5	66	36
On-Site[c]	20	95%	12	±5	47	17
D&D[b]	32	100%	15	±3	42	18

[a] Confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40, CFR Part 61, Appendix E, concentration limit is 8,300 aCi/m³.
[c] Ten times public limit in b.

EU was detected once (near the eastern end of DP Road) and DU 15 times during 2009 (Figure 4-12). All the DU detections occurred in the same quarter and appear to be from the same event. The source of this DU was probably legacy waste on LANL property lofted by strong winds.

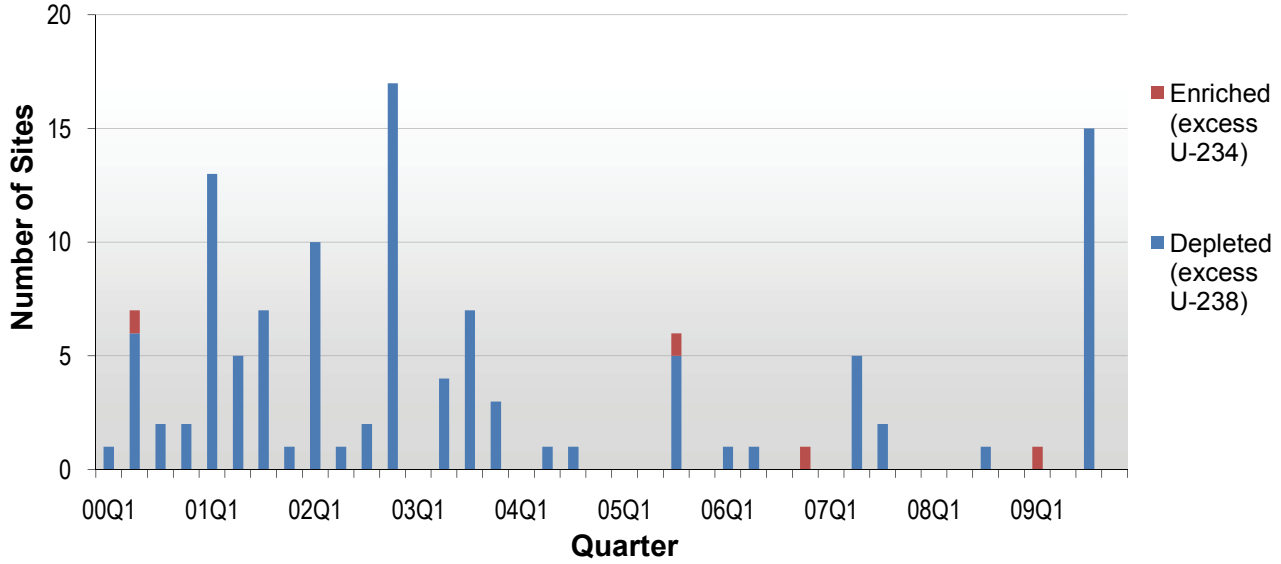


Figure 4-12. Number of sites where enriched or depleted uranium has been detected since 2000.

Concentrations for uranium isotopes typically peak during windier quarters (Figure 4-13). Over the last five years the trends are flat.

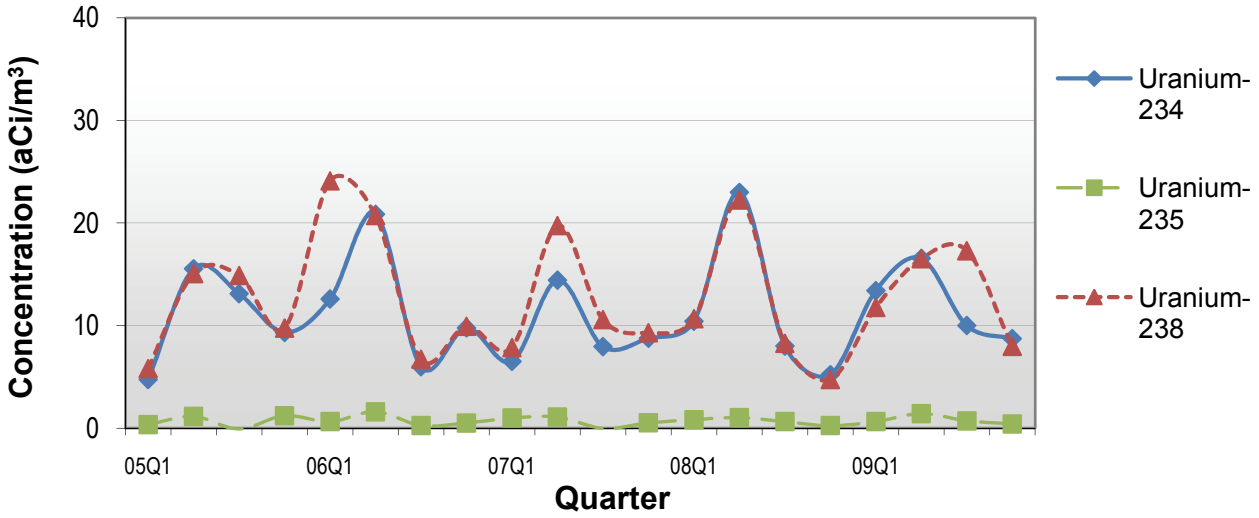


Figure 4-13. Quarterly all-station average concentrations of uranium isotopes.

h. Gamma Spectroscopy Measurements

For gamma screening, we group filters across sites in "clumps" for each sampling period. The clumps were analyzed for the following analytes: arsenic-73, arsenic-74, cadmium-109, cobalt-57, cobalt-60, cesium-134, cesium-137, manganese-54, sodium-22, rubidium-83, rubidium-103, selenium-75, and zinc-65. None have been detected in the last five years. We investigate the measurement of any of these analytes above its minimum detectable activity.

We also analyze the natural radionuclides beryllium-7, potassium-40, and lead-210. However, we only initiate investigations when elevated levels are found. No elevated levels of these were found during 2009.

5. Special Monitoring

In July we monitored a controlled burn in Bandelier National Monument. Eight high-volume samplers ran for a few days. No elevated levels were detected for any of the most likely elements or isotopes expected.

B. STACK SAMPLING FOR RADIONUCLIDES

1. Introduction

Radioactive materials are an integral part of many activities at LANL. Some operations involving these materials may be vented to the environment through a stack or other forced air release point. Members of the stack monitoring team at LANL evaluate these operations to determine potential impacts to the public and the environment. Emissions are estimated using engineering calculations and radionuclide materials usage information with the assumption there are no emission controls in place, such as the high-efficiency particulate air filters which are present on all stacks. If this evaluation shows that emissions from a stack may potentially result in a member of the public receiving as much as 0.1 mrem in a year, LANL must sample the stack in accordance with 40 CFR Part 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" (Rad-NESHAP) (EPA 1989). During 2009, we identified 26 stacks meeting this criterion.

2. Sampling Methodology

In 2009, we continuously sampled 26 stacks for the emission of radioactive material to the ambient air. LANL categorizes its radioactive stack emissions into one of four types: (1) particulate matter, (2) vaporous activation products, (3) tritium, and (4) gaseous mixed activation products (GMAP). For each of these emission types, LANL employs an appropriate sampling method, as described below.

We sample emissions of radioactive particulate matter generated by operations at facilities, such as the Chemistry and Metallurgy Research Building and the TA-55 Plutonium Facility, using a glass-fiber filter. A continuous sample of stack air is pulled through a filter that captures small particles of radioactive material. We collect these samples weekly and ship them to an off-site analytical laboratory. The analytical laboratory uses gross alpha/beta counting and gamma spectroscopy to identify any increase in emissions and to identify short-lived radioactive materials. Every six months, the analytical laboratory composites these samples and analyzes them to determine the cumulative activity on all the filters of radionuclides such as uranium-234, -235, and-238, plutonium-238 and -239/240, and americium-241. We use the isotopic data to calculate emissions from the stack for the six-month period.

A charcoal cartridge samples emissions of vapors, such as bromine-82, and highly volatile compounds, such as selenium-75, generated by operations at the Los Alamos Neutron Science Center (LANSCE) and hot cell activities at the Chemistry and Metallurgy Research Building and TA-48. A continuous sample of stack air is pulled through a charcoal filter that adsorbs vaporous emissions of radionuclides. This charcoal filter is mounted downstream of a glass-fiber filter (discussed above) that removes any particulates from this sample media prior to the vapor sampling. Gamma spectroscopy determines the amount and identity of the radionuclide(s) present on the charcoal filter, which is collected weekly at the same time as the filter.

We measure tritium emissions from LANL's tritium facilities with a collection device known as a bubbler. This device enables us to determine not only the total amount of tritium released but also whether it is in the elemental (HT) or oxide (HTO) form. The bubbler pulls a continuous sample of air from the stack, which is then "bubbled" through three sequential vials containing ethylene glycol. The ethylene glycol collects the water vapor from the sample of air, including any tritium that may be part of a water molecule (HTO). "Bubbling" through these three vials removes essentially all HTO from the air, leaving only HT. The air is then passed through a palladium catalyst that converts the HT to HTO. The sample is pulled through three additional vials containing ethylene glycol, which collect the newly formed HTO. We collected the vials of ethylene glycol weekly and sent them to an analytical laboratory for liquid scintillation counting to determine the amount of HTO and HT.

In previous years, we monitored stacks at LANSCE for tritium. After an historical evaluation of HTO emissions from LANSCE in 2001, we discontinued sampling tritium following the July 2001 report period based on the low historical emissions of HTO from TA-53 and the low relative contribution of tritium to the off-site dose from TA-53 emissions. Emissions of tritium reported in 2009 from LANSCE are based on 2001 tritium generation rates.

We measure GMAP emissions from LANSCE activities using real-time monitoring data. A sample of stack air is pulled through an ionization chamber that measures the total amount of radioactivity in the sample. Gamma spectroscopy and decay curves are used to continuously identify specific radioisotopes and the quantity of each. From these data, the total emissions of each radionuclide are calculated.

3. Sampling Procedures and Data Analysis

a. Sampling and Analysis

Analytical methods used comply with EPA requirements in 40 CFR 61, Appendix B, Method 114 (EPA 1989). Section F of this chapter presents the results of analytical quality assurance measurements. This section discusses the sampling and analysis methods for each type of LANL's emissions.

b. Particulate Matter Emissions

We remove and replace the glass-fiber filters that each week sample facilities with significant potential for radioactive particulate emissions, and we then ship them to an off-site analytical laboratory. Prior to shipping, we screen each sample filter with a hand-held instrument to determine if there are any unusually high levels of gross alpha or beta radioactivity. The laboratory performs analyses for the presence of alpha and beta radioactivity after the sample has been allowed to decay for approximately one week (to allow short-lived radon progeny to decay). In addition to alpha and beta analyses, the laboratory performs gamma spectroscopy analysis to identify specific isotopes in the sample. While alpha and beta counting are performed on individual glass-fiber filters, gamma spectroscopy is performed on "clumps" of filters, a group of seven or eight filters stacked together to allow quick analysis for gamma-emitting radionuclides. Subsequent analyses, if needed, are performed on individual filters.

The glass-fiber filters are composited every six months for radiochemical analysis because gross alpha/beta counting cannot identify specific radionuclides. We use the data from these composite analyses to quantify emissions of radionuclides, such as the isotopes of uranium and plutonium. The Rad-NESHAP team compares the results of the isotopic analysis with gross activity measurements to ensure that the requested analyses (e.g., uranium-234, -235, and -238; and plutonium-238 and -239/240, etc.) identify all significant activity in the composites.

For particulate filters from the LANSCE accelerator facility, the analytical laboratory only performs gamma spectroscopy analyses based on the anticipated suite of emissions from this facility. Again, we perform hand-screening of each filter prior to shipping them to the off-site analytical laboratory.

c. Vaporous Activation Products Emissions

We remove and replace the charcoal canisters weekly at facilities with the potential for significant vaporous activation products emissions and ship the samples to the off-site analytical laboratory where gamma spectroscopy identifies and quantifies the presence of vaporous radioactive isotopes. For charcoal filters, gamma spectroscopy analyses are performed on individual filters instead of clumped filters.

d. Tritium Emissions

Each week, we collected tritium bubbler samples, used to sample facilities with the potential for significant elemental and oxide tritium emissions, and transport them to LANL's Health Physics Analytical Laboratory. The Health Physics Analytical Laboratory adds an aliquot of each sample to a liquid scintillation cocktail and determines the amount of tritium in each vial by liquid scintillation counting.

e. Gaseous Mixed Activation Products (GMAP) Emissions.

To record and report GMAP emissions, we used continuous monitoring, rather than off-line analysis, for two reasons. First, the nature of the emissions is such that standard filter paper and charcoal filters will not collect the radionuclides of interest. Second, the half-lives of these radionuclides are so short that the activity would decay away before any sample could be analyzed off-line. The GMAP monitoring system includes a flow-through ionization chamber in series with a gamma spectroscopy system. Total GMAP emissions are measured with the ionization chamber. The real-time current this ionization chamber measures is recorded on a strip chart and the total amount of charge collected in the chamber over the entire beam operating cycle is integrated on a daily basis. The gamma spectroscopy system analyzes the composition of these GMAP emissions. Using decay curves and energy spectra to identify the various radionuclides, we determine the relative composition of the emissions. Decay curves are typically taken one to three times per week based on accelerator operational parameters. When major ventilation configuration changes are made at LANSCE, new decay curves and energy spectra are recorded.

4. Analytical Results

Measurements of LANL stack emissions during 2009 totaled approximately 796 Ci (compared to 1,600 Ci in 2008). Of this total, tritium emissions contributed approximately 80 Ci (compared to 780 Ci in 2008), and air activation products from LANSCE stacks contributed nearly 716 Ci (compared to nearly 815 Ci in 2008). Combined airborne emissions of materials such as plutonium, uranium, americium, and thorium were less than 0.000027 Ci. Emissions of particulate matter plus vaporous activation products (P/VAP) were about 0.141 Ci, which is consistent with recent years.

Table 4-11 provides detailed emissions data for LANL buildings with sampled stacks.

Table 4-11
Airborne Radioactive Emissions from LANL Buildings with Sampled Stacks in 2009 (Ci)

TA-Bldg	H-3[a]	Am-241	Pu[b]	U[c]	Th[d]	P/VAP[e]	GMAP[f]	Sr-90[g]
TA-03-029		2.48×10^{-6}	1.29×10^{-5}	1.06×10^{-5}	2.50×10^{-7}			2.34×10^{-8}
TA-03-102								
TA-16-205/450	4.76×10^{1}							
TA-48-001						7.69×10^{-3}		
TA-50-001								1.15×10^{-7}
TA-50-037					2.88×10^{-9}			
TA-50-069			2.23×10^{-10}					
TA-53-003	1.64×10^{1}					1.82×10^{-4}	4.79×10^{1}	
TA-53-007	5.25					5.84×10^{-3}	6.68×10^{2}	
TA-55-004	7.45	5.10×10^{-10}	8.59×10^{-10}					
Total[h]	7.67×10^{1}	2.48×10^{-6}	1.29×10^{-5}	1.06×10^{-5}	2.53×10^{-7}	1.37×10^{-2}	7.75×10^{2} [i]	1.62×10^{-7}

Note: Some buildings have more than one sampled stack.

[a] Includes both gaseous and oxide forms of tritium.

[b] Includes Pu-238, Pu-239, and Pu-240.

[c] Includes U-234, U-235, and U-238. Does not include radioactive progeny of U-238.

[d] Includes Th-228, Th-230, and Th-232.

[e] P/VAP–Particulate/vapor activation products (with measured radionuclides and short-lived radioactive progeny).

[f] GMAP–Gaseous mixed activation products.

[g] Strontium-90 values include short-lived radioactive progeny of yttrium-90.

[h] Some differences may occur because of rounding.

[i] Total for GMAP includes 59.6 curies released from diffuse sources at TA-53.

Table 4-12 provides a detailed listing of the constituent radionuclides in the groupings of GMAP and P/VAP.

Table 4-13 presents the half-lives of the radionuclides typically emitted by LANL. During 2009, the LANSCE facility non-point source emissions of activated air comprised approximately 57 Ci of carbon-11 and 2 Ci of argon-41.

5. Long-Term Trends

Figures 4-14 to 4-17 present radioactive emissions from sampled LANL stacks and illustrate trends in measured emissions for plutonium, uranium, tritium, and GMAP emissions, respectively. As the figures demonstrate, emissions from plutonium and uranium isotopes stayed relatively steady over recent years, varying slightly each year but staying in the low-microcurie range. Tritium emissions showed a decrease in emissions relative to recent years, reflecting minimal operations taking place at the main tritium facility during the year. In 2009, emissions of GMAP decreased slightly from 2008 levels and are still very low relative to the one-year elevation in 2005, as described below.

LANSCE operated in the same configuration as recent years, with continuous beam operations to the 1L Target and the Lujan Neutron Scattering Center, causing the majority of radioactive air emissions. Operations to the 1L Target took place from late spring of 2009 through the end of the calendar year.

The emissions control system at the LANSCE 1L Target is a "delay line," which retains the short-lived activation products for a short time before release out the stack. This time interval allows decay of the short-lived radionuclides to non-radioactive components. A cracked valve in the inlet of this delay system caused substantially elevated emissions in 2005, compared with previous years. Additional delay line sections were installed in May and November 2005 and the defective valve was fixed in late 2005. The additional delay line contributed to the relatively low emissions in 2006 through 2009. In all years, emissions were below all regulatory limits.

Figure 4-18 shows the individual contribution of each emission type to total LANL emissions. It clearly shows that GMAP emissions and tritium emissions make up the vast majority of radioactive stack emissions. This plot does not directly relate to off-site dose because some radionuclides have a higher dose impact per curie released than others. GMAP and tritium remain the highest contributors to the total curies released. These gas-phase nuclides are not easily removed from an exhaust stack air stream by standard control techniques, such as filtration. GMAP and tritium emissions continue to fluctuate as the major emissions type; tritium facility operations and LANSCE operations vary from year to year. GMAP emissions are normally the greatest source of off-site dose from the airborne pathway because of the close proximity of the LANSCE facility to the LANL boundary.



Table 4-12
Detailed Listing of Activation Products Released from Sampled LANL Stacks in 2009 (curies)

TA-Building	Nuclide	Emission (Ci)
TA-48-0001	As-74	0.00000104
TA-48-0001	Br-77	0.00000276
TA-48-0001	Ga-68	0.00362
TA-48-0001	Ge-68	0.00362
TA-48-0001	Hg-197	0.000149
TA-48-0001	Hg-197m	0.000149
TA-48-0001	Se-75	0.000108
TA-48-0001	As-73	0.000000168
TA-48-0001	Ga-68	0.0000106
TA-48-0001	Ge-68	0.0000106
TA-48-0001	Hg-197	0.0000105
TA-48-0001	Hg-197m	0.0000105
TA-48-0001	Se-75	0.0000000884
TA-53-0003	Ar-41	1.92
TA-53-0003	Be-7	0.0000640
TA-53-0003	Br-76	0.0000269
TA-53-0003	Br-77	0.0000211
TA-53-0003	Br-82	0.0000573
TA-53-0003	C-11	46.0
TA-53-0003	Mn-54	0.000000198
TA-53-0003	Na-22	0.000000118
TA-53-0003	Na-24	0.0000127
TA-53-0007	Ar-41	13.6
TA-53-0007	As-73	0.00000656
TA-53-0007	Be-7	0.000000523
TA-53-0007	Br-76	0.000488
TA-53-0007	Br-77	0.0000915
TA-53-0007	Br-82	0.00233
TA-53-0007	C-10	1.06
TA-53-0007	C-11	500.0
TA-53-0007	Hg-197	0.00117
TA-53-0007	Hg-197m	0.00117
TA-53-0007	I-126	0.000000706
TA-53-0007	N-13	30.5
TA-53-0007	N-16	0.946
TA-53-0007	Na-24	0.000548
TA-53-0007	O-14	2.02
TA-53-0007	O-15	120.0
TA-53-0007	Os-191	0.0000135
TA-53-0007	Se-75	0.0000162

Table 4-13
Radionuclide Half-Lives

Nuclide	Half-Life
H-3	12.3 yr
Be-7	53.4 d
C-10	19.3 s
C-11	20.5 min
N-13	10.0 min
N-16	7.13 s
O-14	70.6 s
O-15	122.2 s
Na-22	2.6 yr
Na-24	14.96 h
P-32	14.3 d
K-40	1,277,000,000 yr
Ar-41	1.83 h
Mn-54	312.7 d
Co-56	78.8 d
Co-57	270.9 d
Co-58	70.8 d
Co-60	5.3 yr
As-72	26 h
As-73	80.3 d
As-74	17.78 d
Br-76	16 h
Br-77	2.4 d
Br-82	1.47 d
Se-75	119.8 d
Sr-85	64.8 d
Sr-89	50.6 d
Sr-90	28.6 yr
I-131	8 d
Cs-134	2.06 yr
Cs-137	30.2 yr
Os-183	13 h
Os-185	93.6 d
Os-191	15.4 d
Hg-193	3.8 h
Hg-195	9.5 h
Hg-195m	1.67 d
Hg-197	2.67 d
Hg-197m	23.8 h
U-234	244,500 yr
U-235	703,800,000 yr
U-238	4,468,000,000 yr
Pu-238	87.7 yr
Pu-239	24,131 yr
Pu-240	6,569 yr
Pu-241	14.4 yr
Am-241	432 yr

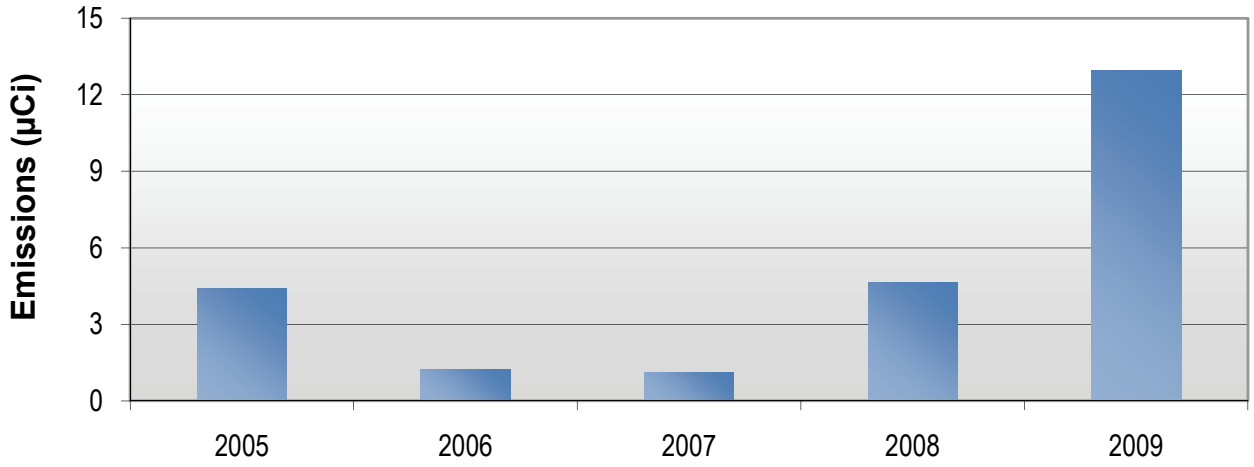


Figure 4-14. Plutonium emissions from sampled LANL stacks.

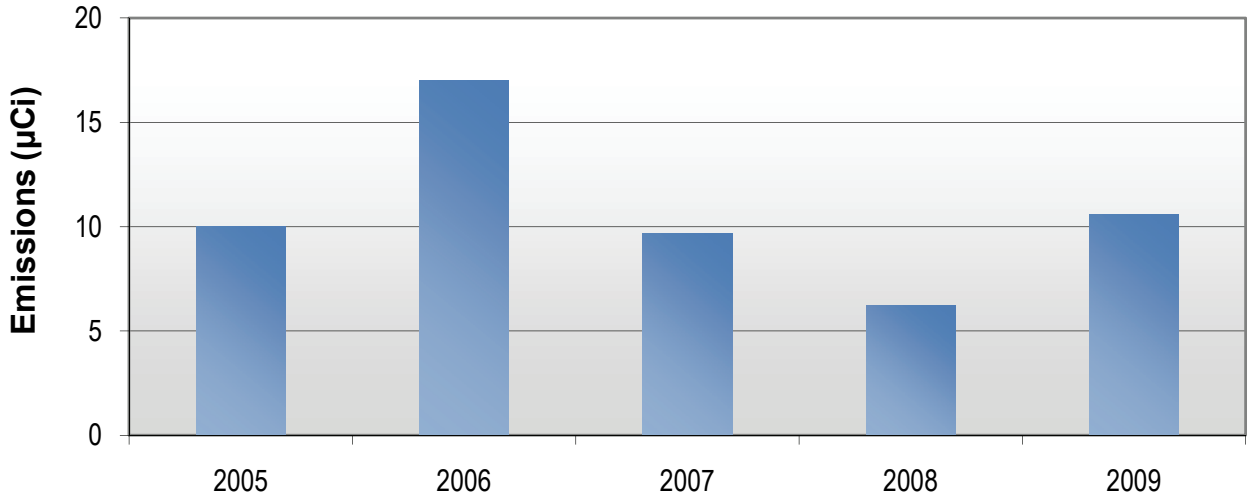


Figure 4-15. Uranium emissions from sampled LANL stacks.

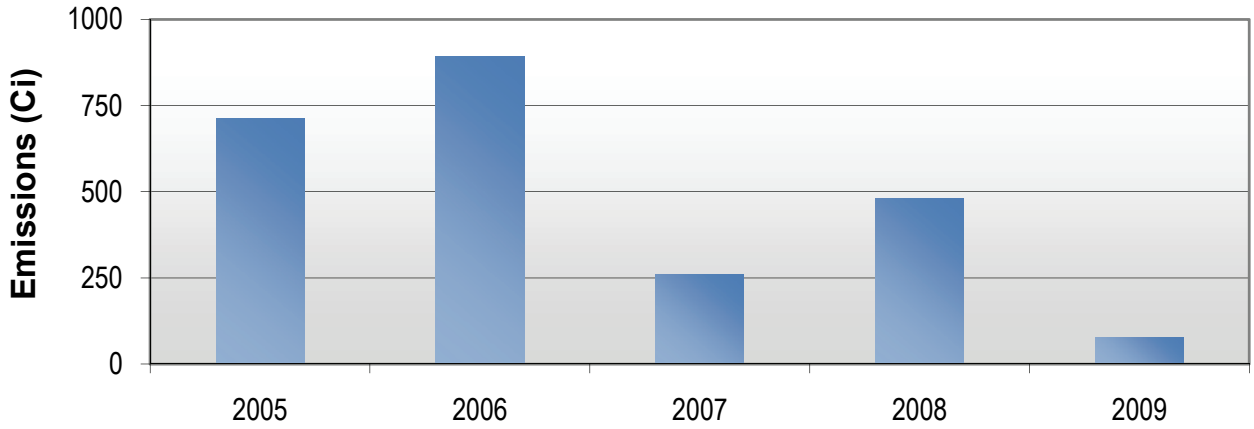


Figure 4-16. Tritium emissions from sampled LANL stacks.

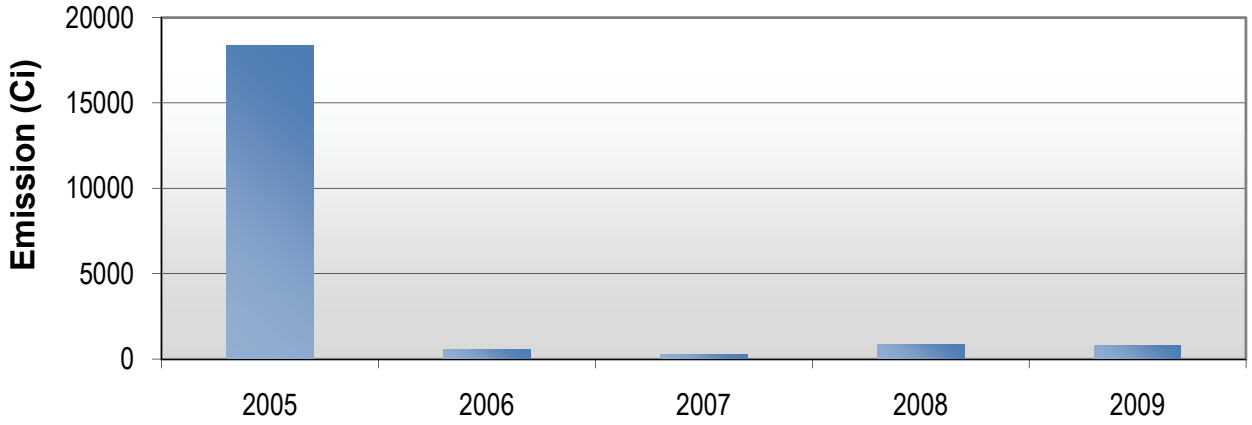


Figure 4-17. GMAP emissions from sampled LANL stacks.

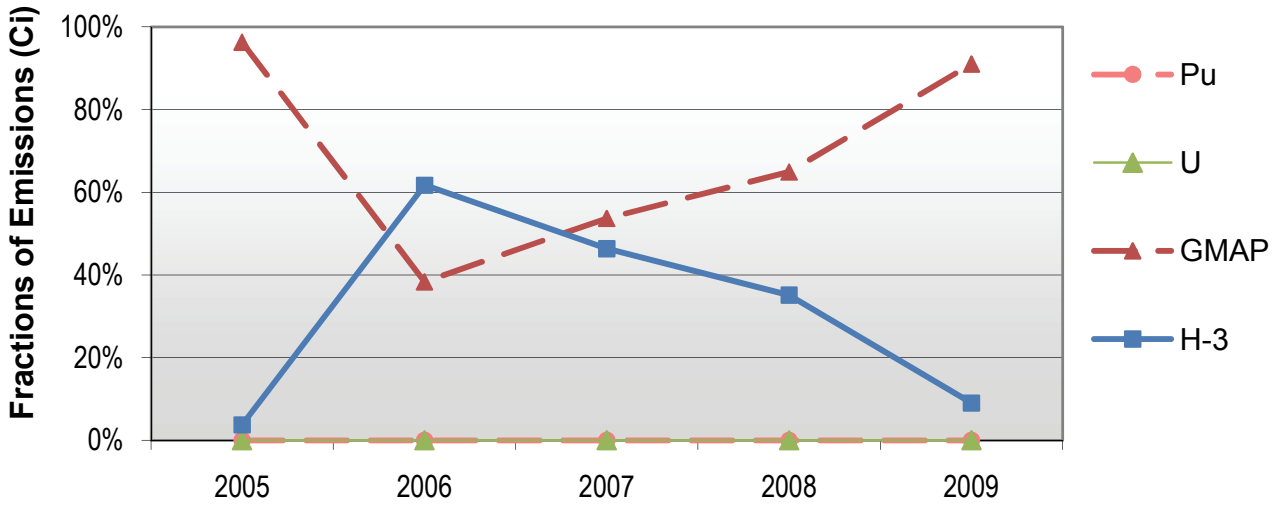


Figure 4-18. Fraction of total annual stack emissions resulting from plutonium, uranium, tritium, and GMAP.

C. GAMMA AND NEUTRON RADIATION MONITORING PROGRAM

1. Introduction

We monitor gamma and neutron radiation in the environment—that is, outside of the workplace—according to the criteria specified in McNaughton et al. (2000) as part of a network of radiation detectors known as the Direct Penetrating Radiation Monitoring Network (DPRNET). Naturally occurring radiation originates from terrestrial and cosmic sources. It is extremely difficult to distinguish man-made sources from the natural background because the natural radiation doses are generally much larger than those from man-made sources. The external dose rate from natural terrestrial and cosmic sources measured by the dosimeters varies from approximately 100 to 200 mrem/yr.

2. Monitoring Network

a. Dosimeter Locations

In an attempt to distinguish any impact from LANL operations on the public, we located 93 thermoluminescent dosimeter (TLD) stations around LANL and in the surrounding communities. There is a TLD at every AIRNET station (shown in Figures 4-1 and 4-3). The corresponding TLD station numbers are listed in Supplementary Data Table S4-10. Additional stations are around TA-54, Area G (shown in Figure 4-19); at TA-53, LANSCE (eight stations); at Santa Clara Pueblo (five stations); and inside the Pueblo de San Ildefonso sacred area (two stations).

b. Neutron Dosimeters

We monitor potential neutron doses with 47 albedo TLD stations near known or suspected sources of neutrons: TA-53 (LANSCE) and TA-54 (Area G). Albedo dosimeters are sensitive to neutrons and use a hydrogenous material that causes neutron backscatter to simulate the human body.

c. Neutron Background

We measure the neutron background at station #25, near Bandelier National Monument, and #101 in Santa Fe. During 2009, the average neutron background at these two stations was 1.7 mrem. To be consistent with previous estimates, we use 2 mrem/yr as our estimated neutron background.

3. Quality Assurance

The calibration laboratory at LANL's Health Physics Measurements Group (RP-2) calibrates the dosimeters every quarter of the calendar year. The DOE Laboratory Accreditation Program has accredited the dosimeters that RP-2 provides, and RP-2 provides quality assurance (QA) for the dosimeters. The uncertainty in the TLD data is estimated from the standard deviation of data from dosimeters exposed to the same dose. The overall uncertainty (one standard deviation) is similar to previous data and is 8%.

4. Results

The annual dose equivalents at all stations except those within TA-53 or near Area G are consistent with natural background radiation and with previous measurements. Detailed results are listed in the Supplemental Data Table S4-10. The only locations with a measurable contribution from LANL operations are within the boundaries of TA-53 (LANSCE) and near TA-54 (Area G). Figure 4-19 shows the locations of the stations at TA-54, Area G.

South of the line of TLDs from #601 to #608, Area G is a controlled-access area, so these data are not representative of a potential public dose. However, TLDs #642 and #643 are close to the boundary of the Pueblo de San Ildefonso sacred area, which is accessible to members of the Pueblo. Furthermore, TLDs #133 and #134 are deployed by Pueblo staff within the boundaries of the sacred area.

After subtracting background, the annual doses measured by TLDs #134, #642, and #643 were 15 mrem, 10 mrem, and 7 mrem, respectively. The dose measured by TLD #134 is higher than the others because TLDs #642 and #643 are in Cañada del Buey and are partially shielded by the rim of the canyon. These are the doses that would be received by a person who is at the location of the TLDs 24 hours per day, 365 days per year. As discussed in Chapter 3, we apply an occupancy factor of 1/16 (NCRP 1976) so the public dose near TLD #134 is calculated to be 0.9 mrem/yr, which is similar to previous years.

TLD #133 is located several hundred meters farther from Area G and measures nothing above the terrestrial and cosmic-ray natural background. This is expected because of the distance and the shielding provided by the air. Annual doses of 12 mrem were measured by TLDs #651 and #652, which are located along Pajarito Road, south of Area G. This section of Pajarito Road has limited public access.

D. NONRADIOLOGICAL AMBIENT AIR MONITORING

1. Introduction

The non-radioactive ambient air monitoring network measures concentrations of total suspended particulates and some selected non-radiological species in communities near LANL. The program consists of four ambient particulate matter monitoring units at two locations plus selected AIRNET samples, which are analyzed for the non-radiological constituents aluminum, calcium, and beryllium.

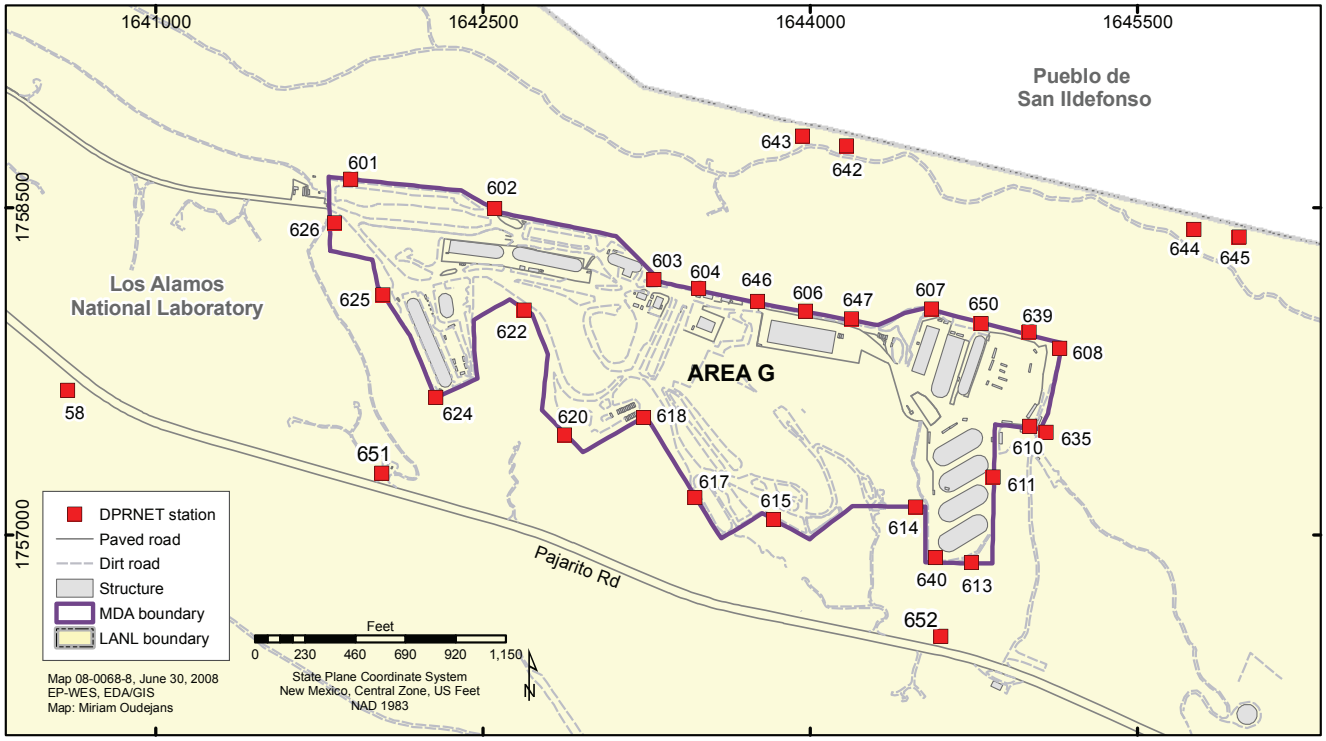


Figure 4-19. Thermoluminescent dosimeter locations at TA-54, Area G, as part of the Direct Penetrating Radiation Monitoring Network (DPRNET).

2. Air Monitoring Network and Equipment

Ambient particulate matter monitoring continued at the old White Rock Fire Station on Rover Boulevard and at the Los Alamos Medical Center. Two monitors run at each location: one for particles smaller than 10 micrometers (PM-10) and another for those smaller than 2.5 micrometers (PM-2.5). A tapered-element oscillating microbalance ambient particulate monitor is fitted with an appropriate sample inlet. The microbalance has an oscillating ceramic "finger" with a filter that collects particles. The mass of accumulated particulate matter is derived and saved for later download. These data measure the dust and pollutant loadings in the atmosphere.

3. Ambient Air Concentrations

In 2009, the particulate matter data collection efficiency was about 93%. Annual averages and 24-hour maxima are shown in Table 4-14. The annual averages and the 24-hour maxima for both PM-2.5 and PM-10 are well below EPA standards.

Table 4-14
PM-2.5 and PM-10 Concentration Data Summary for 2009 (µg/m³)

Station Location	Constituent	Maximum 24-Hour (µg/m³)	Annual Average (µg/m³)
Los Alamos Medical Center	PM-10	38	14
	PM-2.5	20	7
White Rock Fire Station	PM-10	35	14
	PM-2.5	13	7
EPA Standard[a]	PM-10	150	n/a[b]
	PM-2.5	35	15

[a] EPA 40 CFR Part 50 and www.epa.gov/air/criteria.html.

[b] None applicable.

4. Detonation and Burning of Explosives

LANL uses explosives at firing sites and maintains records that include the type of explosives used and other materials expended. Supplemental Table S4-10 summarizes the amounts of expended materials for the last three years. LANL also burns scrap and waste explosives because of treatment requirements and safety concerns. In 2009, LANL burned roughly 3,600 kilograms of high explosives. An assessment of the ambient impacts of high-explosives testing (DOE 1999) indicated no adverse air-quality impacts.

5. Beryllium Sampling

We analyzed quarterly composite samples from 38 sites for beryllium, aluminum, and calcium (Supplemental Data Table S4-11). These sites are located near potential beryllium sources at LANL or in nearby communities. New Mexico has no ambient air quality standard for beryllium. All concentrations measured this year were below 1% of the NESHAP standard of 10 ng/m^3 from 40 CFR Part 61 Subpart C (EPA 1989) and were similar to those of recent years. Aluminum and calcium are used to evaluate elevated uranium measurements. No unusual concentrations were measured.

E. METEOROLOGICAL MONITORING

1. Introduction

Data obtained from the meteorological monitoring network support many Laboratory activities, including emergency management and response, regulatory compliance, safety analysis, engineering studies, and environmental surveillance programs. To accommodate the broad demands for weather data at the Laboratory, the meteorology team measures a wide variety of meteorological variables across the network, including wind, temperature, pressure, relative humidity and dew point, precipitation, and solar and terrestrial radiation. The Meteorological Monitoring Plan (Johnson and Young 2008) provides details of the meteorological monitoring program. An electronic copy of the "Meteorological Monitoring Plan" is available online at http://www.weather.lanl.gov/.

2. Monitoring Network

A network of seven stations gathers meteorological data at the Laboratory (Figure 4-20). Four of the stations are located on mesa tops (TA-6, TA-49, TA-53, and TA-54), two are in canyons (TA-41 in Los Alamos Canyon and MDCN in Mortandad Canyon), and one is on top of Pajarito Mountain (PJMT). A precipitation gauge is also located in North Community (NCOM) of the Los Alamos town site. The TA-6 station is the official meteorological measurement site for the Laboratory. A sonic detection and ranging (SODAR) instrument is part of the TA-6 meteorological station and measures wind speed and direction to an elevation of approximately 2000 meters above ground level.

3. Sampling Procedures, Data Management, and Quality Assurance

We place instruments in the meteorological network in areas with good exposure to the elements being measured, usually in open fields, to avoid wake effects on wind and precipitation measurements. Temperature and wind are measured at multiple levels on open lattice towers at TA-6, TA-41, TA-49, TA-53, and TA-54. The multiple levels provide a vertical profile of conditions important in assessing boundary layer flow and stability conditions. The multiple levels also provide redundant measurements that support data quality checks. The boom-mounted temperature sensors are shielded and aspirated to minimize solar-heating effects. The Mortandad Canyon (MDCN) station includes a 10-m tripod tower which measures wind at a single level (tower top). In addition, temperature and humidity are measured at ground level at all stations except North Community (NCOM) which only measures precipitation.

Data loggers at the station sites sample most of the meteorological variables at 0.33 Hz, store the data, average the samples over a 15-min period, and transmit the data to a Hewlett-Packard workstation located at the Meteorology Laboratory (TA-59) by telephone or cell phone. The workstation automatically edits measurements that fall outside of realistic ranges. Time-series plots of the data are also generated for a meteorologist's data-quality review. Daily statistics of certain meteorological variables (e.g., daily minimum and maximum temperatures, daily total precipitation, maximum wind gust, etc.) are also generated and checked for quality. For over 50 years, we have provided these daily weather statistics to the National Weather Service. In addition, cloud type and percentage cloud cover are logged three times daily.

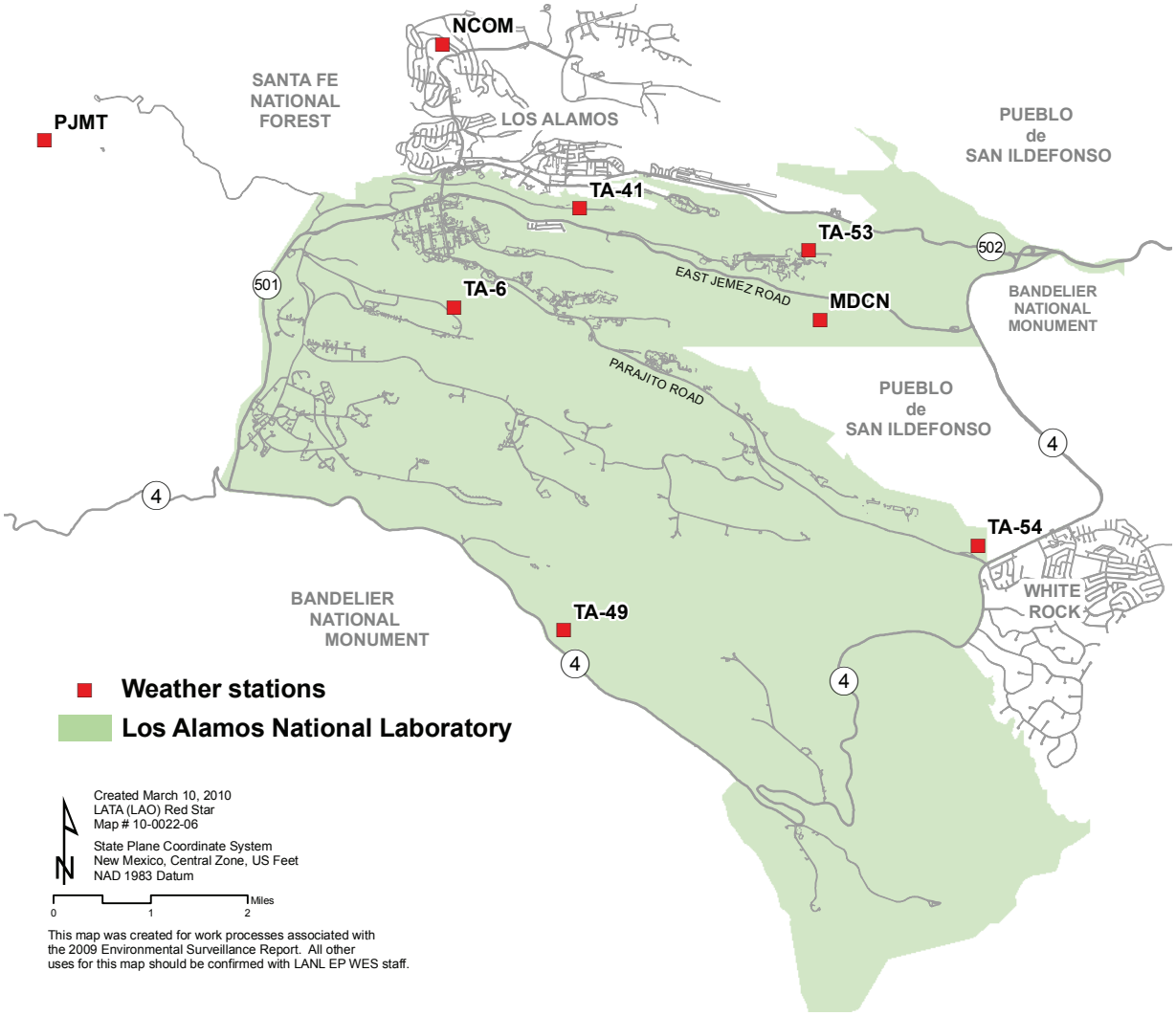


Figure 4-20. Location of meteorological monitoring towers and rain gauges.

We calibrate all meteorological instruments through the LANL Standards and Calibration Laboratory on an annual basis. An external audit of the instrumentation and methods is typically performed once every three to five years. The most recent audit was an "assist visit" by the DOE Meteorological Coordinating Council (DMCC) in August 2006. The DMCC report can be requested at http://www.weather.lanl.gov/. An external subcontractor inspects and performs maintenance on the station network structures and hoists on an annual basis.

4. Climatology

Los Alamos has a temperate, semiarid mountain climate. Atmospheric moisture levels are low, and clear skies are present about 75% of the time. These conditions lead to high solar heating during the day and strong long-wave radiative cooling at night. Winters are generally mild, with occasional winter storms. Spring is the windiest season. Summer is the rainy season, with frequent afternoon thunderstorms. Fall is typically dry, cool, and calm. The climate statistics summarized here are from analyses of historical meteorological databases maintained by the meteorology team and following Bowen (1990 and 1992).

The years from 1971 to 2000 represents the time period over which the climatological standard normal is defined. According to the World Meteorological Organization, the standard should be 1961–1990 until 2021 when 1991–2020 will become the standard, and so on every 30 years (WMO 1984). In practice, however, normals are computed every decade, and so 1971–2000 is generally used. Our averages are calculated according to this widely followed practice.

December and January are the coldest months. The majority (90%) of minimum temperatures during December and January range from 4°F to 31°F. Minimum temperatures are usually reached shortly before sunrise. Ninety percent of maximum temperatures, which are usually reached in mid-afternoon, range from 25°F to 55°F. The record low temperature of -18°F was recorded on January 13, 1963. Wintertime arctic air masses that descend into the central United States tend to have sufficient time to heat before they reach our southern latitude so the occurrence of local subzero temperatures is rare. Winds during the winter are relatively light, so extreme wind chills are uncommon.

Temperatures are highest from June through August. Ninety percent of minimum temperatures during these months range from 45°F to 61°F. Ninety percent of maximum temperatures range from 67°F to 89°F. The record high temperature of 95°F was recorded on June 29, 1998.

The average annual precipitation, which includes both rain and the water equivalent from frozen precipitation, is 18.95 in. The average annual snowfall is 58.7 in. The largest winter precipitation events in Los Alamos are caused by storms approaching from the west to southwest. Snowfall amounts are also occasionally enhanced as a result of orographic lifting of the storms by the high terrain. The record single-day snowfall is about 39 in., which occurred between 11 a.m. on January 15, 1987, and 11 a.m. the next day. The record single-season snowfall is 153 in. set in 1986–87.

Precipitation in July and August account for 36% of the annual precipitation and encompass the bulk of the rainy season, which typically begins in early July and ends in mid-September. Afternoon thunderstorms form as moist air from the Gulf of California and the Gulf of Mexico is convected and/or orographically lifted by the Jemez Mountains. The thunderstorms yield short, heavy downpours and an abundance of lightning.

The complex topography of Los Alamos influences local wind patterns. Often a distinct diurnal cycle of winds occurs. As air close to the ground is heated during the day, it tends to flow upslope along the ground. This is called anabatic flow. During the night, cool air that forms close to the ground tends to flow downslope and is known as katabatic flow. As the daytime anabatic breeze flows up the Rio Grande valley, it adds a southerly component to the prevailing westerlies of the Pajarito Plateau. Nighttime katabatic flow enhances the local westerly winds. Flow in the east-west-oriented canyons of the Pajarito Plateau is generally aligned with the canyons, so canyon winds are usually from the west at night as katabatic flow and from the east during the day.

5. 2009 in Perspective

Figure 4-21 presents a graphical summary of Los Alamos weather for 2009. The figure depicts the year's monthly average temperature ranges, monthly precipitation, and monthly snowfall totals compared to monthly normals (averages during the 1971–2000 time period). Table 4-15 presents a tabular perspective of Los Alamos weather during 2009.

The year 2009 was slightly warmer and drier than normal. The average annual temperature in 2009 of 48.7°F exceeded the normal annual average of 47.9°F by 0.8°F. The total precipitation of 18.6 in. was 98% of normal (18.95 in.). The first half of the year was generally warmer than normal and the second half was colder than normal, with the exception of November in particular. The year began with two very dry months but precipitation caught up during a very wet May through July. August and November were again very dry, and September, October, and December had roughly normal precipitation. Although precipitation amounts see-sawed during 2009, the total at year's end was close to normal. And despite over 14 inches of snow from December 6 to 7, the year ended with only 74% of the normal year's total snowfall, or 43.3 inches.

Temperature and precipitation data have been collected in the Los Alamos area since 1910. Figure 4-22 shows the historical record of temperatures in Los Alamos from 1925 through 2009. The annual average temperature is not the average temperature per se, but the mid-point between daily high and low temperatures, averaged over the year. One-year averages are shown in green in Figure 4-22. Every year since 1998 has been warmer than the 1971–2000 normal, which is just under 48°F. To aid in showing longer-term trends, the five-year running mean is also shown. With five-year averaging, for example, it appears that the warm spell during the past decade is not as extreme as the warm spell during the early-to-mid 1950s. On the other hand, the current warm trend is much longer-lived with twelve straight years of above average temperatures.

Table 4-15
Monthly and Annual Climatological Data for Los Alamos During 2009

Month	Temperatures[a] (°F)								Precipitation[a] (inches)				12-meter wind[b] (mph)				
	Averages				Extremes						Snowfall				Peak Gusts		
	Daily Maximum	Daily Minimum	Overall	Departure[c]	Highest	Date	Lowest	Date	Total	Departure[c]	Total	Departure[c]	Average Speed	Departure[d]	Speed	From	Date
January	41.6	21.9	31.7	3.1	50	19th	10	28th	0.26	-0.7	4.8	-9.0	5.2	-0.2	40.3	NW	27th
February	48.3	25.7	37.0	4.0	63	23rd	13	15th	0.02	-0.73	0.2	-8.8	7.3	1.0	42.8	WNW	17th
March	53.2	29.0	41.1	2.2	66	21st	14	27th	1.18	-0.1	8.7	-2.2	8.7	1.6	55.1	W	30th
April	58.5	33.9	46.2	0.3	74	30th	19	2nd	1.31	0.26	9.8	5.0	9.1	0.9	56.9	WSW	3rd
May	71.3	45.9	58.6	3.8	82	20th	32	3rd	2.14	0.71	0	-0.9	8.5	0.4	39.2	WNW	13th
June	73.6	50.7	62.1	-2.6	83	23rd	41	3rd	2.67	1.23	0	0	7.5	-0.5	44.3	N	3rd
July	81.4	56.0	68.7	1.1	88	13th	48	30th	4.01	1.04	0	0	7.6	0.7	50.4	NNE	21st
August	80.4	54.0	67.2	1.8	89	5th	46	26th	1.66	-1.67	0	0	7.7	1.2	50.4	SSW	12th
September	70.6	46.4	58.5	-0.9	81	2nd	32	22nd	1.95	-0.13	0	0.1	7.2	0.5	44.8	W	30th
October	57.6	35.5	46.6	-2.3	69	19th	16	29th	1.87	0.33	1.6	-1.3	7.3	0.9	49.5	NW	20th
November	53.3	30.1	41.7	4.7	67	6th	17	16th	0.26	-0.93	1.6	-3.7	6.0	0.3	33.1	WSW	13th
December	33.0	14.9	23.9	-5.9	48	1st	-2	4th	1.27	0.35	16.7	5.6	5.8	0.4	59.6	WNW	8th
Year	**60.3**	**37.1**	**48.7**	**0.8**	**89**	**Aug 5**	**-2**	**Dec 4**	**18.6**	**-0.35**	**43.4**	**-15.3**	**7.3**	**0.5**	**59.6**	**WNW**	**Dec 8**

[a] Data from Technical Area 6, the official Los Alamos weather station.

[b] Wind data from Technical Area 53. Technical Area 6 wind data were too incomplete in 2009 to extract monthly values.

[c] Departure columns indicate positive or negative departure from 1971-2000 (30-year) climatological norm.

[d] Departure column indicates positive or negative departure from 1992-2009 (18-year) climatological norm.

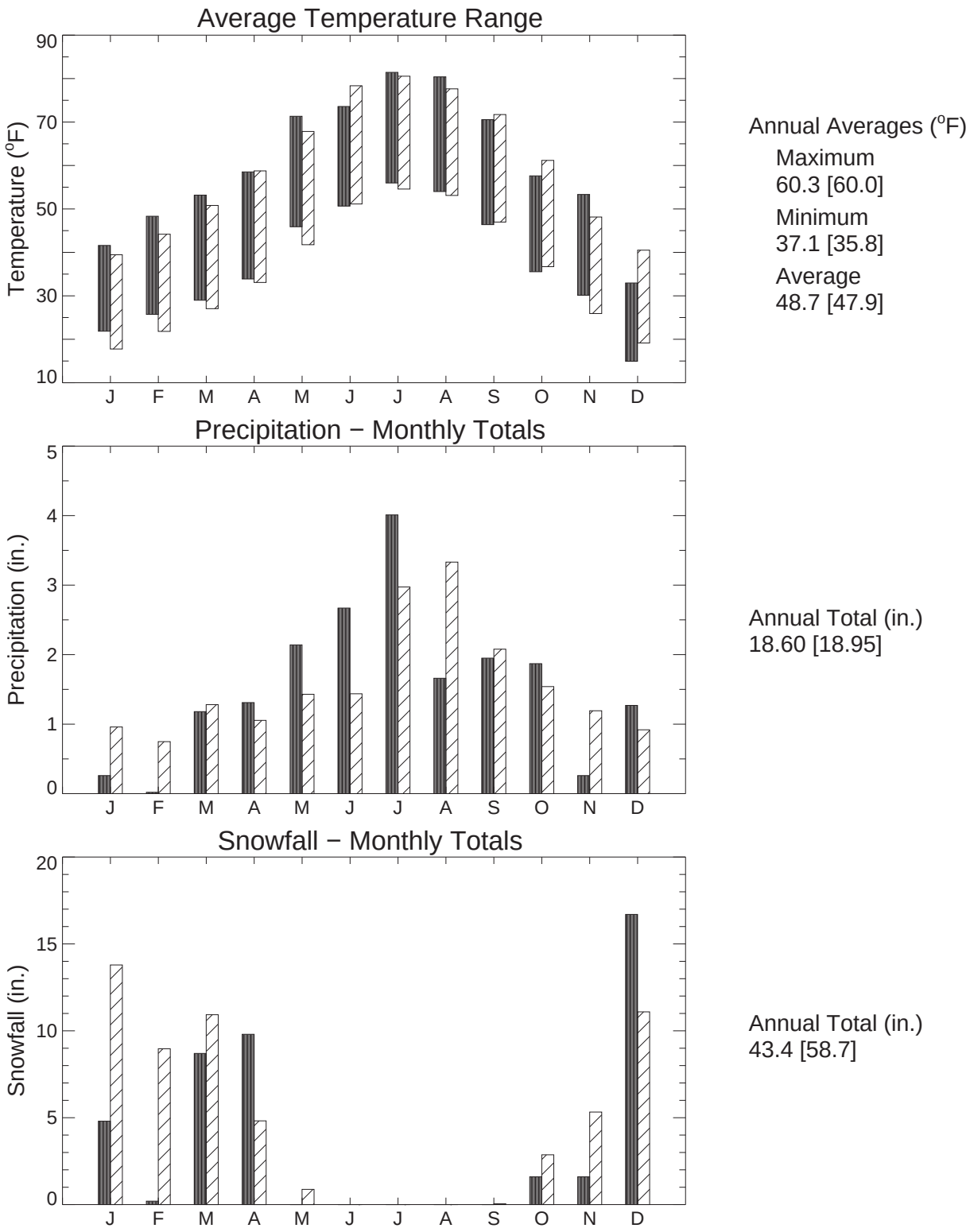


Figure 4-21. Weather summary for Los Alamos for 2009 at the TA-6 meteorology station.

Figure 4-23 shows the historical record of the annually summed total precipitation. The most recent drought spanned the years 1998 through 2003, and 2004 and 2005 brought surplus precipitation to help restore normal conditions. The 2009 total of 18.6 in. was slightly below normal. As with the historical temperature profile, the five-year running mean is also shown. The five-year average suggests not only that the recent drought is behind us, but that it was the most severe drought during the 80-year record. The 1998 to 2003 drought was longer lived than the 1950's drought, which still holds the record for the driest year in recorded history (1956).

Daytime winds (sunrise to sunset) and nighttime winds (sunset to sunrise) are shown in the form of wind roses in Figure 4-24. Wind roses depict the percentage of time that wind blows from each of 16 direction bins. For example, winds are directly from the south at TA-6 over 12% of the time during days in 2009. Winds are directly from the north about 3% of the time during the day. Wind roses also show the distribution of wind speed. About 6% of the time, for example, winds at TA-6 are from the south and range from 2.5 to 5 meters per second. Winds from the south at TA-6 exceed 7.5 meters per second only a fraction of 1% of the time, and winds are calm there 1.2% of the time.

The wind roses are based on 15-minute-averaged wind observations for 2009 at the four Pajarito Plateau stations. Although it is not shown here, wind roses from different years are almost identical, indicating that wind patterns are constant when averaged over a year.

Daytime winds measured by the four Pajarito Plateau stations are predominately from the south, consistent with the typical upslope flow of heated daytime air moving up the Rio Grande valley. Nighttime winds on the Pajarito Plateau are lighter and more variable than daytime winds and typically have a westerly component, resulting from a combination of prevailing westerly winds and downslope katabatic flow of cooled mountain air.

Winds on the Pajarito Plateau are faster during the day than at night. This is due to vertical mixing that is driven by sunshine. During the day, the mixing is strong and brings momentum down to the surface, resulting in faster surface winds. At night, there is little mixing so wind at the surface receives less boosting from aloft.

F. QUALITY ASSURANCE PROGRAM

1. Quality Assurance Program Development

During 2009, the air quality monitoring and compliance organizations implemented approximately 18 revised procedures and three QA project plans to reflect constant improvements. These plans and procedures describe or prescribe all planned and systematic activities needed to provide confidence that processes perform satisfactorily. Quality-related documents are available at www.lanl.gov/environment/air/qa.shtml.

2. Field Sampling Quality Assurance

a. Methods

Overall quality of this portion of the program is maintained through the rigorous use of documented procedures that govern all aspects of the sample collection program.

Particulate and water-vapor samples are (1) collected from commercially available media of known performance, (2) collected under common chain-of-custody procedures using field-portable electronic data systems to minimize the chances of data transcription errors, and (3) prepared in a secure and radiologically clean laboratory for shipment. We deliver the samples to all internal and external analytical laboratories under full chain-of-custody, including secure FedEx shipment, and track them at all stages of their collection and analysis through the AIRNET and RADAIR relational databases.

Field sampling completeness is assessed every time the analytical laboratory returns the AIRNET biweekly gross alpha/beta data. RADAIR field sampling completeness is evaluated each week upon receipt of the gross alpha/beta and tritium bubbler data. All these calculations are performed for each ambient air and stack sampling site and are included in the QA memo prepared by stack monitoring staff to evaluate every data group received from a supplier.

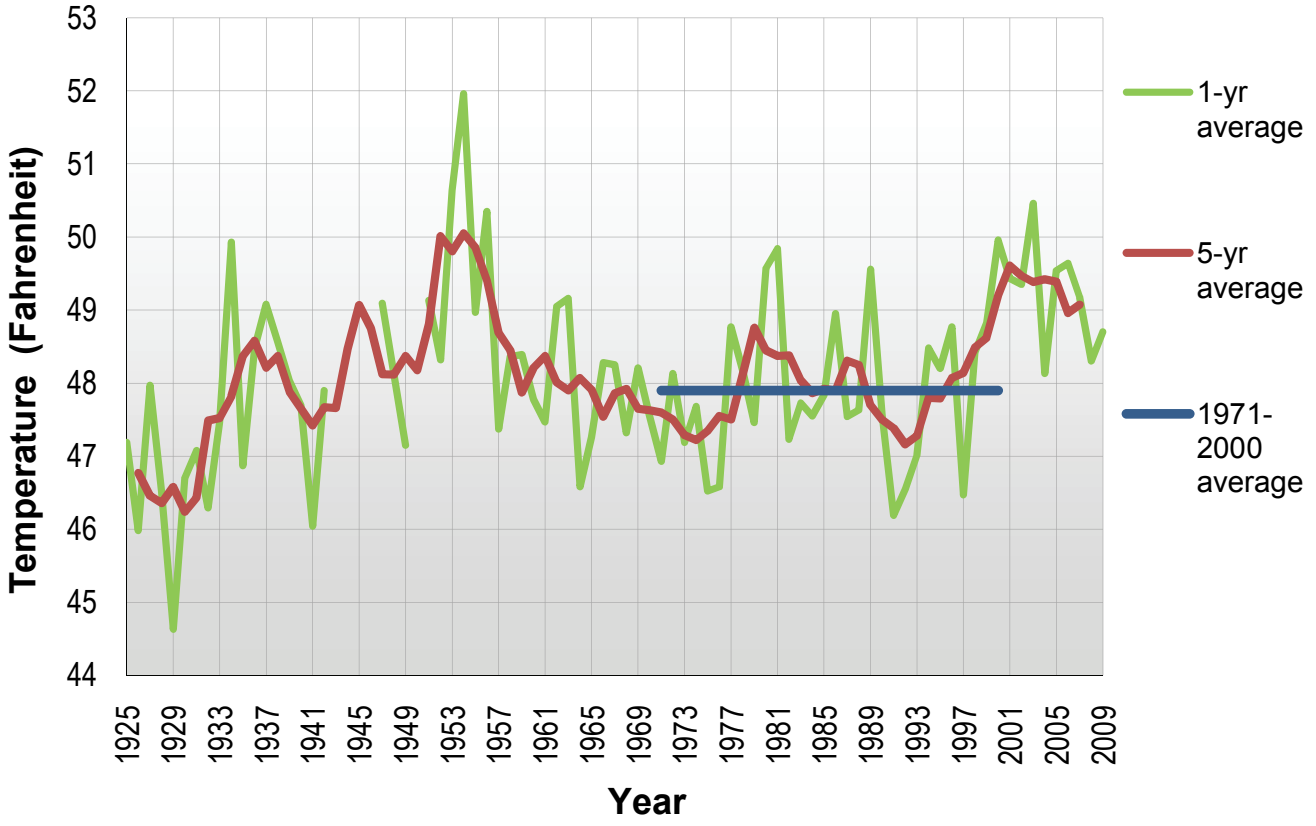


Figure 4-22. Temperature history for Los Alamos.

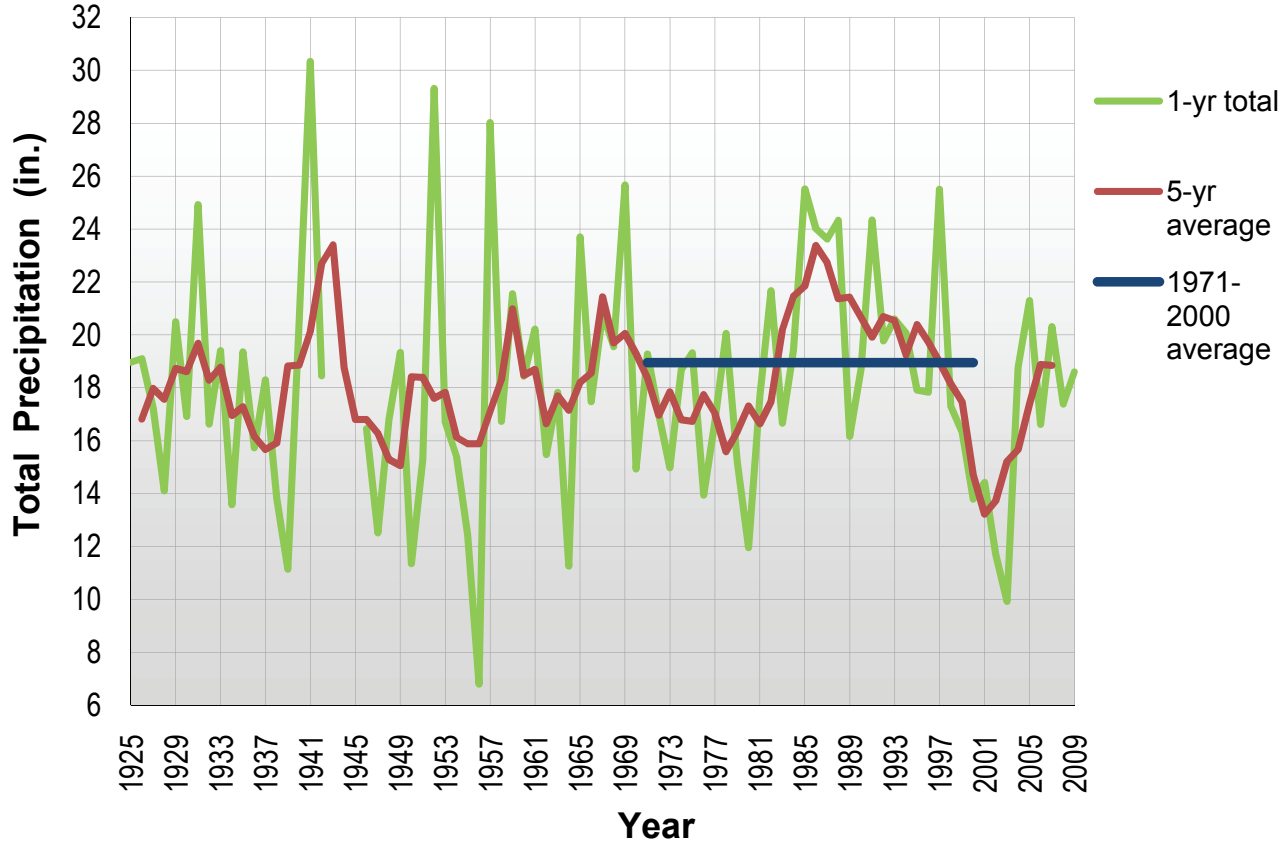


Figure 4-23. Total precipitation history for Los Alamos.

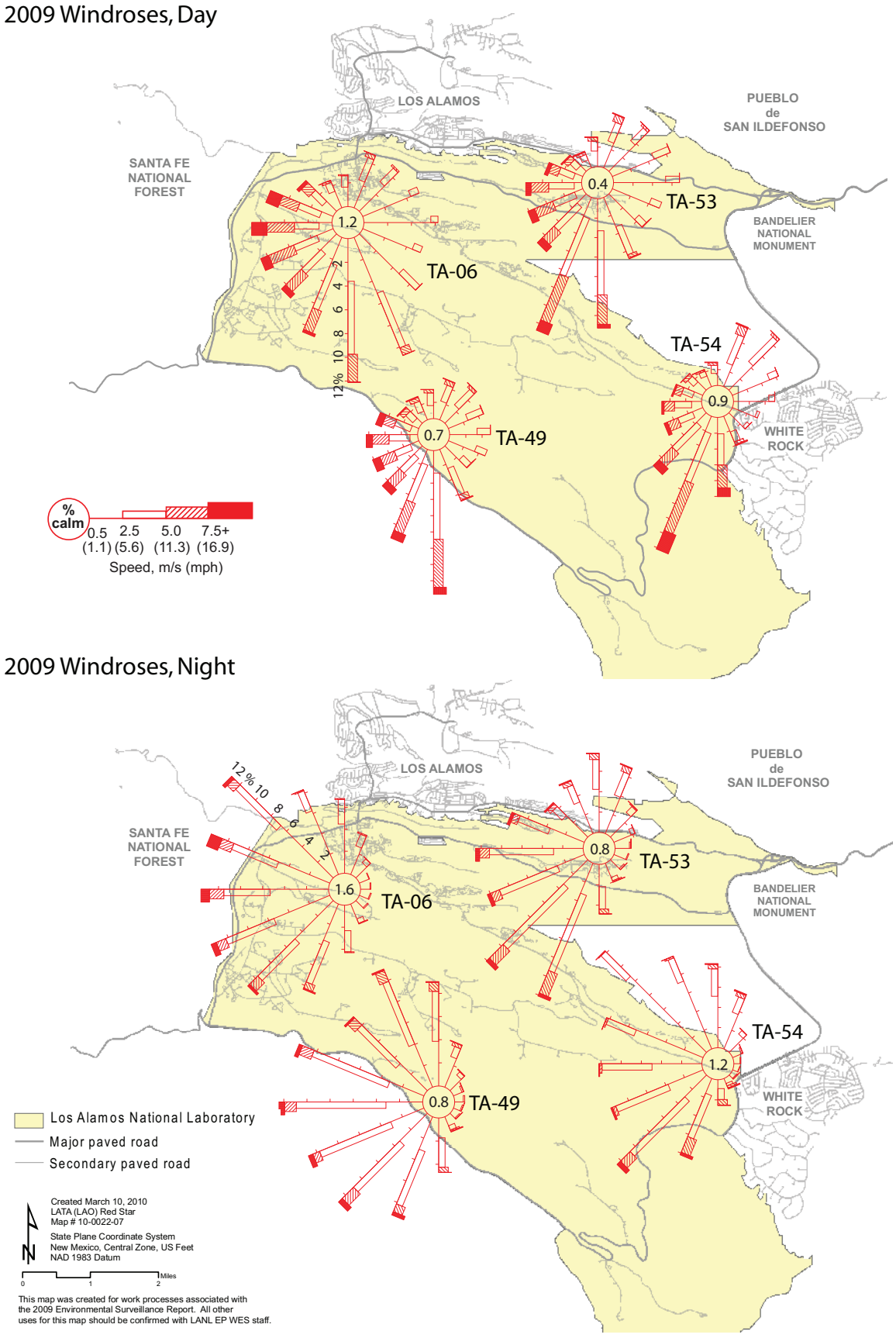


Figure 4-24. Daytime and nighttime wind roses for 2009.

b. Results

Field sample completeness for AIRNET was 100% for filters and 98.4% for silica gel (tritium samples). Field sample completeness for stack samples was 100%. In AIRNET the sample run time was 98.5% for filters and 98.2% for gels. The stack run time was 99.65%.

3. Analytical Laboratory Quality Assessment

a. Method

LANL writes specific statements of work to govern the acquisition and delivery of analytical-chemistry services after the Data Quality Objective process has identified and quantified our program objectives. We send these statements of work to potentially qualified suppliers who undergo a pre-award, on-site assessment by experienced and trained quality systems and chemistry-laboratory assessors. Statement of work specifications, professional judgment, and quality system performance at each laboratory, including recent past performance on nationally conducted performance evaluation programs, are primarily used to award contracts for specific types of radiochemical and inorganic chemical analyses.

Each analytical laboratory conducts its chain-of-custody and analytical processes under its own quality plans and analytical procedures. We submit independently prepared blind spiked samples with each sample set to be analyzed for tritium. Preliminary data are returned by email in an electronic data deliverable of specified format and content. The analytical laboratory also submits a full paper set of records that serves as the legally binding copy of the data. Each set of samples contains all the internal QA/quality control data the analytical laboratory generates during each phase of analysis, including laboratory control standards, process blanks, matrix spikes, duplicates, and replicates, when applicable. The electronic data are uploaded into either the AIRNET or RADAIR databases and immediately subjected to a variety of quality and consistency checks. Analytical completeness is calculated, tracking and trending of all blank and control-sample data is performed, and all tracking information documented in the quality assessment memo mentioned in the field sampling section. All parts of the data management process are tracked electronically in each database, and periodic reports to management are prepared.



b. Results

Analytical data completeness was 100% for AIRNET filters, 98.4% for AIRNET silica gel, and 97.866% for stacks. The overall results of the quality monitoring in 2009 indicate that all analytical laboratories maintained the same high level of control observed in the past several years.

4. Analytical Laboratory Assessments

During 2009, one internal and one external laboratory performed all analyses reported for AIRNET and stack samples. Paragon Analytics, Inc., Fort Collins, Colorado, provided the following analyses:

- Biweekly gross alpha, gross beta, and gamma analyses of filters for AIRNET.
- Biweekly analyses for tritium in AIRNET silica gel.
- Weekly gross alpha, gross beta, gamma, and stable beryllium analyses on stack samples.
- Quarterly analyses for alpha-emitting isotopes (americium, plutonium, and uranium) and stable beryllium, calcium, and aluminum on AIRNET quarterly composite samples.
- Semester analyses of composites of stack filters for gross alpha, gross beta, americium-241, gamma-emitting isotopes, lead-210, polonium-210, plutonium isotopes, strontium-90, thorium isotopes, and uranium isotopes.

The Laboratory's on-site Health Physics Analytical Laboratory (HSR-4) performed instrumental analyses of tritium in stack emissions.

LANL assessed Paragon Analytics during 2006, and we found that the laboratory provides very high quality work in compliance with all LANL requirements. This laboratory has consistently performed well. The laboratory annually participates in two national performance evaluation studies and the study sponsors have consistently judged the analytical laboratory to have acceptable performance for all analytes attempted in all air sample matrices.

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5. Groundwater Monitoring



contributing authors:
David B. Rogers and Nita Patel

To Read About **Turn to Page**

Introduction 131
Hydrogeologic Setting 131
Groundwater Standards 137
Monitoring Network 138
Summary of 2009 Sampling Results 143
Groundwater Sampling Results by Constituents 147
Groundwater Sampling Results by Watershed 152
Quality Assurance of Groundwater, Surface Water, and Sediment Analyses 196
References 202

A. INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) routinely analyzes groundwater samples to monitor water quality beneath the Pajarito Plateau and the surrounding area. The Laboratory conducts groundwater monitoring and characterization programs to comply with the requirements of the Department of Energy (DOE) Orders and New Mexico (NM) and federal regulations. The objectives of the Laboratory's groundwater programs are to determine compliance with waste discharge requirements and to evaluate any impact of Laboratory activities on groundwater resources.

Because of the Laboratory's semiarid, mountainside setting, significant groundwater is found only at depths of more than several hundred feet. The Los Alamos County public water supply comes from supply wells that draw water from deep zones of the regional aquifer, the top of which is found at a depth that ranges between 600 to 1,200 ft. Groundwater protection efforts at the Laboratory focus on the regional aquifer underlying the area and also include the shallow perched groundwater found within canyon alluvium and the perched groundwater at intermediate depths above the regional aquifer.

Most of the groundwater monitoring conducted during 2009 was carried out according to the Interim Facility-wide Groundwater Monitoring Plans (LANL 2008a, 2009a) approved by the New Mexico Environment Department (NMED) under the Compliance Order on Consent (Consent Order). The LANL Environmental Programs Directorate collected groundwater samples from wells and springs within or adjacent to the Laboratory and from the nearby Pueblo de San Ildefonso.

B. HYDROGEOLOGIC SETTING

The following sections describe the hydrogeologic setting of the Laboratory and include a summary of groundwater contaminant sources and distribution. Additional detail can be found in a report summarizing results of investigations conducted under the Hydrogeologic Workplan from 1998 through 2004 (LANL 2005a). This and many other reports are available at http://lanl.gov/environment/.

1. Geologic Setting

The Laboratory is located in northern New Mexico on the Pajarito Plateau, which extends eastward from the Sierra de los Valles, the eastern range of the Jemez Mountains (Figure 5-1). The Rio Grande borders the Laboratory on the east. Rocks of the Bandelier Tuff cap the Pajarito Plateau. The tuff was formed from volcanic ashfall deposits and pyroclastic flows that erupted from the Jemez Mountains volcanic center approximately 1.2 to 1.6 million years ago. The tuff is more than 1,000 ft thick in the western part of the plateau and thins eastward to about 260 ft adjacent to the Rio Grande.

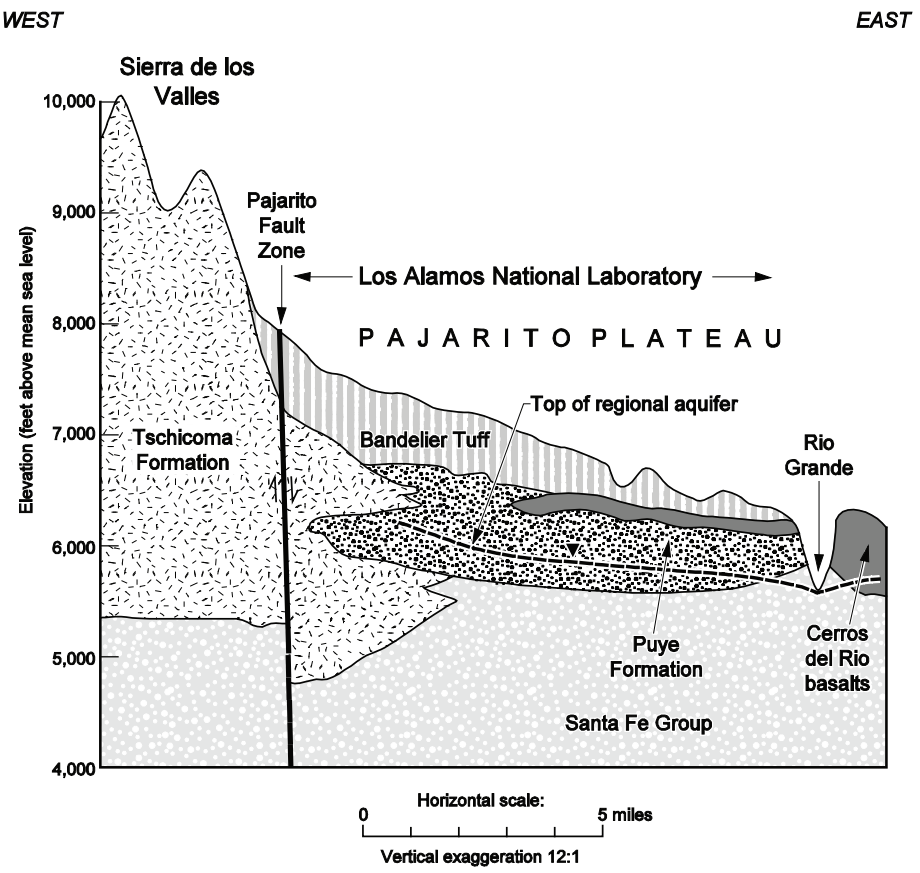


Figure 5-1. Generalized geologic cross-section of the Pajarito Plateau.

On the western part of the Pajarito Plateau, the Bandelier Tuff overlaps the Tschicoma Formation, which consists of older volcanics that form the Jemez Mountains (Figure 5-1). The Puye Formation conglomerate underlies the tuff beneath the central and eastern portion of the plateau. The Cerros del Rio basalt flows interfinger with the Puye Formation conglomerate beneath the Laboratory. These formations overlie the sediments of the Santa Fe Group, which extend across the Rio Grande Valley and are more than 3,300 ft thick.

2. Groundwater Occurrence

Due to its location on a semiarid mountainside, the Laboratory land sits atop a thick zone of mainly unsaturated rock, with the principal aquifer found 600 to 1,200 ft below the ground surface. Groundwater beneath the Pajarito Plateau occurs in three modes, two of which are perched (Figure 5-2). Perched groundwater is a zone of saturation with limited extent that is retained above less permeable layers and is separated from underlying groundwater by unsaturated rock.

The three modes of groundwater occurrence are (1) perched alluvial groundwater in canyon bottoms, (2) discontinuous zones of intermediate-depth perched groundwater whose location is controlled by availability of recharge and by subsurface changes in rock type and permeability, and (3) the regional aquifer beneath the Pajarito Plateau. The regional aquifer extends throughout the neighboring Española Basin.

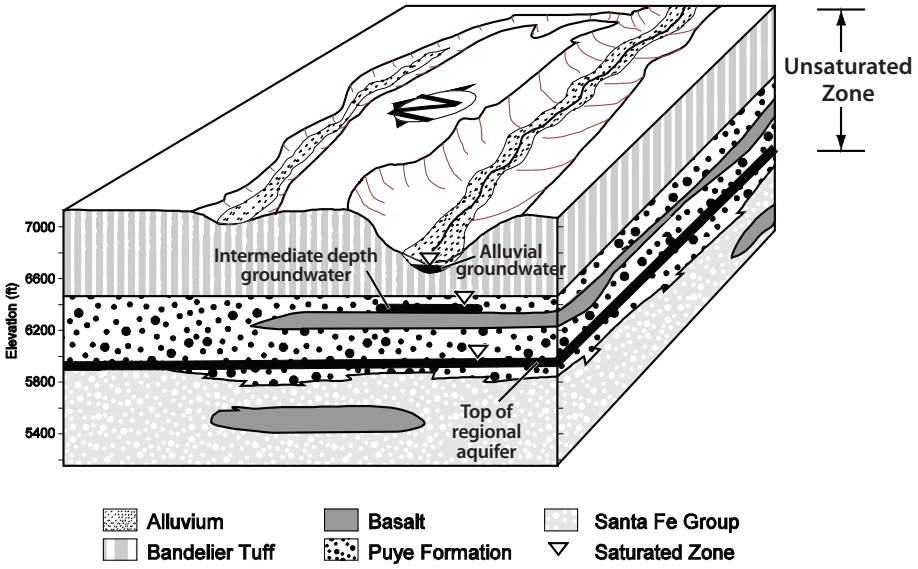


Figure 5-2. Illustration of geologic and hydrologic relationships in the Pajarito Plateau, showing the three modes of groundwater occurrence.

Stream runoff may be supplemented or maintained by Laboratory discharges. Many relatively dry canyons have little surface water flow and little or no alluvial groundwater. Streams have filled some parts of canyon bottoms with alluvium up to a thickness of 100 ft. In wet canyons, runoff percolates through the alluvium until downward flow is impeded by less permeable layers of tuff or other rock, maintaining shallow bodies of perched groundwater within the alluvium. These saturated zones have limited extent; evapotranspiration and percolation into underlying rocks deplete the alluvial groundwater as it moves down the canyon.

Underneath portions of Pueblo, Los Alamos, Mortandad, Sandia, and other canyons, intermediate perched groundwater occurs within the lower part of the Bandelier Tuff and the underlying Puye Formation and Cerros del Rio basalt (Figure 5-2). These intermediate-depth groundwater bodies are formed in part by recharge from the overlying perched alluvial groundwater. The intermediate groundwater may be discontinuous or may connect with other zones across canyons. Depths of the intermediate perched groundwater vary. For example, the depth to intermediate perched groundwater is approximately 120 ft in Pueblo Canyon, 450 ft in Sandia Canyon, and 500–750 ft in Mortandad Canyon.

Some intermediate perched groundwater occurs in volcanic rocks on the flanks of the Sierra de los Valles to the west of the Laboratory. This water discharges at several springs and yields a significant flow from a gallery in Water Canyon. Two types of intermediate groundwater occur in the southwest portion of the Laboratory just east of the Sierra de los Valles. A number of intermediate springs, fed by local recharge, discharge from mesa edges along canyons. Also, intermediate groundwater is found in the Bandelier Tuff at a depth of approximately 700 ft. The source of this deeper perched groundwater may be percolation from streams that discharge from canyons along the mountain front or may be underflow of recharge from the Sierra de los Valles.

The regional aquifer occurs at a depth of 1,200 ft along the western edge of the plateau and 600 ft along the eastern edge (Figures 5-1 and 5-3). The regional aquifer lies about 1,000 ft beneath the mesa tops in the central part of the plateau. This is the only aquifer in the area capable of serving as a municipal water supply. Water in the regional aquifer generally flows east or southeast toward the Rio Grande. Groundwater model studies indicate that underflow of groundwater from the Sierra de los Valles is the main source of regional aquifer recharge (LANL 2005a). Groundwater velocities vary spatially but are typically 30 ft/yr.

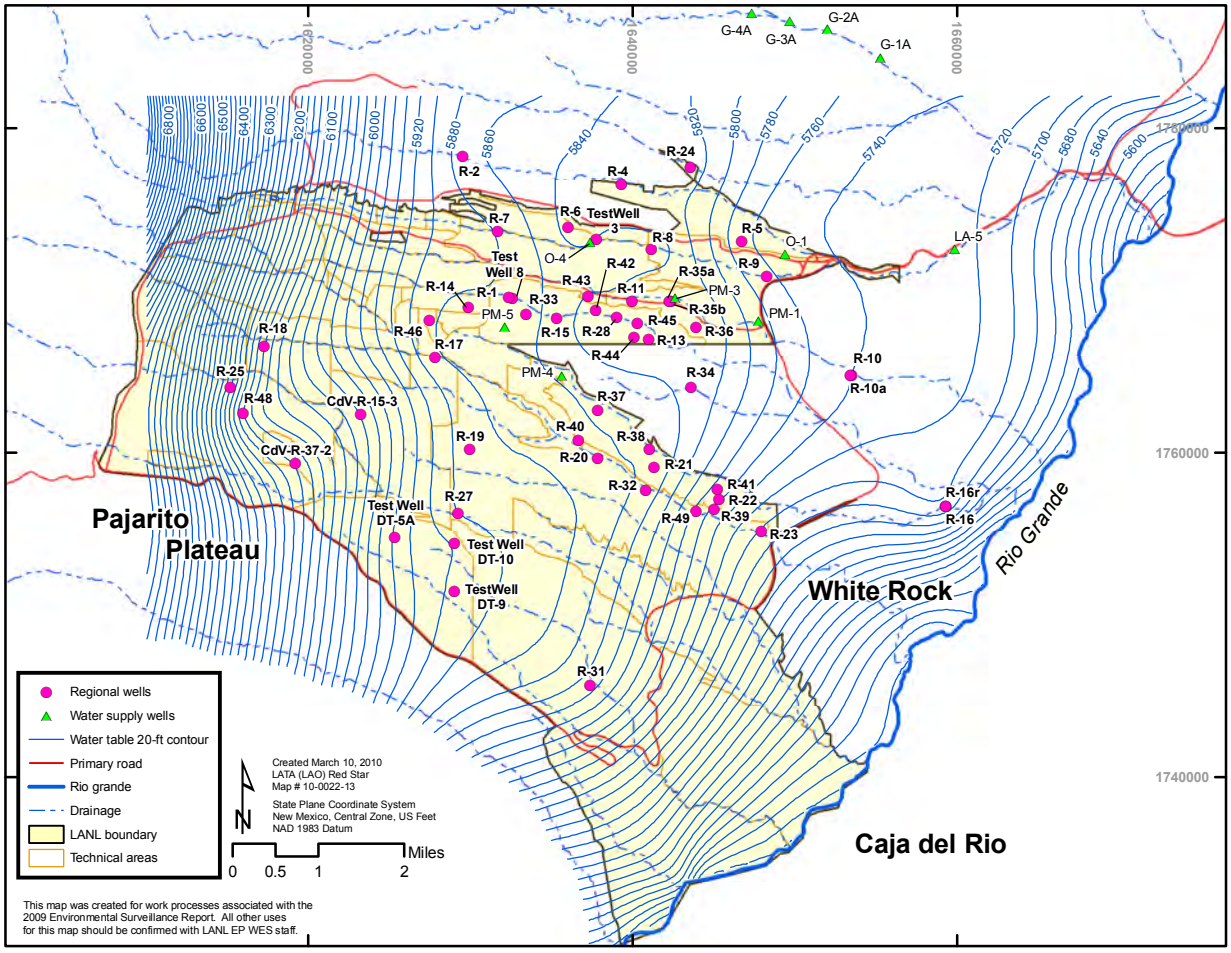


Figure 5-3. Contour map of average water table elevations for the regional aquifer (based on a map in LANL 2009b). This map represents a generalization of the data; other interpretations are possible.

The surface of the aquifer rises westward from the Rio Grande within the Tesuque Formation, part of the Santa Fe Group (Figure 5-1). Underneath the central and western part of the plateau the aquifer rises farther into the Cerros del Rio basalt and the lower part of the Puye Formation.

The regional aquifer is separated from alluvial and intermediate perched groundwater by approximately 350 to 620 ft of unsaturated tuff, basalt, and sediments with generally low moisture content (<10%). Water lost by downward seepage from alluvial and intermediate groundwater zones travels through the underlying rock by unsaturated flow. This percolation is a source of certain contaminants, mobile in water, which may reach the regional aquifer within a few decades. The limited extent of the alluvial and intermediate groundwater bodies, along with the dry rock that underlies them, restricts their volumetric contribution to recharge reaching the regional aquifer.

3. Overview of Groundwater Quality

Since the 1940s, liquid effluent discharge by the Laboratory has affected water quality in the shallow perched alluvial groundwater that lies beneath the floor of a few canyons. Liquid effluent discharge is also the primary means by which Laboratory contaminants have affected the quality of intermediate perched zones and the regional aquifer. Where contaminants are found at depth, the setting is either a canyon where alluvial groundwater is usually present (perhaps because of natural runoff or Laboratory effluents) or a location beneath a mesa-top site where large amounts of liquid effluent have been discharged.

The contaminated alluvial and intermediate perched groundwater bodies are separated from the regional aquifer by hundreds of feet of dry rock, so recharge from the shallow groundwater occurs slowly. As a result, less contamination reaches the regional aquifer than is found in the shallow perched groundwater bodies, and impacts on the regional aquifer are reduced or not present.

Drainages that received liquid radioactive effluents include Mortandad Canyon, Pueblo Canyon from its tributary Acid Canyon, and Los Alamos Canyon from its tributary DP Canyon (Figure 5-4). Rogers (2001) and Emelity (1996) summarize radioactive effluent discharge history at the Laboratory.

Because of releases of power plant cooling water and water from the Laboratory's Sanitary Wastewater Systems (SWWS) Plant, Sandia Canyon has received the largest liquid discharge volumes of any canyon. Water Canyon and its tributary Cañon de Valle have received effluents produced by high explosives (HE) processing and experimentation (Glatzmaier 1993; Martin 1993).

Over the years, Los Alamos County has operated several sanitary wastewater treatment plants in Pueblo Canyon (ESP 1981). Only the Los Alamos County Wastewater Treatment Plant is currently operating. The Laboratory has also operated numerous sanitary treatment plants, three of which are shown in Figure 5-4.

Since the early 1990s, the Laboratory has significantly reduced both the number of industrial outfalls (from 141 to 17) and the volume of water released (by more than 80%). From 1993 to 1997, total estimated average flow was 1,300 million gallons per year (M gal./yr); flow decreased to 230 M gal./yr from 1998 to 2005 (Rogers 2006) and to 133 M gal./yr in 2009. The quality of the remaining discharges has been improved through treatment process improvements so that they meet applicable standards.

Certain chemicals are good indicators of the possible effect of Laboratory effluents on groundwater. These chemicals are described as being chemically conservative; that is, their concentrations are usually not affected by chemical reactions. Examples of these conservative chemicals include perchlorate, tritium, hexavalent chromium, and, to a lesser extent, nitrate. Nitrate is often conservative but its concentration may be affected by bacterial activity. Groundwater that has background concentrations of perchlorate, tritium, hexavalent chromium, and nitrate is not necessarily affected by LANL discharges.

Liquid effluent discharges have affected intermediate perched groundwater and the regional aquifer to a lesser degree. The intermediate groundwater in various locations shows localized contamination from Laboratory operations, including presence of tritium, high explosives compounds, chlorinated organic chemical compounds, dioxane(1,4-), hexavalent chromium, barium, boron, perchlorate, fluoride, and nitrate.



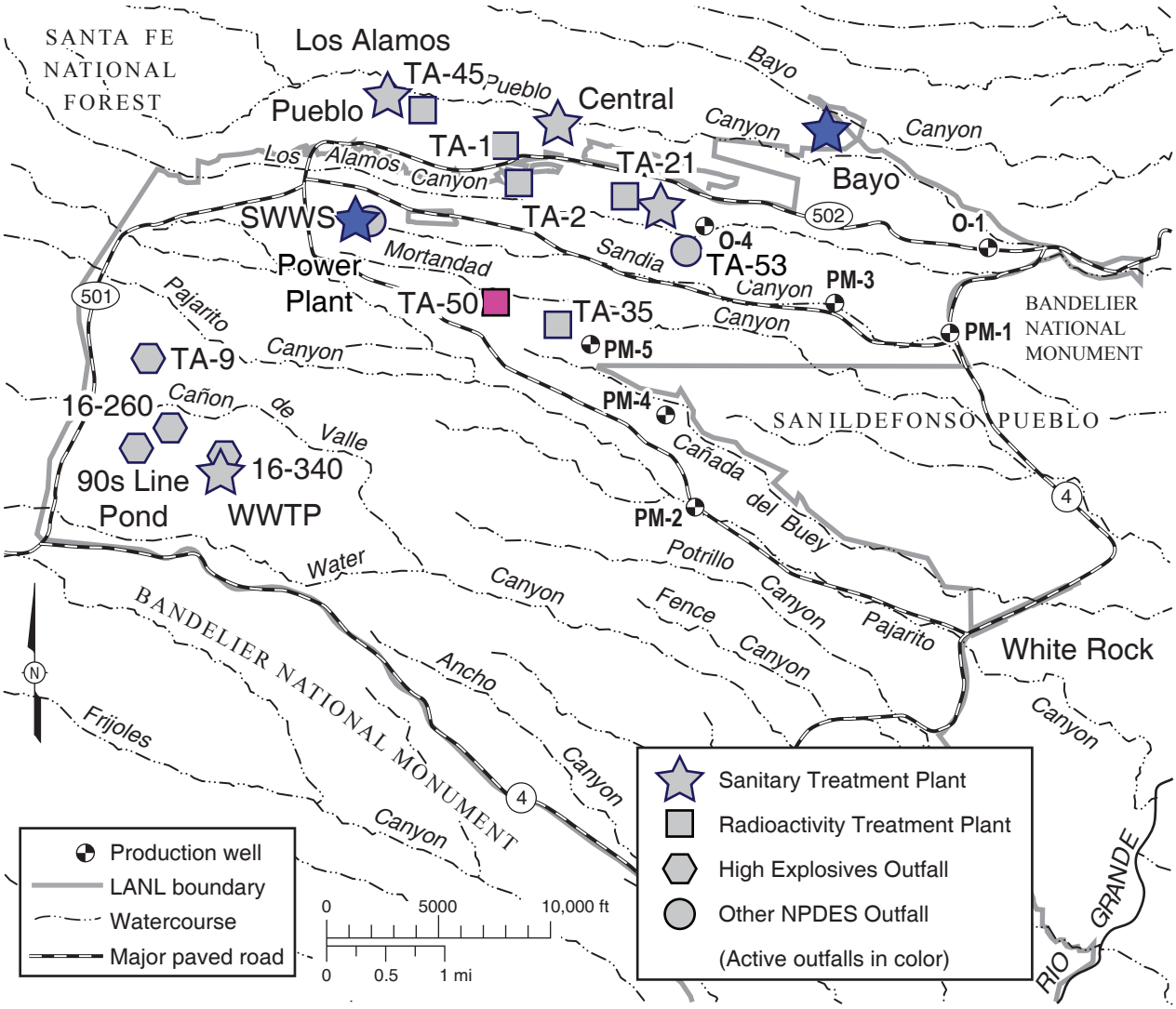


Figure 5-4. Major liquid release sources (effluent discharge) potentially affecting groundwater. Most outfalls shown are inactive.

In 2009, the HE compound Research Department Explosive (RDX) continued to be detected in the regional aquifer at Pajarito Canyon monitoring well R-18. The RDX concentration was at 10% of the Environmental Protection Agency's (EPA's) Human Health tap water screening level of 6.1 µg/L. Earlier detection of RDX in the regional aquifer at regional aquifer well R-25 (to the south of R-18) was probably due to cross-contamination from shallower well screens that occurred for several months before the sampling system was installed, allowing flow between the screens.

Hexavalent chromium and nitrate have been found in several regional aquifer monitoring wells. In regional aquifer monitoring wells R-42 and R-28 in Mortandad Canyon, hexavalent chromium is found at concentrations of about 20 times and eight times the 50 µg/L NM groundwater standard. Nitrate (as nitrogen) concentrations in regional aquifer monitoring wells R-43 and R-11 in Sandia Canyon and R-42 in Mortandad Canyon are up to 70% of the 10 mg/L NM groundwater standard. Traces of tritium and perchlorate are also found in the regional aquifer. Tritium activities are far below the EPA maximum concentration level (MCL) of 20,000 pCi/L, but at a few wells, perchlorate concentrations are above the 4 µg/L Consent Order screening level.

Beginning in late 2008, trichloroethene was detected at 1,147 ft in Pajarito Canyon regional aquifer monitoring well R-20. Trichloroethene detections have continued for five consecutive sample events through the end of 2009. The concentrations have increased to 60% of the 5 µg/L EPA MCL screening level.

With one exception, drinking water wells in the Los Alamos area have not been impacted by Laboratory discharges. The exception is well O-1 in Pueblo Canyon, where perchlorate was found during 2009 at concentrations up to 58% of the 4 µg/L Consent Order screening level. These values are also 16% of the Environmental Protection Agency's (EPA's) interim health advisory for perchlorate in drinking water of 15 µg/L. Even though the perchlorate levels are below regulatory limits, this well is not used by Los Alamos County for water supply. All drinking water produced by the Los Alamos County water supply system meets federal and state drinking water standards.

C. GROUNDWATER STANDARDS AND SCREENING LEVELS

In evaluating groundwater samples, we applied regulatory standards and risk levels as described in Table 5-1. For drinking water supply wells, which draw water from the regional aquifer, we compared concentrations of radionuclides in samples to (1) the derived concentration guides (DCGs) for ingested water calculated from DOE's 4-mrem/yr drinking water dose limit and (2) the EPA MCLs. EPA MCLs are the maximum permissible level of a contaminant in water delivered to any user of a public water system. Thus, compliance with the MCL is measured after treatment; measurements in a water supply well may be higher.

For radioactivity in groundwater other than drinking water, there are NM groundwater standards for uranium and radium. For risk-based screening of other radioactivity, groundwater samples from sources other than water supply wells may be compared with DOE's 4-mrem/yr drinking water DCGs and with EPA MCLs. The DCGs for the 100-mrem/yr public dose limit apply as effluent release guidelines. Where used in this chapter for such comparison purposes, in assessing water samples from sources other than water supply wells, these DCGs and EPA MCLs are referred to as screening levels.

The NM drinking water regulations and EPA MCLs apply as regulatory standards to nonradioactive constituents in water supply samples after treatment. They may be used as risk-based screening levels for other groundwater samples. The New Mexico Water Quality Control Commission (NMWQCC) groundwater standards (NMWQCC 2002) apply to concentrations of nonradioactive chemical quality parameters in all groundwater samples. Except for mercury and organic compounds, these standards apply only to dissolved (that is, filtered) concentrations. Because many metals are either chemically bound to or components of aquifer material that makes up suspended sediment in water samples, the unfiltered concentrations of these substances are often higher than the filtered concentrations. The EPA MCLs are intended for application to water supply samples that generally have low turbidity. As the EPA does not specify that the MCLs apply to dissolved concentrations, we use them to screen both filtered and unfiltered concentrations. The Consent Order specifies a screening level for perchlorate of 4 µg/L.

NMWQCC (2002) specifies how to determine standards for the toxic pollutants listed in the NMWQCC groundwater standards, if they have no other state or federal standard. Accordingly, we screened results for these compounds at a risk level of 10^{-5} for cancer-causing substances or a hazard quotient of one (HQ = 1) for non-cancer-causing substances. A HQ of one or less indicates that no (noncancer) adverse human health effects are expected to occur from that chemical. We used the EPA Human Health tap water screening levels to screen these toxic pollutant compounds (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm). For cancer-causing substances, the EPA Human Health tap water screening levels are at a risk level of 10^{-6}, so we use 10 times the values to screen at a risk level of 10^{-5}. These screening levels are updated several times each year; the April 15, 2009 edition was used to prepare this report.

Groundwater is a source of flow to springs and other surface water used by neighboring tribal members and wildlife. NMWQCC's surface water standards (NMWQCC 2000), including the wildlife habitat standards, also apply to this surface water (for a discussion of surface water, see Chapter 6).

Table 5-1
Application of Standards or Screening Levels to LANL Groundwater Monitoring Data

Constituent	Sample Type	Standard	Risk-Based Screening Level	Reference	Location	Notes
Radionuclides	Water supply wells	DOE 4-mrem/yr DCGs, EPA MCLs	None	DOE Order 5400.5, 40 CFR 141-143	On-site and off-site	A 4-mrem/yr dose limit and EPA MCLs apply to water provided to users of drinking water systems
Radionuclides	Effluent samples	DOE 100-mrem/yr DCGs	None	DOE Order 5400.5	On-site	DOE public dose limit of 100 mrem/yr applies to effluent discharges
Radionuclides	Non water supply groundwater samples	None	4-mrem/yr DCGs EPA MCLs	DOE Order 5400.5, 40 CFR 141-143	On-site and off-site	A 4-mrem/yr dose limit and EPA MCLs are for comparison purposes because they apply only to drinking water systems
Non-radionuclides	Water supply wells	EPA MCLs, NM groundwater standards, EPA Human Health 10^{-5}, and HQ = 1 tap water risk levels for NM toxic pollutants with no standard	None	40 CFR 141-143, 20.6.2 NM Administrative Code, http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm	On-site and off-site	EPA MCLs apply to water provided to users of drinking water systems; use EPA Human Health tap water table for 10^{-5} and HQ = 1 risk levels
Non-radionuclides	Non-water supply groundwater samples	NM groundwater standards, EPA Human Health 10^{-5} and HQ = 1 tap water risk levels for NM toxic pollutants with no standard	EPA MCLs	40 CFR 141-143, 20.6.2 NM Administrative Code, http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm	On-site and off-site	NMED regulations apply to all groundwater; EPA MCLs are for comparison purposes because they apply only to drinking water systems. Use EPA Human Health tap water table for 10^{-5} and HQ = 1 risk levels

D. MONITORING NETWORK

In 2005, DOE and its Operations and Management Contractor and NMED signed a Consent Order, which specifies the process for conducting groundwater monitoring at the Laboratory. The Consent Order requires that the Laboratory annually submit an Interim Facility Groundwater Monitoring Plan (Interim Plan) to NMED for its approval. The first Interim Plan was approved in June 2006 (LANL 2006). Groundwater monitoring conducted during calendar year 2009 was carried out according to two Interim Plans approved by NMED under the Consent Order (LANL 2008a, 2009a).

Groundwater sampling locations are divided into three principal groups related to the three modes of groundwater occurrence: perched alluvial groundwater beneath the floor of some canyons, localized intermediate-depth perched groundwater systems, and the regional aquifer (Figures 5-5 through 5-9).

To document the potential impact of Laboratory operations on Pueblo de San Ildefonso land, the DOE signed a memorandum of understanding in 1987 with the Pueblo and the Bureau of Indian Affairs to conduct environmental sampling on Pueblo land. Groundwater monitoring stations at Pueblo de San Ildefonso are shown in Figure 5-9 and mainly sample the regional aquifer. Basalt Spring, Los Alamos Spring, and Pine Rock Spring are intermediate groundwater sampling points, and wells LLAO-4 and LLAO-5 sample alluvial groundwater. The Laboratory also monitors Los Alamos County water supply wells (Figure 5-7) and three City of Santa Fe supply wells (Figure 5-9).

LANL conducts a regular program of water level measurements for monitoring wells. A summary of groundwater level measurements for 2009 is given in Koch et al. (2010).

1. Regional Aquifer and Intermediate Perched Groundwater Monitoring

Sampling locations for the regional aquifer and intermediate perched groundwater include monitoring wells, supply wells, and springs. The majority of the monitoring network consists of wells constructed since the Hydrogeologic Workplan (LANL 1998). The Laboratory added several new wells to the monitoring well network in 2009, as described in Chapter 2, Section B.9.b. A column on the supplemental data tables for Chapter 5 (located on the included compact disc) identifies the groundwater zones sampled by different ports of the wells and gives the depth of the sampled well port for multiscreen wells or top of the sampled well screen for single screen wells.

The Laboratory collected samples from 12 Los Alamos County water supply wells in three well fields that produce drinking water for the Laboratory and the community. The water supply wells are screened up to lengths of 1,600 ft within the regional aquifer, and they draw samples that integrate water over a large depth range. Los Alamos County owns and operates these wells and is responsible for demonstrating that the supply system meets Safe Drinking Water Act requirements. This chapter reports on supplemental sampling of those wells by the Laboratory.

Additional regional aquifer samples came from wells located on Pueblo de San Ildefonso lands and from the Buckman well field operated by the City of Santa Fe.

We also sample numerous springs near the Rio Grande because they represent natural discharge from the regional aquifer (Purtymun et al., 1980). Sampling the springs allows us to detect possible discharge of contaminated groundwater from underneath the Laboratory into the Rio Grande.

2. Alluvial Groundwater Monitoring

To determine the effect of present and past industrial discharges on water quality, we used shallow wells and some springs to sample perched alluvial groundwater in several canyons. In any given year, some of these alluvial observation wells may be dry, and water samples cannot be obtained. Some observation wells in Water, Fence, and Sandia canyons have been dry most often since their installation in 1989. All but one of the wells in Cañada del Buey are generally dry.

3. Well Redevelopment and Conversion

By conducting monitoring network well assessments in all of the Pajarito Plateau watersheds in 2007 and 2008, LANL determined the adequacy of wells in each watershed for producing representative groundwater quality and the need for additional wells. As part of these assessments, we identified the existing wells that could be adequate if rehabilitated. As a result, two wells were rehabilitated in 2007, three were rehabilitated in 2008, one was rehabilitated and another was partially rehabilitated in 2009. Rehabilitation involves active cleaning of the well, redevelopment of conditions near the screens, and conversion to a well with fewer screens and a different sampling system.

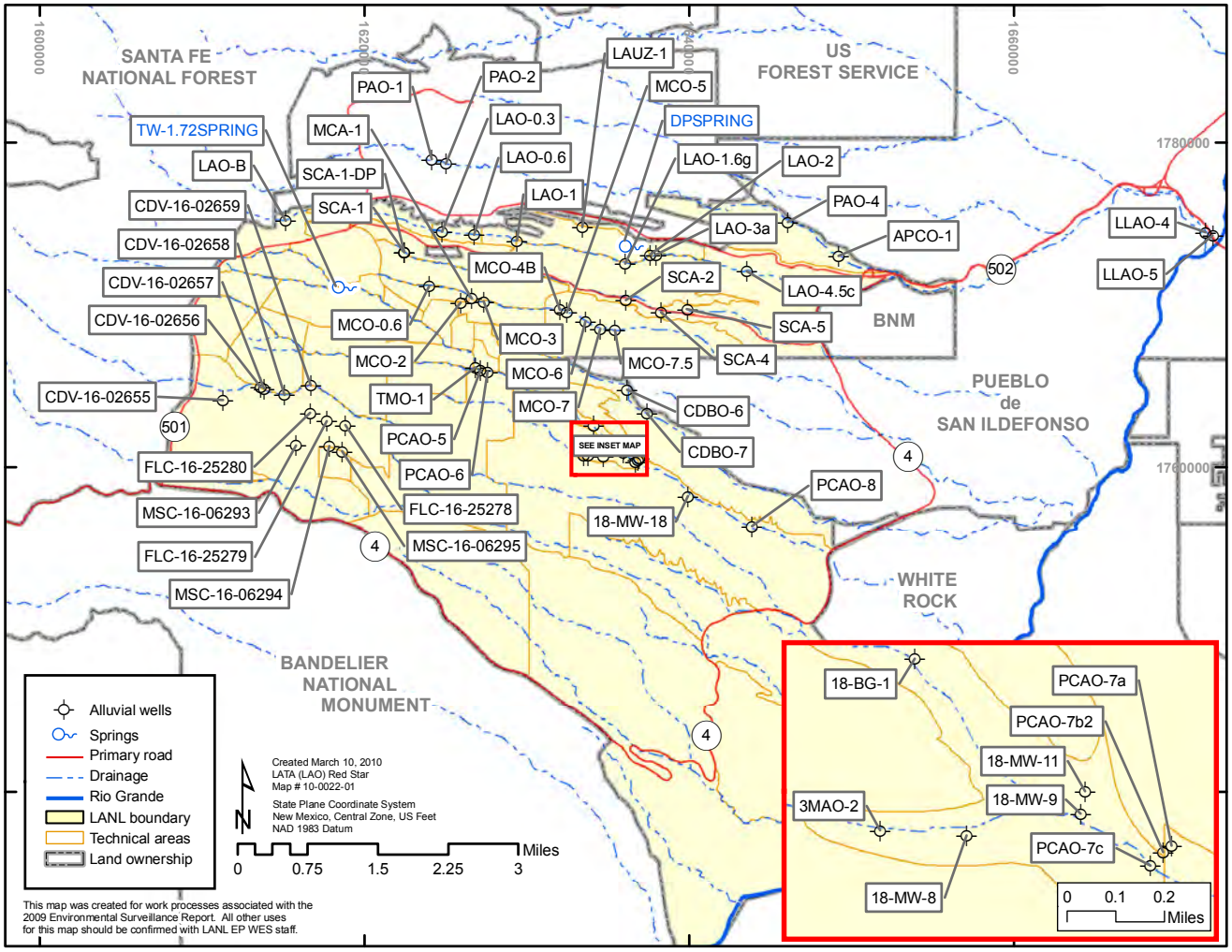


Figure 5-5. Springs and wells used for alluvial groundwater monitoring.

As background, in some LANL characterization wells the use of fluids to assist well drilling affected the chemistry of groundwater samples. From 1998 through 2006, more than 40 new wells were drilled for hydrogeologic characterization beneath the Pajarito Plateau as part of the Laboratory's Hydrogeologic Workplan (LANL 1998) or as part of corrective measures. Of these wells, some have screens in perched intermediate zones, most have screens in the regional aquifer, and a few have screens in both. Concerns about the reliability or representativeness of the groundwater quality data obtained from some wells stem from the potential for residual drilling fluids and additives to mask the present and future detection of certain contaminants.

Wells drilled since 2007 have been drilled without the use of drilling fluids other than water (with minor exceptions of using foam approximately 100 ft above the water table) in the saturated zone. These wells also undergo extensive well development at the outset to reduce the turbidity of water samples.

The project for rehabilitation of older characterization wells was completed in 2009 with redevelopment at R-22 and rehabilitation and conversion of R-16. These wells were selected for redevelopment because of their importance as locations for groundwater monitoring. At R-16, physical redevelopment methods included jetting with simultaneous pumping, swabbing, and additional extensive pumping. Following physical redevelopment, samples were collected and analyzed for key geochemical indicator parameters, as described in the "Well Screen Analysis Report, Rev. 2" (LANL 2007a), to determine the extent of the improvement in water quality.

At R-22, only a first phase of redevelopment was conducted. A summary of redevelopment results for each of the wells is as follows:

- R-16 was converted from a three-screen to a dual-screen well with a Baski sampling system, which allows active purging before sampling. The top screen and the bottom screen were retained and the middle screen was isolated from these with packers. The two screens that were retained improved in water quality and in hydraulic properties (LANL 2009c).
- R-22 has five screens. The lowermost screen had shown detections of tritium and the uppermost screen was in question as a viable screen. To better understand whether the tritium at screen 5 resulted from being carried down during well drilling or was real and to improve the quality of screen 1, only a first phase of redevelopment was conducted. The first phase consisted of conducting specific capacity tests at all five screens and in the open casing, followed by extensive purging at screen 5 (approximately 70,000 gallons) and extended pumping at a low rate for about two weeks at screen 1. Water quality results indicated an absence of tritium after the extended purging at screen 5. Screen 1 was shown to be viable for collecting water samples. Both screens showed minor organic concentrations. A detailed description of phase 1 activities is in LANL (2009d). A decision has not been made regarding phase 2 activities.

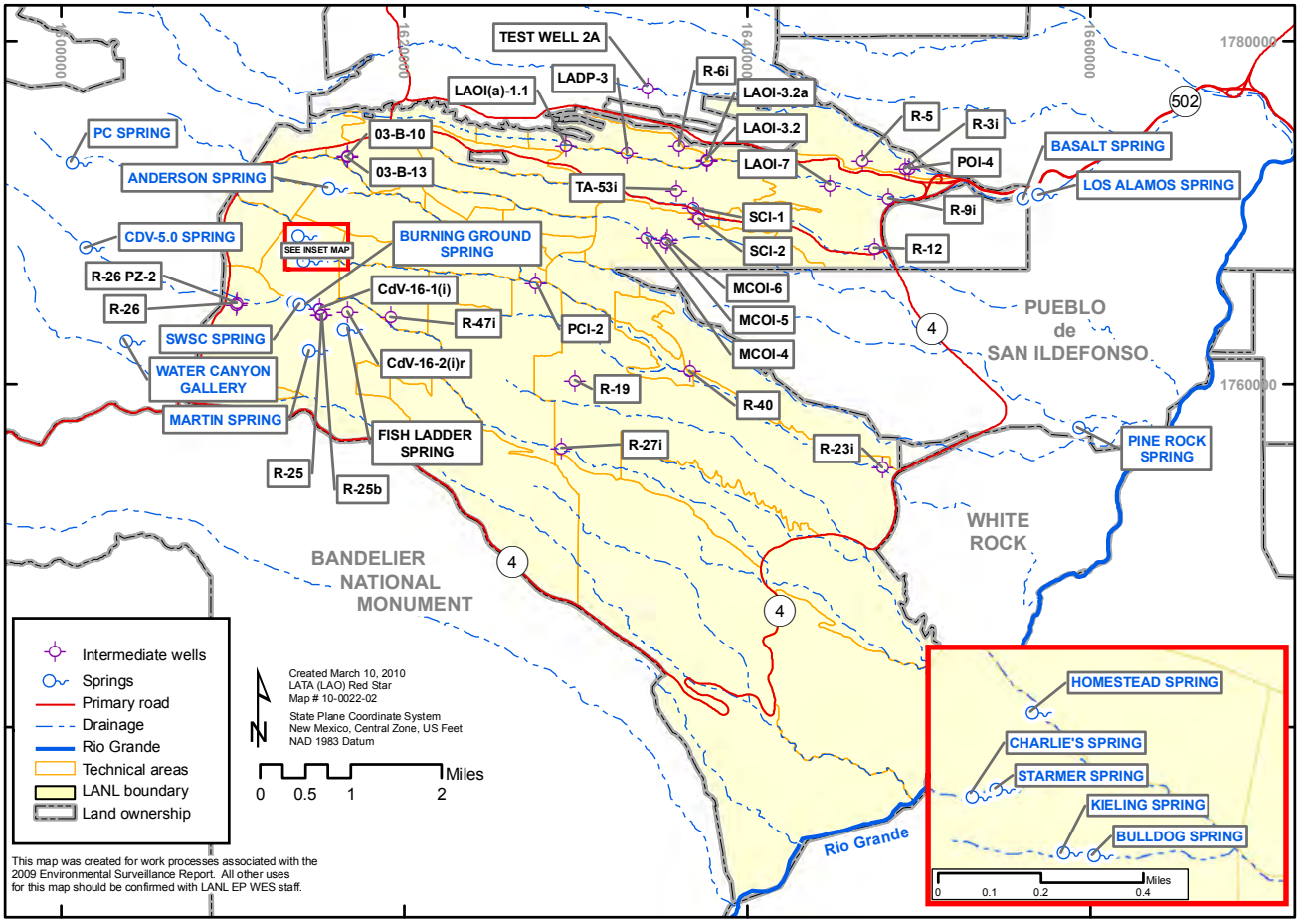


Figure 5-6. Springs and wells used for intermediate-depth perched zone monitoring.

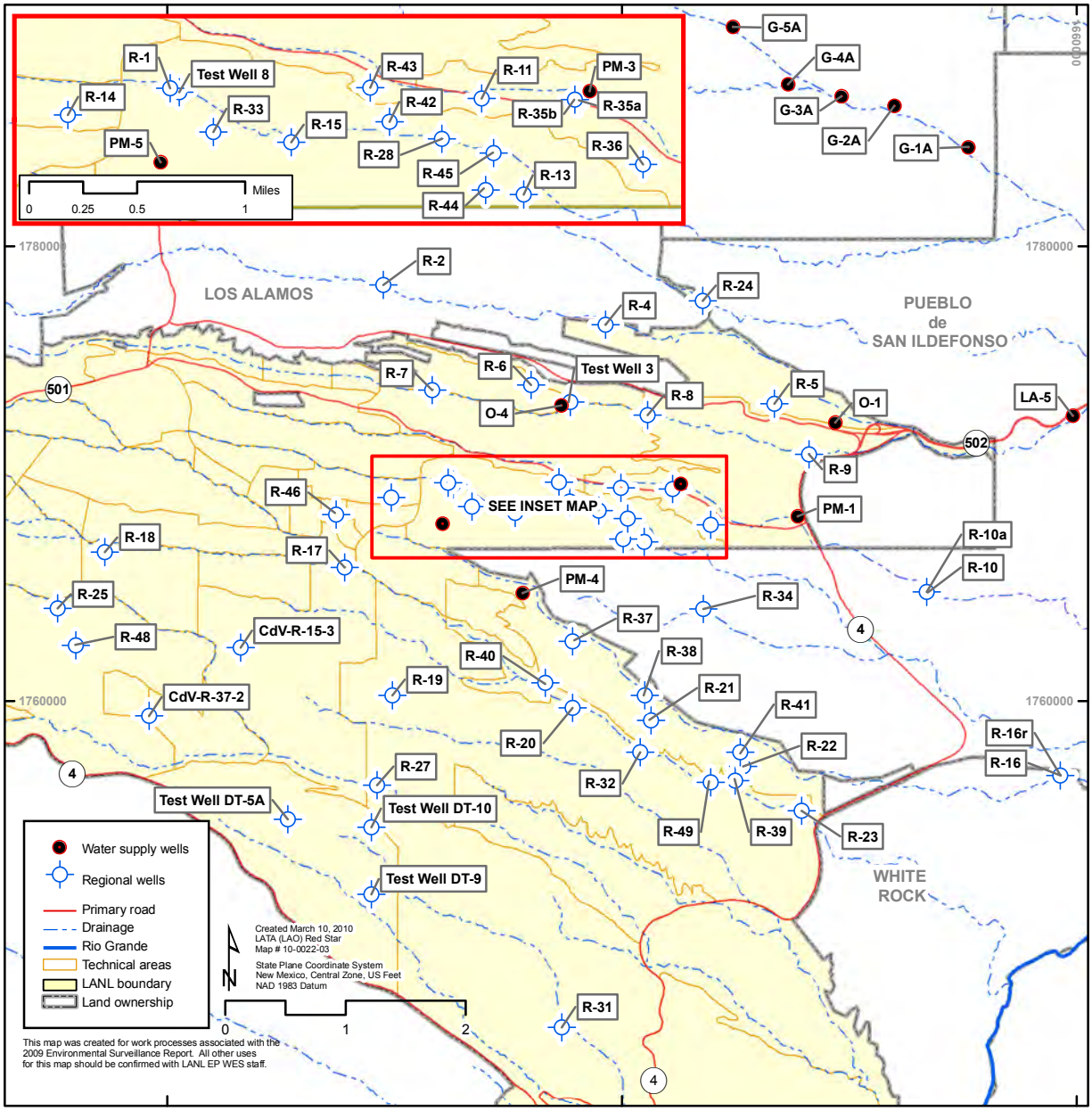


Figure 5-7. Wells used for regional aquifer monitoring.

4. Well Plugging and Abandonment

The Laboratory plugged and abandoned a number of wells in 2009 and will continue to plug and abandon additional wells. A description of monitoring wells, their construction, and physical attributes was compiled to assist in determining priorities for plugging and abandonment (LANL 2009e). In 2009, five wells were plugged and abandoned: CdV-16-2(i), Test Well 8, MCOBT-4.4, 03-B-09, and 03-B-10. The wells were plugged and abandoned so they would not provide conduits for contaminants. Details of plugging and abandonment methods are in plugging and abandonment reports for CdV-16-2(i) (LANL 2009f), TW-8 (LANL 2009g), MCOBT-4.4 (LANL 2009h) and 03-B-09 and 03-B-10 (LANL 2009i).

E. SUMMARY OF 2009 SAMPLING RESULTS

In 2009 LANL sampled 244 groundwater wells, well ports, and springs in 599 separate sampling events. The samples collected were analyzed for about 237,506 separate results. If results for field parameters (for example, temperature or pH) and field quality control blanks are excluded, the samples were analyzed for 167,584 results. The total numbers of results are given in Table 5-2 for each analytical suite and groundwater zone. The bottom row of the table gives the number of sample results, not including field quality control blanks or field parameters.

Table 5-3 gives the total number of sample results that were above the screening levels described in Section C. About 0.2% of the results had values greater than a screening level. These totals are based on omitting field quality control blanks, field parameters, and measurements made at an in-house analytical laboratory. Samples analyzed in-house are used mainly for evaluating water quality in wells affected by drilling fluids, which are not used for compliance monitoring. The analytes, number of times above the screening level, and the screening level value are given in Table 5-4.

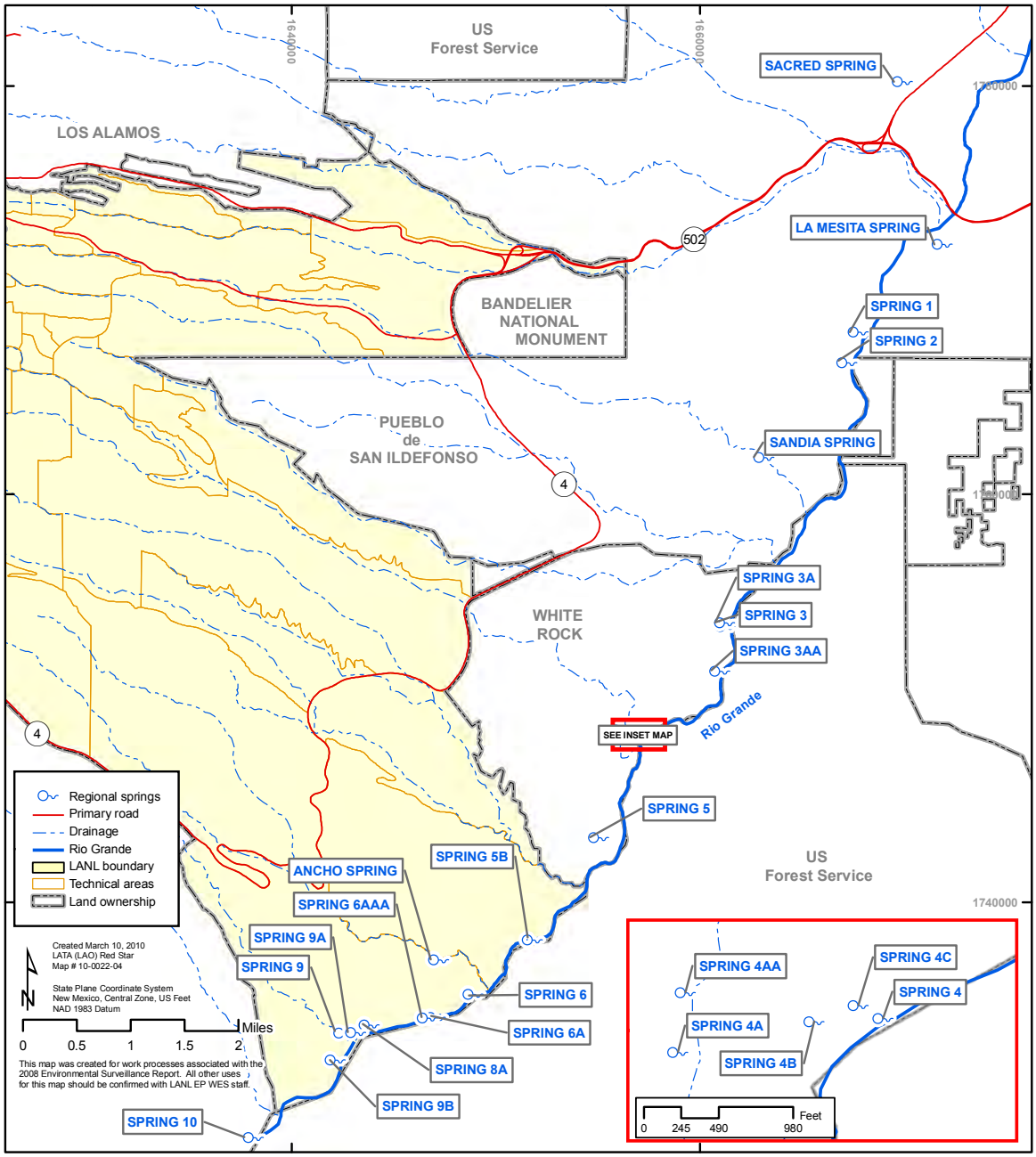


Figure 5-8. Springs used for regional aquifer monitoring.

Table 5-2
Total Number of Groundwater Sample Results Collected by LANL in 2009

Groundwater Zone	Total Results	Dioxins & Furans	Diesel Range Organics	General Inorganic Chemistry	Herbicides	High Explosives	Isotopes	Metals	Pesticides & PCBs	Radio-activity	Semivolatile Organic Compounds	Volatile Organic Compounds
Alluvial	47,476	650		4,219	160	2,000	59	5,827	1,072	1,647	10,560	21,282
Alluvial Spring	852			96		46	5	147	8	70	160	320
Intermediate	50,942	1,100	3	4,136	270	2,341	134	5,897	2,023	1,828	10,800	22,410
Intermediate Spring	10,665			1,198		871	14	1,864	16	458	1,840	4,404
Regional	110,435	3,150		10,846	550	4,302	329	17,887	4,234	4,160	19,200	45,777
Regional Spring	10,569			1,062		552	30	1,642	32	531	1,920	4,800
Water Supply	6,567		3	707		420		667	160	530	1,360	2,720
Total	**237,506**	**4,900**	**6**	**22,264**	**980**	**10,532**	**571**	**33,931**	**7,545**	**9,224**	**45,840**	**101,713**
Number of groundwater sample results omitting field parameters and field quality control blanks												
Total	**167,584**	**4,250**	**4**	**16,743**	**980**	**8,693**	**571**	**31,858**	**6,545**	**9,122**	**38,560**	**50,258**

Table 5-3
Total Number of Groundwater Sample Results above Screening Levels in 2009
(Omitting Field Parameters, Field Quality Control Blanks, and Data Analyzed In-House)

Analytical Suite	Total Results	Dioxins & Furans	Diesel Range Organics	General Inorganic Chemistry	Herbicides	High Explosives	Isotopes	Metals	Pesticides & PCBs	Radio-activity	Semivolatile Organic Compounds	Volatile Organic Compounds
Number of results	158,733	4,250	4	14,358	980	8,693	40	25,923	6,545	9,122	38,560	50,258
Number above Screening Level	326	0	0	76	0	26	0	148	1	21	26	28
% above Screening Level	0.21	0.00	0.00	0.53	0.00	0.30	0.00	0.57	0.02	0.23	0.07	0.06

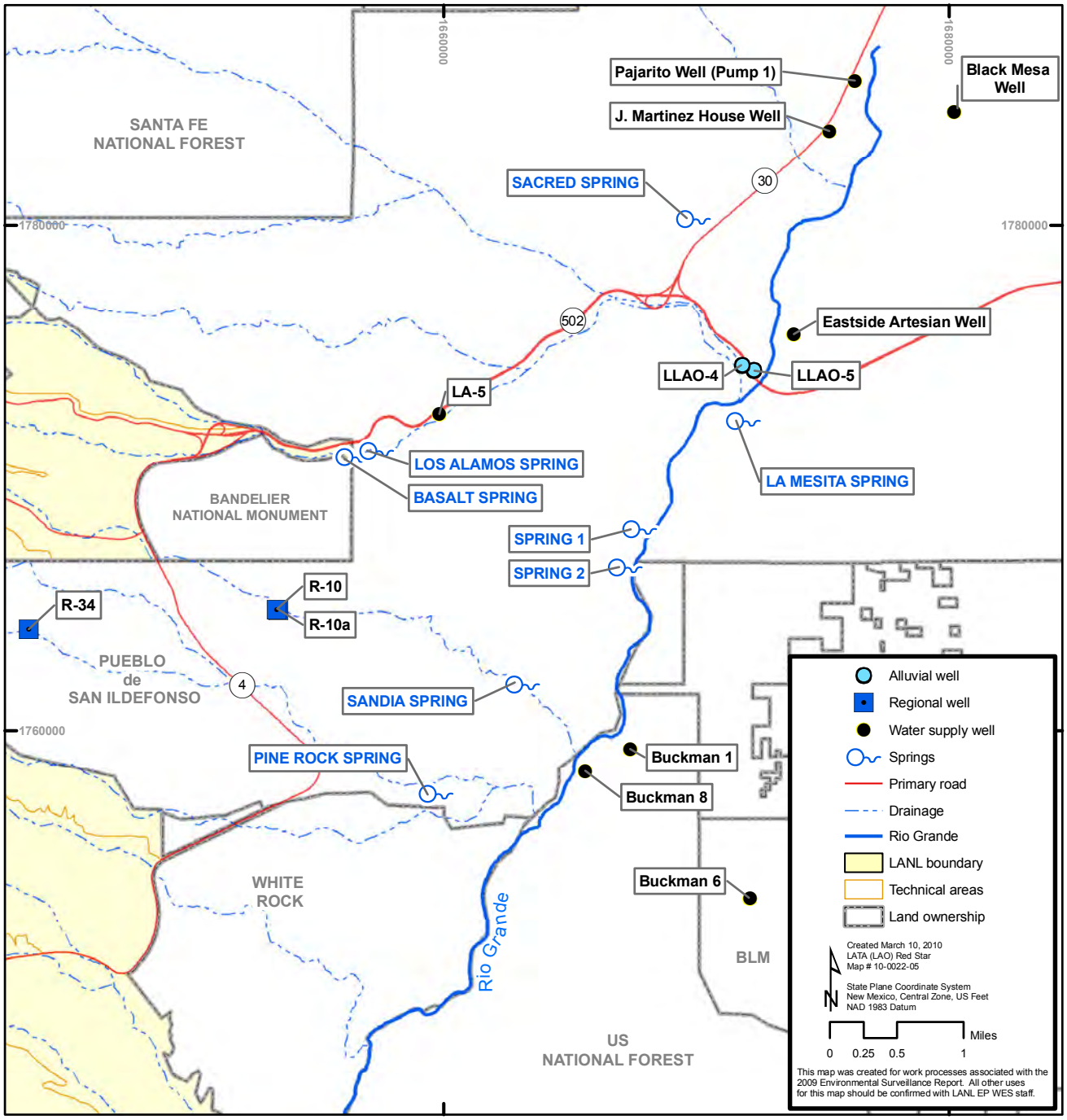


Figure 5-9. Springs and wells used for groundwater monitoring at the City of Santa Fe Buckman well field and on Pueblo de San Ildefonso lands.

The total number of sample results that were above the screening levels (Tables 5-3 and 5-4) may be high for several reasons. In many cases the given screening level may not apply to a particular groundwater sample. For example, some of the screening levels (the EPA MCLs and EPA Human Health tap water screening levels) apply specifically to drinking water, and not to a sample result from a non-drinking water source. As well, for a particular sample event, multiple measurements made for an analyte may be included in the total. The multiple measurements could include both filtered and unfiltered sample results, multiple analytical laboratory analyses (for example, made on diluted samples to improve analytical accuracy), and results from field duplicate samples. The monitoring results are described in detail in the following sections.

Table 5-4
Groundwater Analytes with Results above Screening Levels in 2009
(Omitting Field Parameters, Field Quality Control Blanks, and Data Analyzed in-House)

Suite or Analyte	No. of Results	Screening Level	Units	Screening Level Type
General Inorganic Chemistry	76			
Chloride	11	250	mg/L	NM groundwater standard
Perchlorate	49	4	µg/L	NM Consent Order
Cyanide (total)	1	0.2	mg/L	EPA MCL
Nitrate + Nitrite	11	10	mg/L	NM groundwater standard
Total Dissolved Solids	4	1,000	mg/L	NM groundwater standard
High Explosives	**26**			
RDX	26	6.11	µg/L	EPA Human Health tap water screening level
Metals	**148**			
Aluminum	12	5,000	µg/L	NM groundwater standard
Arsenic	9	10	µg/L	EPA MCL
Boron	2	750	µg/L	NM groundwater standard
Barium	17	1,000	µg/L	NM groundwater standard
Cadmium	1	5	µg/L	EPA MCL
Chromium (dissolved)	21	50	µg/L	NM groundwater standard
Chromium (total)	13	100	µg/L	EPA MCL
Iron	34	1,000	µg/L	NM groundwater standard
Manganese	28	200	µg/L	NM groundwater standard
Nickel	1	200	µg/L	NM groundwater standard
Lead (total)	9	15	µg/L	EPA MCL
Antimony	1	6	µg/L	EPA MCL
Radioactivity	**20**			
Americium-241	1	1.2	pCi/L	DOE 4 mrem/yr DCG
Gross Beta	6	50	pCi/L	EPA Drinking Water Screening Level
Plutonium-238	1	1.6	pCi/L	DOE 4 mrem/yr DCG
Plutonium-239/240	1	1.2	pCi/L	DOE 4 mrem/yr DCG
Radium-228	1	4	pCi/L	DOE 4 mrem/yr DCG
Strontium-90	9	8	pCi/L	EPA MCL
Uranium	1	30	µg/L	NM groundwater standard
Pesticides/PCBs	1			
Toxaphene (Technical Grade)	1	0.61	µg/L	EPA Human Health tap water screening level
Semivolatile Organic Compounds	26			
Benzo(a)pyrene	1	0.2	µg/L	EPA MCL
Benzo(b)fluoranthene	1	0.29	µg/L	EPA Human Health tap water screening leve
Bis(2-ethylhexyl)phthalate	22	6	µg/L	EPA MCL
Dibenz(a,h)anthracene	1	0.029	µg/L	EPA Human Health tap water screening level
Indeno(1,2,3-cd)pyrene	1	0.29	µg/L	EPA Human Health tap water screening level
Volatile Organic Compounds	28			
Benzene	2	5	µg/L	EPA MCL
Dichloroethene[1,1-]	4	5	µg/L	NM groundwater standard
Tetrachloroethene	1	5	µg/L	EPA MCL
Trichloroethane[1,1,1-]	10	60	µg/L	NM groundwater standard
Trichloroethene	2	5	µg/L	EPA MCL

MCL = Maximum contaminant level
DCG = DOE derived concentration guide

F. GROUNDWATER SAMPLING RESULTS BY CONSTITUENTS

The supplemental data tables for this chapter present groundwater quality monitoring data for 2009 (on the included compact disc). Columns on the data tables identify the groundwater zones sampled—whether alluvial, intermediate, or regional; the latter includes water supply wells—or indicate if the location is a spring. For wells with several sampling ports, the depth and groundwater zone sampled for each port appear in the table. For single-screen wells, the depth of screen top is given. Springs have a depth of 0 ft, and wells with unknown depth list a value of –1. Supplemental Data Table S5-1 provides definitions for sample description codes used in the data tables.

Table S5-2 lists the results of radiochemical analyses of groundwater samples for 2009. The table also gives the total propagated one-sigma (one standard deviation) analytical uncertainty and the analysis-specific minimum detectable activity (MDA), where available. A "<" symbol indicates that based on the analytical laboratory or secondary validation qualifiers the result was a nondetect. Uranium was analyzed by chemical methods and by isotopic methods. Table S5-3 shows low-detection-limit tritium results.

Table S5-4 lists radionuclides detected in groundwater samples, as reported by the analytical laboratory. For most radionuclide measurements, we reported a detection as an analytical result that does not include an analytical laboratory (or in some cases, secondary validation) qualifier code of X or U (which indicates that the result is a nondetect). The analytical laboratory reports a result that is greater than the measurement-specific MDA as detected. Some low-detection-limit tritium data do not have laboratory qualifiers; in that case, a result is considered as detected when analytical results are greater than three times the reported (one-sigma) uncertainty.

Data with qualifier codes other than X or U are shown in Table S5-4 to provide additional information on analytical results; in some cases, there were analytical quality issues. The table shows two categories of qualifier codes: those from the analytical laboratory and those from secondary validation (Tables S5-5, S5-6, and S5-7). After we received the analytical laboratory data packages, an independent contractor, Analytical Quality Associates, Inc. (AQA), performed a secondary validation on the packages. The reviews by AQA include verifying that holding times were met, that all documentation is present, and that analytical laboratory quality control measures were applied, documented, and kept within contract requirements.

Because uranium, gross alpha, and gross beta are usually detected in water samples and to focus on the higher measurements, Table S5-4 only includes occurrences of these measurements above threshold values. (All of the results are included in Table S5-2.) We selected threshold levels of 5 µg/L for uranium, 5 pCi/L for gross alpha, and 20 pCi/L for gross beta, which are lower than the respective EPA MCLs or screening levels (30 µg/L for uranium, 15 pCi/L for gross alpha, and 50 pCi/L for gross beta). The right-hand columns of Table S5-4 compare results with the regulatory standards or screening levels listed on the table.

Table S5-8 lists the results of general chemical analyses of groundwater samples for 2009. Table S5-9 lists perchlorate results. We analyzed samples for perchlorate by the liquid chromatography/mass spectrometry/mass spectrometry (LC/MS/MS) method (SW-846:6850). The results of trace metal analyses appear in Table S5-10.

1. Contaminant Distribution Maps

In the following sections, we discuss groundwater quality results for each of the three groundwater modes in the major watersheds that cross the Laboratory. The accompanying maps depict the location of groundwater contaminants that are found at levels near or above screening levels or standards. The maps provide a spatial context for distribution of groundwater contamination.

The contaminant distribution maps show contaminant locations extrapolated beyond the area covered by monitoring wells. This extrapolation takes into account the location of contaminant sources and direction of groundwater flow. Question marks on the maps indicate where contaminant extent is inferred but not confirmed by monitoring coverage. For alluvial groundwater in canyons, the extent of contamination lateral to the canyon is not to scale; contaminated groundwater is confined to the canyon bottom alluvium and is quite narrow at the map scale.

2. Organic Chemicals in Groundwater

In 2009, we analyzed samples from selected springs and monitoring wells for organic chemicals. Table S5-11 summarizes the stations sampled and organic chemical suites for which samples were analyzed. These samples were analyzed for some or all of the following organic chemical suites: volatile organic compounds, semivolatile organic compounds, polychlorinated biphenyls (PCBs), pesticides, diesel-range organics (DRO), and HE. The Quality Assurance (QA) section of this chapter (Section H) covers analytes and analytical methods. Table S5-12 shows organic chemicals detected in 2009 and detections in field QC samples.

Certain organic compounds used in analytical laboratories or derived from sampling equipment are frequently detected in laboratory blanks, that is, contamination introduced by the analytical process is common for these compounds. These compounds include acetone, methylene chloride, toluene, 2-butanone, di-n-butyl phthalate, di-n-octyl phthalate, and bis(2-ethylhexyl)phthalate (Fetter 1993) and many others.

Bis(2-ethylhexyl)phthalate is also derived from plastics including sample bottles and tubing. It was detected repeatedly at several wells since 2005, particularly in a few wells drilled since 2008. In some cases, the compound was found at concentrations above the EPA MCL of 6 µg/L. From the bis(2-ethylhexyl)phthalate concentration histories, it appears that the compound initially leaches from some material used during drilling or well construction. Concentrations generally have fallen significantly during the following one or two years.

Mortandad Canyon intermediate well MCOI-6 showed bis(2-ethylhexyl)phthalate concentrations ranging from 2.3 µg/L to 12.4 µg/L between June 2005 and August 2007 (Figure 5-10). The compound was detected in only one sample since that time. Two other wells constructed nearby at the same time (MCOI-4 and MCOI-5) did not show such frequent bis(2-ethylhexyl)phthalate detections; one June 2006 sample in MCOI-4 contained 16.2 µg/L.

R-32, which underwent redevelopment in late 2007, had bis(2-ethylhexyl)phthalate detections in five sample events after redevelopment (Figure 5-11). The concentrations in these samples ranged from 2.1 µg/L to 6 µg/L. Bis(2-ethylhexyl)phthalate has not been detected since February 2009.

Five newly-drilled wells first sampled in late 2008 or 2009 also show high initial bis(2-ethylhexyl)phthalate detections: regional wells R-36, R-38, R-42, and R-46, and intermediate well TA-53i (Figures 5-12, 5-13, 5-14, 5-15, and 5-16). R-36 (Sandia Canyon) had an initial value of 59 µg/L in May 2008, decreasing to around 10 µg/L through 2009. In May 2009, R-46 (Pajarito Canyon) had a result of 96 µg/L, decreasing to about 30 µg/L during the remainder of 2009.

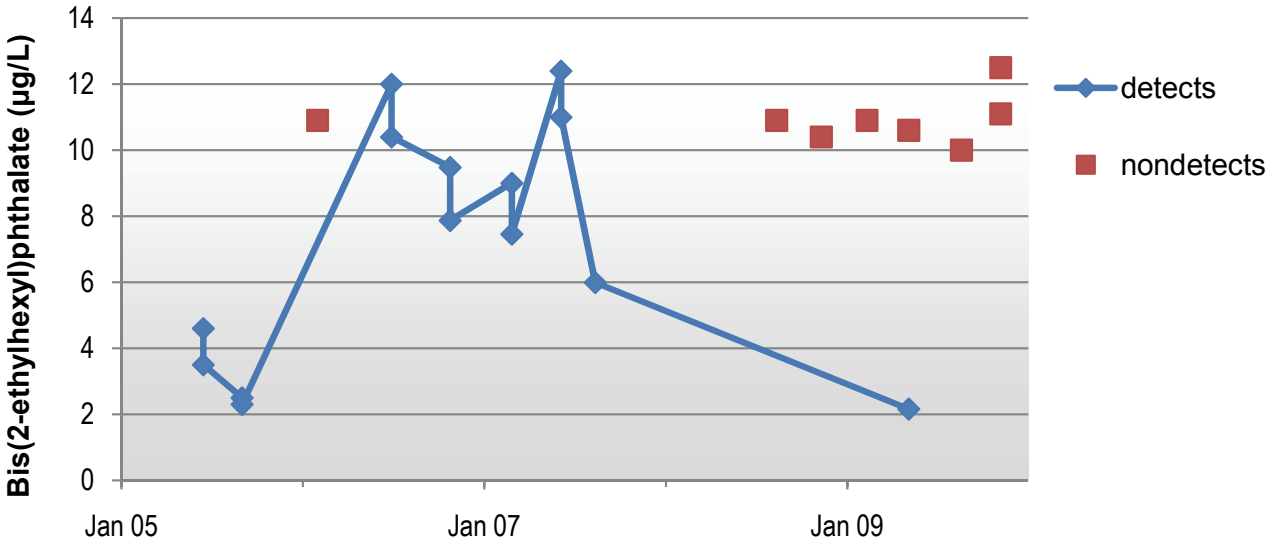


Figure 5-10 **Bis(2-ethylhexyl)phthalate concentration histories. Nondetects are reported at the practical quantitation limit (PQL) of about 11 µg/L; the MDL is about 2.2 µg/L. The EPA MCL is 6 µg/L.**

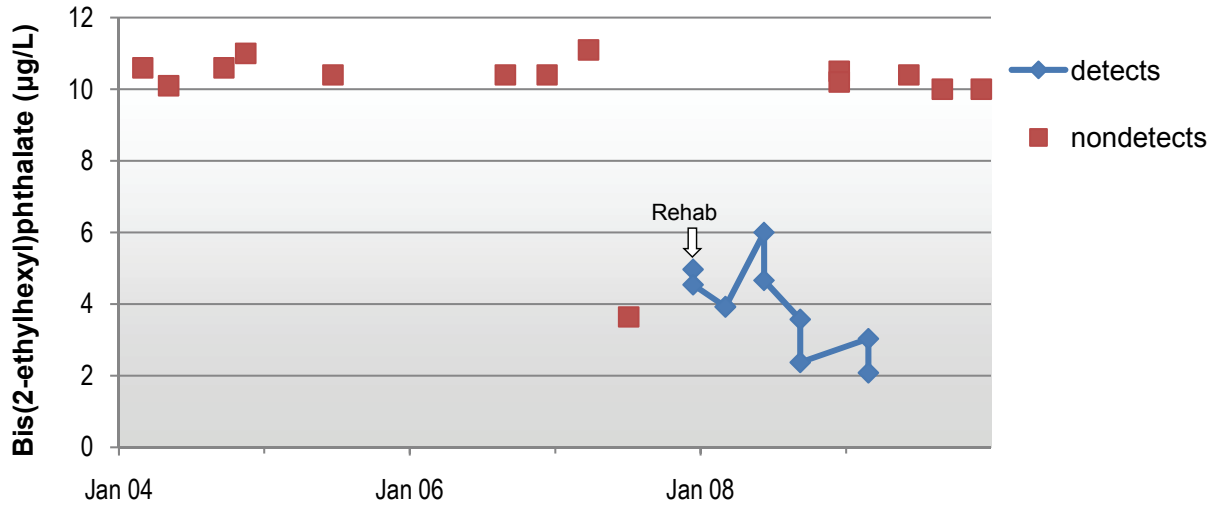


Figure 5-11. **Bis(2-ethylhexyl)phthalate concentration history for regional aquifer monitoring well R-32. Nondetects are reported at the practical quantitation limit (PQL) of about 11 µg/L; the MDL is about 2.2 µg/L. The EPA MCL is 6 µg/L.**

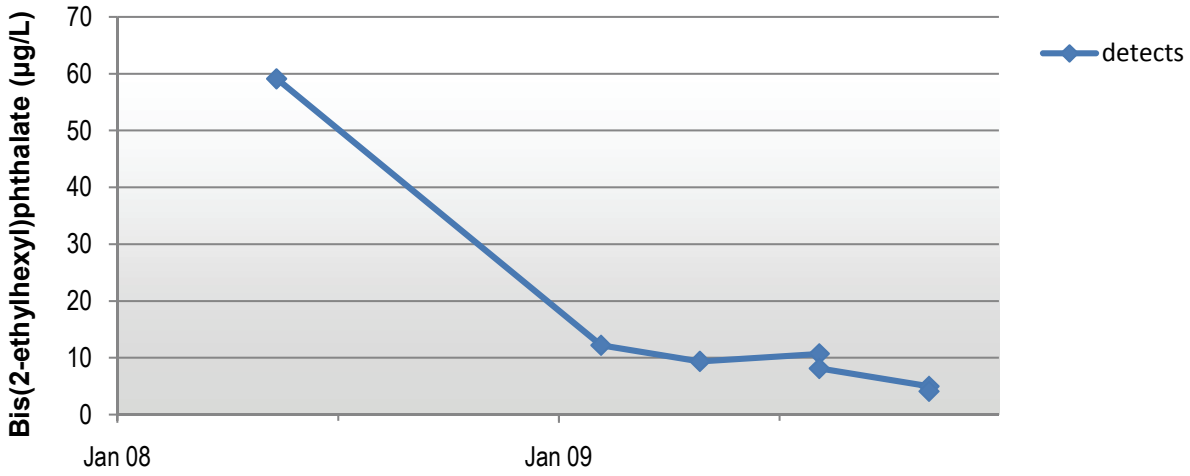


Figure 5-12. **Bis(2-ethylhexyl)phthalate concentration history for regional aquifer monitoring well R-36. The EPA MCL is 6 µg/L.**

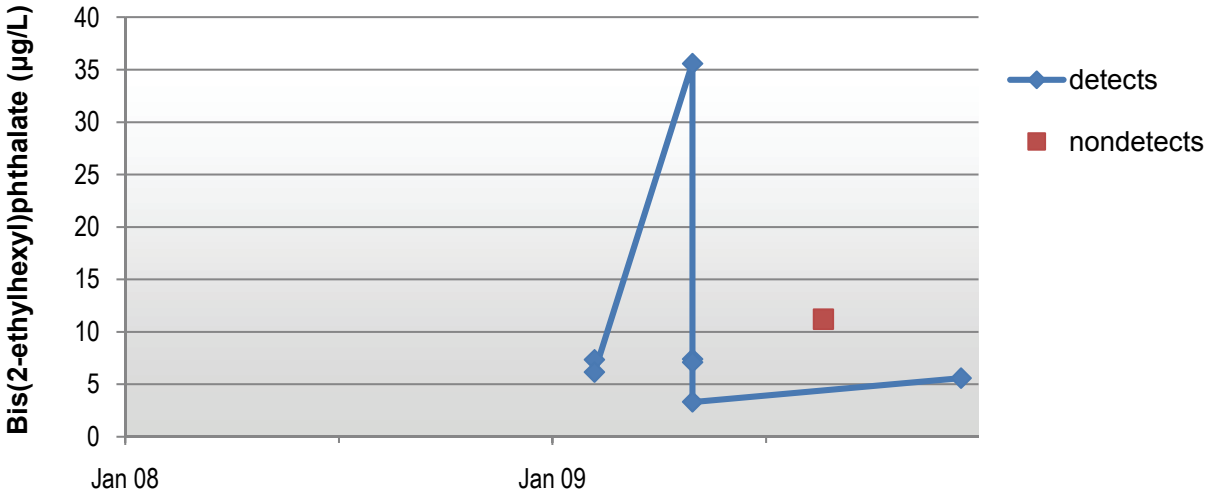


Figure 5-13. **Bis(2-ethylhexyl)phthalate concentration history for regional aquifer monitoring well R-38. Nondetects are reported at the practical quantitation limit (PQL) of about 11 µg/L; the MDL is about 2.2 µg/L. The EPA MCL is 6 µg/L.**

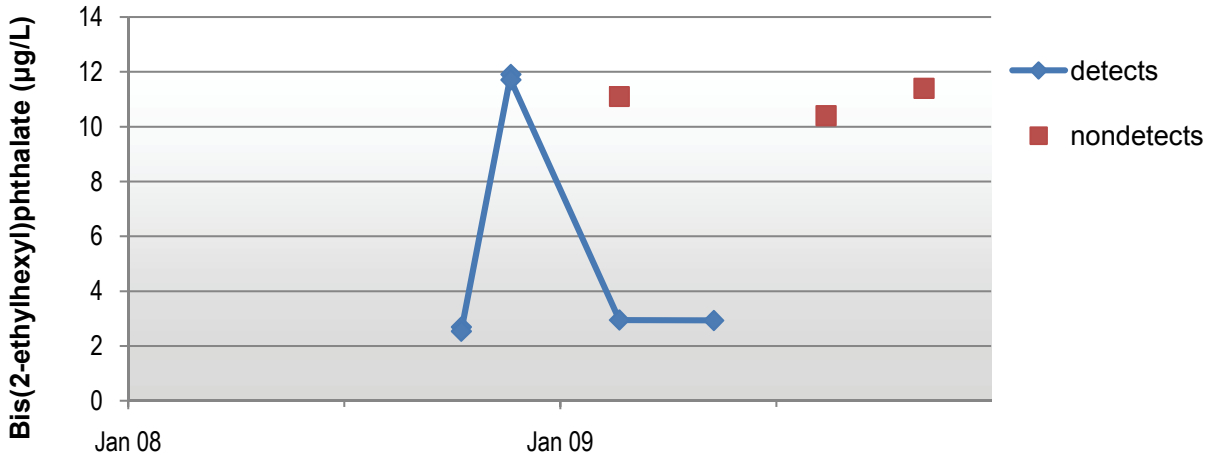


Figure 5-14. **Bis(2-ethylhexyl)phthalate concentration history for regional aquifer monitoring well R-42. Nondetects are reported at the practical quantitation limit (PQL) of about 11 µg/L; the MDL is about 2.2 µg/L. The EPA MCL is 6 µg/L.**

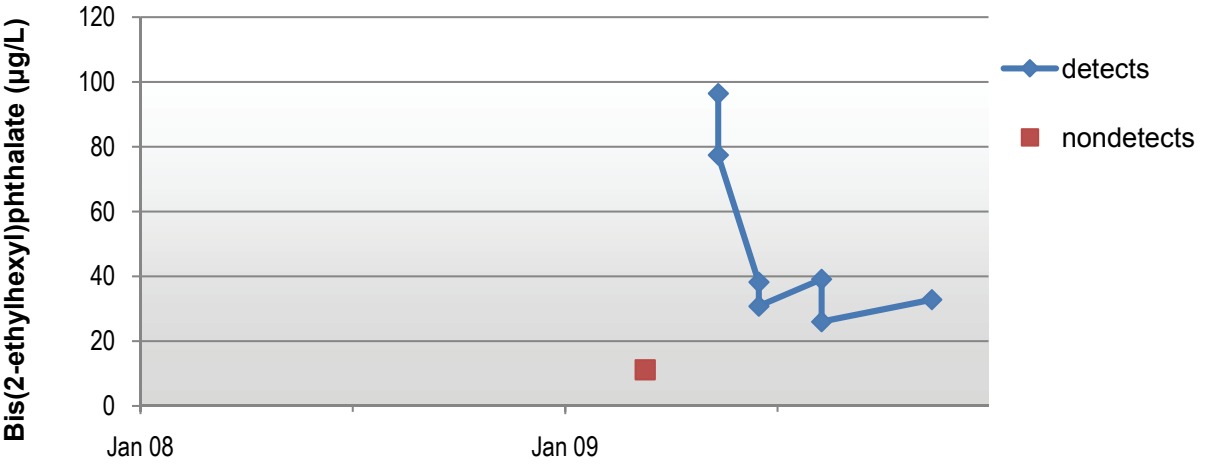


Figure 5-15. **Bis(2-ethylhexyl)phthalate concentration history for regional aquifer monitoring well R-46. Nondetects are reported at the practical quantitation limit (PQL) of about 11 µg/L; the MDL is about 2.2 µg/L. The EPA MCL is 6 µg/L.**

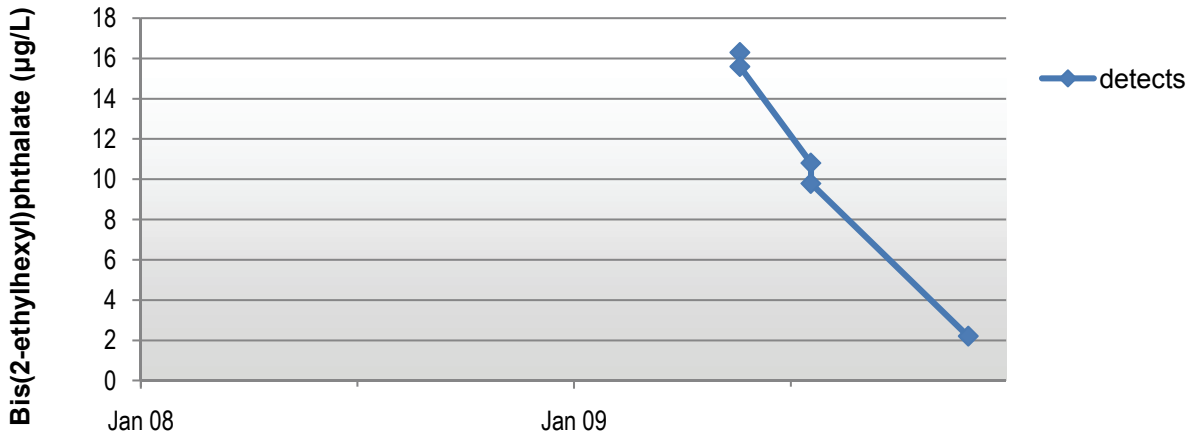


Figure 5-16. **Bis(2-ethylhexyl)phthalate concentration history for intermediate groundwater well R-53i. The EPA MCL is 6 µg/L.**

3. Radioactivity in Groundwater

The principal radioactive element detected in the regional aquifer is naturally occurring uranium, found at high concentrations in springs and wells throughout the Rio Grande Valley. Other radioactivity in groundwater samples comes from members of the decay chains for naturally occurring uranium-235, uranium-238 (including radium-226 and uranium-234), and thorium-232 (including radium-226). Potassium-0 is also a source of natural radioactivity.

In 2009, no activity or concentration value for a radioactivity analyte in a water supply well exceeded any regulatory standard, including the 4-mrem/yr DOE DCGs applicable to drinking water. One value for a naturally occurring radioactivity result in a regional aquifer sample was greater than screening levels (Table 5-5). In 2008 the method for analyzing radium-228 changed from EPA:901.1 to EPA:904, with a corresponding decrease in MDA from a range of 10 to 30 pCi/L to a range of 0.3 to 1 pCi/L. This change in method sensitivity corresponds to an increased number of detections.

Table 5-5
Radioactivity results above screening levels in regional aquifer groundwater for 2009

Chemical	Location	Result	Trends
Radium-228	R-48 in Water Canyon	9.19 pCi/L, above EPA MCL screening level of 5 pCi/L	Naturally occurring isotope, first result; later February 2010 result of 0.95 pCi/L

Pine Rock Spring, which flows from intermediate groundwater on Pueblo de San Ildefonso lands, had a uranium concentration equal to the NM groundwater standard (Table 5-6). The high uranium value may be due to dissolution of uranium from the bedrock by sanitary effluent, which is used to water athletic fields at nearby Overlook Park (Teerlink 2007). Other radioactivity results near screening levels are shown in Table 5-6.

Table 5-6
Radioactivity results near screening levels in intermediate groundwater for 2009

Chemical	Location	Result	Trends
Tritium	MCOI-4, MCOI-5, MCOI-6 in Mortandad Canyon	3,070 to 9,520 pCi/L, below EPA MCL screening level of 20,000 pCi/L	Values decreasing slowly over five years of sampling; wells sample separate isolated perched zones
Uranium	Pine Rock Spring (Pueblo de San Ildefonso)	30 µg/L, at NM groundwater standard of 30 µg/L	Steady over four years, may be leached from bedrock by percolation of sanitary effluent used to irrigate Overlook Park athletic fields

Results for strontium-90 from alluvial groundwater in Los Alamos and Mortandad Canyons were near or exceeded the 4-mrem/yr DOE DCG and EPA MCL screening levels (Table 5-7, Figures 5-17 and 5-18). Note that strontium-90 has a half-life of 28.8 years. Variable americium-241, plutonium-238, and plutonium 239/240 results in some Mortandad Canyon alluvial wells have occasionally exceeded the 4 mrem/yr DOE DCG screening levels, mainly in unfiltered samples.

During 2009, a number of strontium-90 detections occurred in samples from locations that usually have none. Some of these locations included water supply and regional aquifer wells (Otowi-1, Guaje-2A, R-8, R-18, and R-17). Initial results were between 0.4 pCi/L and 2.5 pCi/L for these samples, above the minimum detectable activity of 0.4 pCi/L. Reanalysis of several of these samples produced nondetect results. Upon investigation, the analytical laboratory found that using several counting systems with differing sensitivity gave inconsistent results and resulted in apparent detections. The counting system with lower sensitivity has been replaced.

Table 5-7
Radioactivity results above screening levels in alluvial groundwater for 2009

Chemical	Location	Result	Trends
Americium-241, plutonium-238 and -239/240	MCO-3 in Mortandad Canyon	All near 4 pCi/L, above 1.2 pCi/L to 1.6 pCi/L 4-mrem/yr DOE DCG screening levels; unfiltered sample	Few samples in recent years; results similar to those in 2003 and earlier
Strontium-90	One spring and three wells in DP and Los Alamos Canyons	12.2 pCi/L to 49 pCi/L, above EPA MCL screening level of 8 pCi/L and 40 pCi/L 4-mrem/yr DOE DCG screening level	Decreased since cessation of discharges in 1986, now stable due to retention on sediments
Strontium-90	Four wells in Mortandad Canyon	13.5 pCi/L to 45 pCi/L, above EPA MCL screening level of 8 pCi/L and 40 pCi/L 4-mrem/yr DOE DCG screening level	Fairly stable for 10 years due to retention on sediments

4. Perchlorate in Groundwater

Perchlorate is an important contaminant to monitor at LANL because it was discharged in some effluents and travels readily through groundwater. In December 2008 EPA issued an interim health advisory of 15 µg/L for perchlorate in drinking water. (http://www.epa.gov/safewater/contaminants/unregulated/perchlorate.html). The Consent Order mandates a 4 µg/L screening level for perchlorate.

Several studies indicate that perchlorate occurs naturally in groundwater of arid regions due to atmospheric deposition and other sources. Plummer et al. (2006) found perchlorate concentrations ranging from 0.12 µg/L to 1.8 µg/L in samples of north-central NM groundwater that have ages predating anthropogenic influence and that are not affected by industrial perchlorate sources. At LANL, perchlorate concentrations in groundwater samples from Pueblo, Los Alamos, and Mortandad canyons are above background as a result of past effluent discharges (Figure 5-19). Otherwise perchlorate concentrations are near the values found by Plummer et al. (2006).

G. GROUNDWATER SAMPLING RESULTS BY WATERSHED

In the following sections, we discuss groundwater quality results for each of the three groundwater modes in the major watersheds that cross the Laboratory. The tables and discussions are grouped according to groundwater mode, proceeding from the regional aquifer to the alluvial groundwater. Contamination found in the regional aquifer results from effluents released in past decades because of the time required for percolation to that depth. On the other hand, except for adsorbed or reactive contaminants such as barium or strontium-90, contaminants in alluvial groundwater reflect contamination that occurred during the past few years.

The accompanying tables and text mainly address contaminants found at levels near or above standards or screening levels. In the case of the regional aquifer, information regarding contaminants (such as nitrate, perchlorate, and tritium) found at lower concentrations but possibly indicating contamination by LANL activities is included. The discussion usually addresses radioactivity, general inorganic compounds (major anions, cations, and nutrients), metals, and then organic compounds for each groundwater zone. The accompanying plots and maps give a temporal and spatial context for most of the contaminants found near or above screening levels.

1. Guaje Canyon (includes Rendija and Barrancas Canyons)

Guaje Canyon is a major tributary in the Los Alamos Canyon watershed that heads in the Sierra de los Valles and lies north of Laboratory land. The canyon has not received any effluents from LANL activities (Table 5-8). The Guaje well field, located northeast of the Laboratory, contains five drinking water supply wells. Naturally occurring arsenic has generally been found in this well field at levels above the EPA MCL of 10 µg/L since the field was developed in the early 1950s (Table 5-9). In 2009, all arsenic sample results except one were below the 5 µg/L MDL. Rendija and Barrancas Canyons have seen, respectively, little and no past Laboratory activity, have only ephemeral surface water, and have no known alluvial or intermediate groundwater.

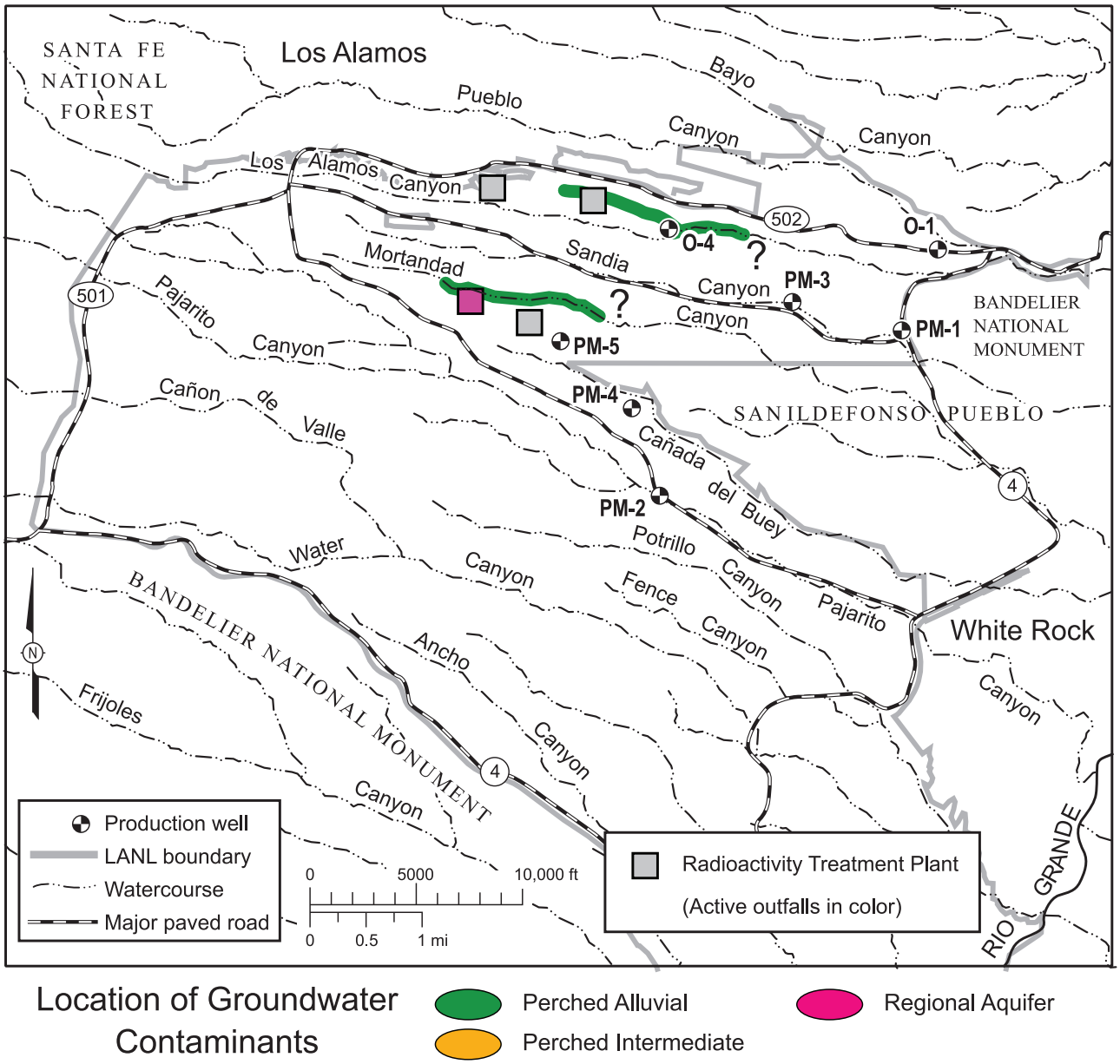


Figure 5-17. Location of groundwater contaminated by strontium-90 above the 8-pCi/L EPA MCL screening level. (The MCL applies only to drinking water, not to alluvial groundwater.) Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage. Along canyons, the extent of alluvial groundwater contamination lateral to the canyon is not to scale; contamination is confined to the alluvium within the canyon bottom and is narrow at the map scale.

2. Los Alamos Canyon (includes Bayo, Acid, Pueblo, and DP Canyons)

Bayo Canyon contained a now-decommissioned firing site. The canyon has only ephemeral surface water and no known alluvial or intermediate groundwater (Table 5-10).

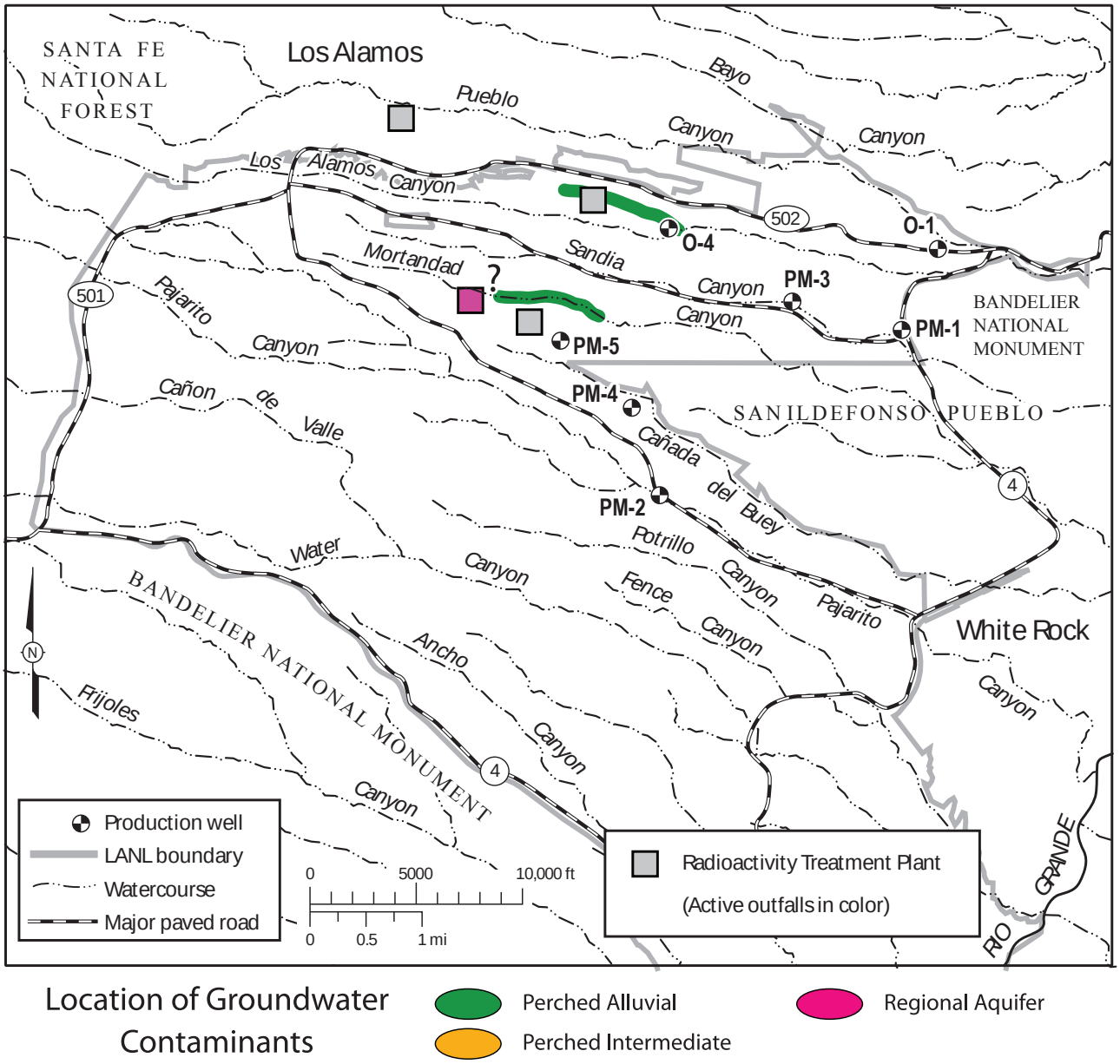


Figure 5-18. Location of groundwater contaminated by radioactivity: areas indicated have the sum of radioactivity from a DOE source (that is, Sr-90, Pu-238, Pu-239/240, and Am-241) above the 4-mrem/yr DOE DCG screening level. (The 4-mrem/yr DOE DCG applies only to drinking water, not to alluvial groundwater.) Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage.

Pueblo Canyon receives effluent from the new Los Alamos County Wastewater Treatment Plant. Acid Canyon, a tributary, received radioactive industrial effluent from 1943 to 1964. Little radioactivity is found in current groundwater samples. Perchlorate results from one regional aquifer monitoring well in this canyon are above the Consent Order screening level, and tritium, nitrate, and fluoride concentrations in some wells are elevated but are below standards. These findings indicate the lingering influence on the regional aquifer of past discharges from radioactive wastewater discharges in Acid Canyon. In the case of nitrate in regional aquifer wells, the source may also be from past sanitary effluent discharges in the upper part of the canyon. In recent years, the high nitrate (as well as total dissolved solids [TDS] and boron) concentrations found in alluvial and intermediate groundwater in lower Pueblo Canyon and downstream in lower Los Alamos Canyon may be due to sanitary effluent from the former Los Alamos County Bayo Sewage Treatment Plant.

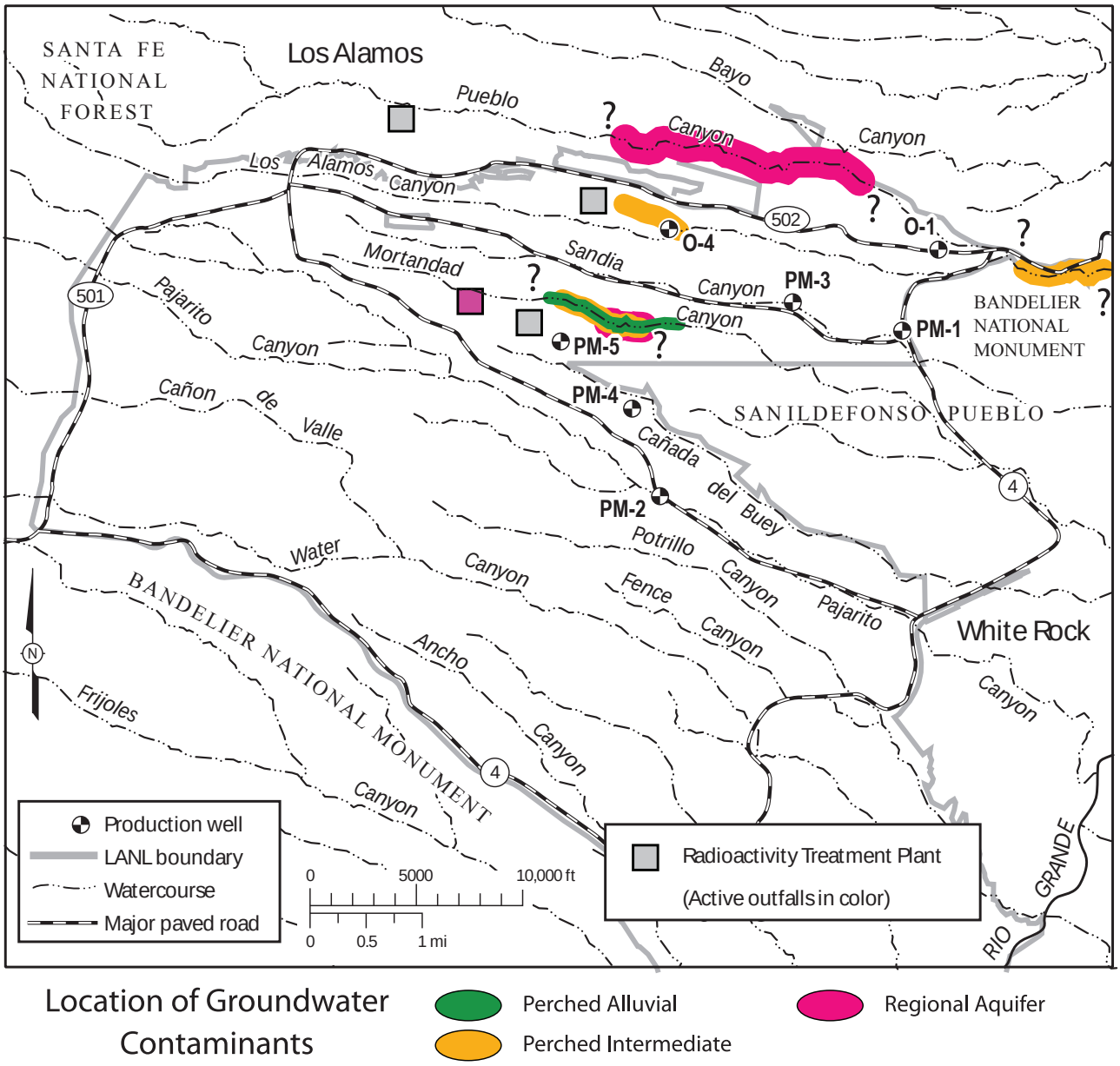


Figure 5-19. Location of groundwater contaminated by perchlorate; the concentrations in the areas indicated are above the 4 µg/L NM Consent Order screening level. Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage.

Los Alamos Canyon received releases of radioactive effluents during the earliest Manhattan Project operations at Technical Area (TA)-1 (1942–1945) and until 1993 from nuclear reactors at TA-2. From 1952 to 1986, a liquid-waste treatment plant discharged effluent containing radionuclides from the former plutonium-processing facility at TA-21 into DP Canyon, a tributary to Los Alamos Canyon. Los Alamos Canyon also received radionuclides and metals in discharges from the sanitary sewage lagoons and cooling towers at the Los Alamos Neutron Science Center (LANSCE) at TA-53. Except for strontium-90, contaminant concentrations in shallow groundwater have decreased dramatically in recent decades.

Table 5-8
Summary of Groundwater Contamination in Guaje Canyon (includes Rendija and Barrancas Canyons)

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Guaje, Rendija, and Barrancas Canyons	Minor non effluent sources	None, alluvial groundwater only in upper Guaje Canyon	No intermediate groundwater	Natural arsenic above EPA MCL

Table 5-9
Groundwater Quality in Guaje Canyon (includes Rendija and Barrancas Canyons)

Chemical	Location	Result	Trends
Arsenic	Regional aquifer water supply wells	< 5 µg/L, below EPA MCL of 10 µg/L; NM groundwater standard is 100 µg/L	Sporadic values above EPA MCL for many years in this well field

Table 5-10
Summary of Groundwater Contamination in Los Alamos Canyon (includes Bayo, Acid, Pueblo, and DP Canyons)

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Bayo Canyon	Minor past dry and liquid sources	No alluvial groundwater	No intermediate groundwater	None
Pueblo and Acid Canyons	Multiple past effluent discharges, current sanitary effluent	Plutonium-239/240 at 70% of 4 mrem/yr DCG screening level, arsenic above EPA MCL screening level	Nitrate at 77% and fluoride at 69% of NM groundwater standard, perchlorate at 86% of Consent Order screening level; cadmium and lead above EPA MCL screening levels in one well	Perchlorate above Consent Order screening level, fluoride at 51% of NM groundwater standard, trace tritium and nitrate
Los Alamos and DP Canyons	Multiple past effluent discharges	Strontium-90 above 4 mrem/yr DCG screening level, gross beta above EPA drinking water screening level, chloride at 64% and TDS at 54% of NM groundwater standards	Perchlorate above Consent Order screening level, tritium at 19% of and (in one well) bis(2-ethylhexyl)phthalate above EPA MCL screening level	None
Lower Los Alamos Canyon	Multiple past effluent discharges	None	Perchlorate above Consent Order screening level, fluoride at 60% of NM groundwater standard	None

a. Pueblo Canyon

The levels of tritium, perchlorate, and nitrate at supply well O-1, though below standards or screening levels, indicate the presence of past effluent and surface water recharge in the regional aquifer (Table 5-11). Los Alamos County does not use the well for water supply, although the concentrations are below the 4 µg/L Consent Order screening level and the 15 µg/L EPA interim health advisory for perchlorate in drinking water.

Table 5-11
Groundwater Quality in Pueblo Canyon (includes Acid Canyon)

Chemical	Location	Result	Trends
Tritium	Water supply well O-1	17 pCi/L, below EPA MCL of 20,000 pCi/L	Variable between 14 pCi/L and 58 pCi/L since 2000
Tritium	Regional aquifer monitoring well R-4	52 pCi/L, below EPA MCL screening level of 20,000 pCi/L	Results higher than unaffected wells, fairly steady for four years of sampling
Perchlorate	Water supply well O-1	1.3 µg/L to 2.3 µg/L, below NMED screening level of 4 µg/L	Variable between 1.2 µg/L and 3 µg/L since 2001
Perchlorate	Regional aquifer monitoring well R-4	4.3 µg/L to 4.6 µg/L, above NMED screening level of 4 µg/L	Results higher than unaffected wells, varied by factor of two during four years of sampling
Fluoride	Regional aquifer monitoring wells R-4 and R-5	0.69 mg/L to 0.81 mg/L, below NM groundwater standard of 1.6 mg/L	Results higher than unaffected wells, fairly steady for four to five years of sampling
Nitrate (as Nitrogen [N])	Regional aquifer monitoring wells R-4 and R-5	1.6 mg/L to 2.2 mg/L, below NM groundwater standard of 10 mg/L	Results higher than unaffected wells, fairly steady for four to five years of sampling
Uranium	Intermediate monitoring well R-3i	9.2 µg/L to 9.7 µg/L, below NM groundwater standard of 30 µg/L	May be leached from bedrock by percolation of sanitary effluent; steady over two years of sampling
Perchlorate	Intermediate monitoring well R-3i	2.7 µg/L to 3.5 µg/L, below NMED screening level of 4 µg/L	Variable between 2.1 µg/L and 3.5 µg/L since 2007
Fluoride	Intermediate monitoring well R-5 at 384 ft	1.1 mg/L, below NM groundwater standard of 1.6 mg/L	Results fairly steady for five years of sampling
Nitrate (as N)	Intermediate monitoring wells POI-4, R-3i	4.4 mg/L to 7.7 mg/L, below NM groundwater standard of 10 mg/L	POI-4 concentrations nearly doubled over 14 years of sampling
Total cadmium, total lead	Test Well 2A	Both are above EPA MCL screening levels	Total concentrations in these ranges for many years due to corrosion of 60-year-old well casing; filtered results are nondetect
Arsenic	Alluvial monitoring well APCO-1	12 µg/L, above EPA MCL screening level of 10 µg/L, below NM groundwater standard of 100 µg/L	Highest result, but similar values for 17 years of samples, may be naturally occurring
Plutonium-239/240	Alluvial monitoring wells PAO-2	Unfiltered result of 0.84 pCi/L, below 4 mrem/yr DCG screening level of 1.2 pCi/L	In range of values for eight years of samples

Only one Pueblo Canyon regional aquifer monitoring well, R-4, located downstream from the former Acid Canyon outfall, shows perchlorate or low-detection-limit tritium values indicative of past discharges. Perchlorate concentrations in R-4 are above the NMED screening level of 4 µg/L (Figures 5-19 and 5-20). The tritium values range up to 60 pCi/L. Two regional aquifer wells (R-4 and R-5) show fluoride values higher than those in

unaffected wells, but the results are below the NM groundwater standard (Figure 5-21).

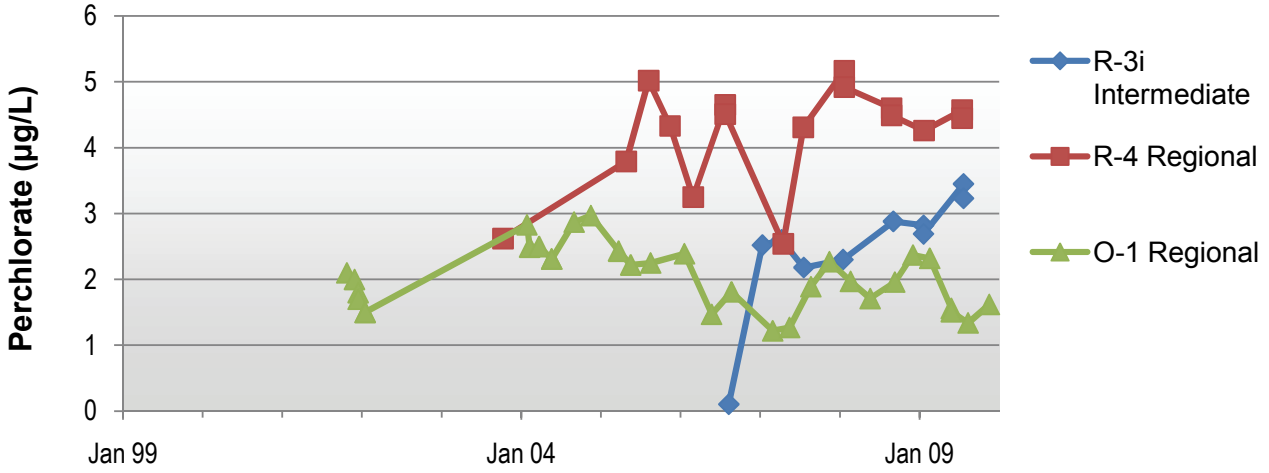


Figure 5-20. Perchlorate in Pueblo Canyon intermediate and regional aquifer groundwater. The Consent Order screening level is 4 µg/L.

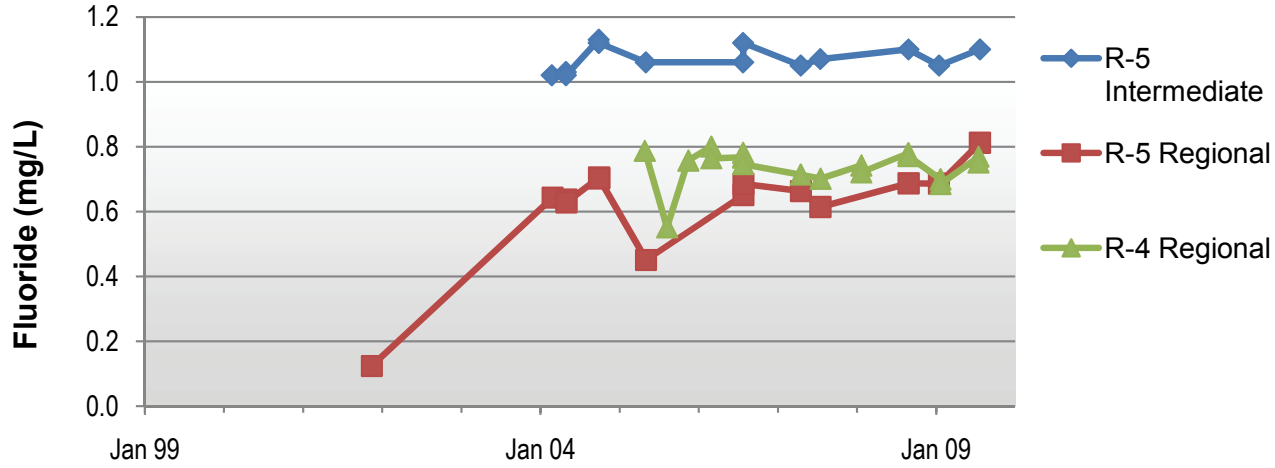


Figure 5-21. Fluoride in Pueblo Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 1.6 mg/L.

Intermediate groundwater also shows the effects of past effluent releases, with concentrations near standards of perchlorate, fluoride, and nitrate (Figures 5-20 through 5-23). The nitrate concentration in intermediate well POI-4 has nearly doubled over 14 years of sampling (Figure 5-24). Intermediate locations R-3i and Basalt Spring show nitrate concentrations and patterns similar to POI-4. An intermediate port in regional aquifer well R-5 shows fluoride values higher than that in unaffected wells, but the results are below the NM groundwater standard (Figure 5-21). The uranium concentrations in samples from Pueblo Canyon intermediate well R-3i ranged from 9.2 µg/L to 9.7 µg/L, above levels in unaffected wells but below the standard. The higher uranium may result from dissolution of uranium from surrounding bedrock by sanitary effluent (Teerlink 2007).

One intermediate well, Test Well 2A, had total cadmium and lead concentrations of 8.2 µg/L and 321 µg/L, above the respective EPA MCL screening levels of 5 µg/L and 15 µg/L. This well was drilled in 1949; it was cased with carbon steel, a lead metal packer connected the screen to the casing, and galvanized pipe was used for well components (pump columns, transducer lines) at different times. Total concentrations for cadmium and lead have been in these ranges for many years due to corrosion and flaking of 60-year-old well casing and fittings; filtered results for these metals in 2009 were nondetect.

Beginning in 2006, several alluvial wells in Pueblo Canyon have shown unusually high unfiltered

plutonium-239/240 results near or above the 4-mrem/yr DOE DCG screening level of 1.2 pCi/L (Figure 5-25). In general, these results corresponded to unusually high sample turbidity. The first high values appeared to be caused by flooding in August 2006 that submerged the wells. In 2009 the highest plutonium-239/240 activity was in PAO-4, at 0.84 pCi/L.

Prior to 2007, samples at many surface water and alluvial groundwater locations were often taken annually. Beginning in 2007, more frequent samples from Pueblo Canyon locations showed higher chloride concentrations in mid-winter and early spring. Along with similar sodium and TDS concentrations trends, this suggests an impact on water quality by runoff from road salting (Figure 5-26). High chloride concentrations in 2007 and 2008 were up to 280 mg/L in surface water and 135 mg/L in groundwater. Locations which previously showed highest winter chloride concentrations were not sampled in early 2009.

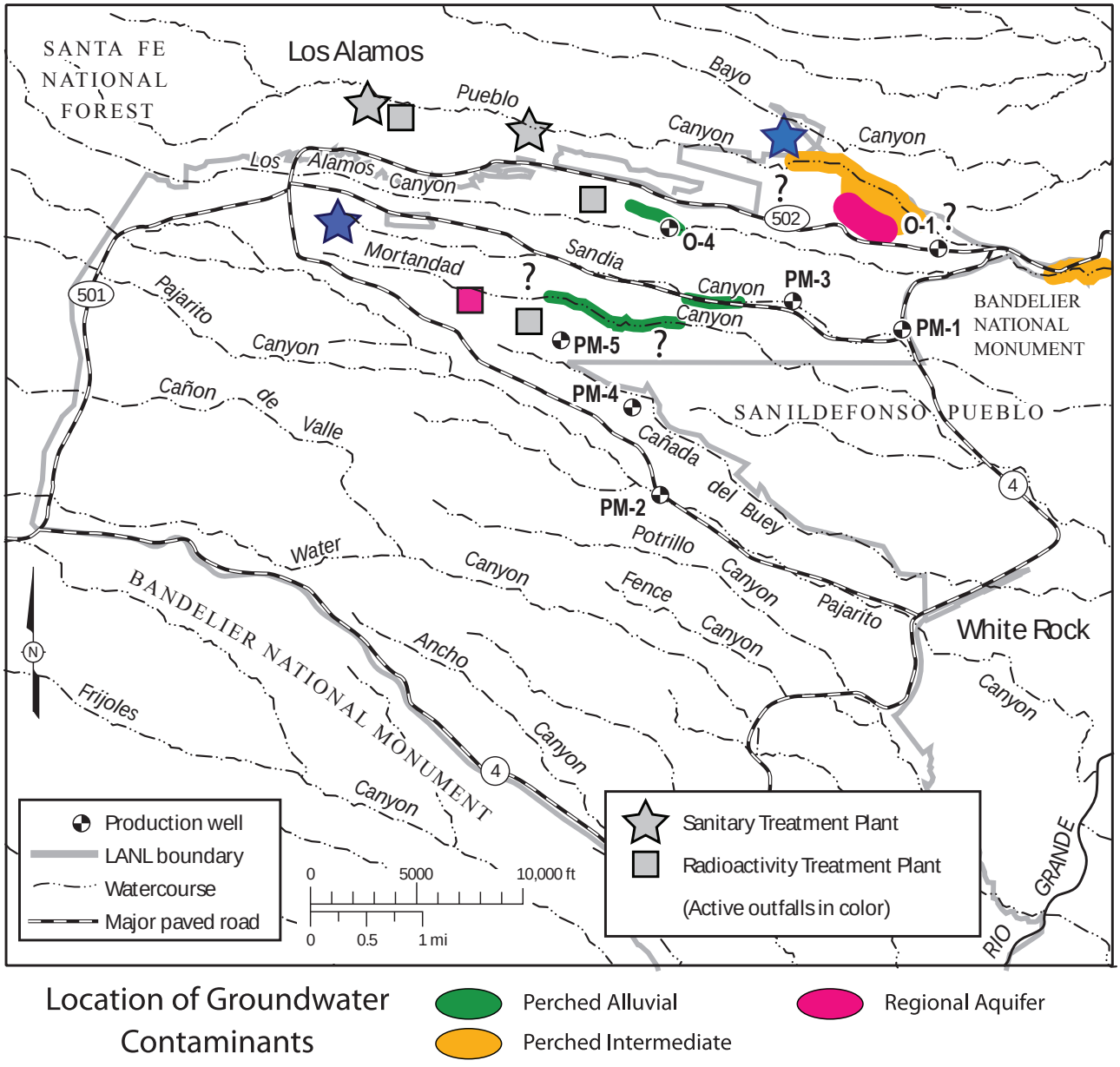


Figure 5-22. Location of groundwater containing fluoride above one half of the 1.6-mg/L NM groundwater standard. Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage.

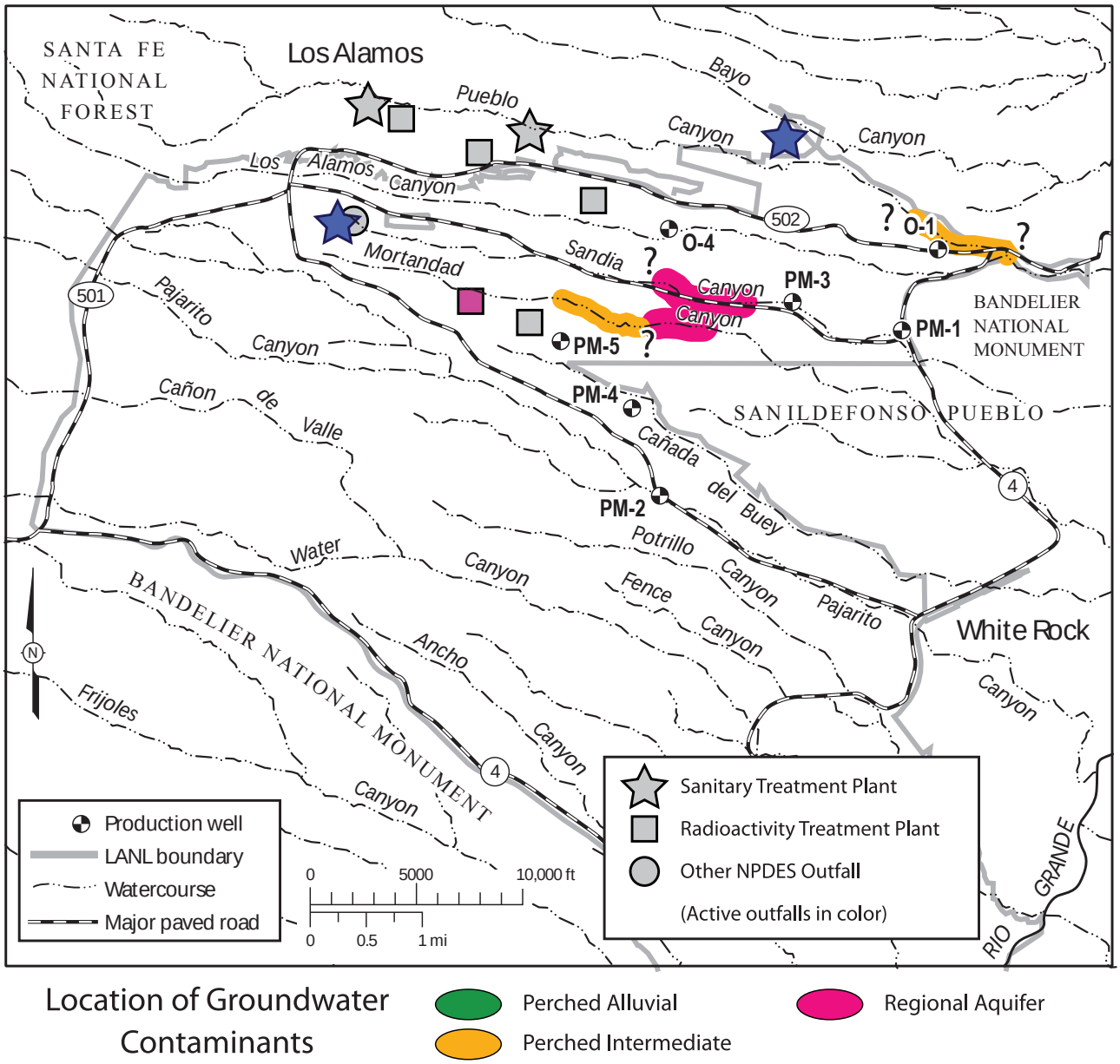


Figure 5-23. Location of groundwater containing nitrate (as nitrogen) above one half of the 10 mg/L NM groundwater standard. Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage.

b. Los Alamos Canyon

Alluvial and intermediate groundwater in Los Alamos Canyon show effects of past effluent releases (Table 5-12).

Samples from intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, and LAOI-7 contained up to 3,880 pCi/L of tritium (Figure 5-27). These moderate values indicate a residual impact of past effluent discharges; the wells lie downstream from the former radioactive liquid waste discharge from TA-21 in DP Canyon. Nitrate (as nitrogen) concentrations in these wells have fluctuated over the period of sampling (Figure 5-28) but are below the 10 mg/L NM groundwater standard. The perchlorate concentrations in these wells ranged up to 7.5 µg/L, above the NMED screening level of 4 µg/L (Figure 5-19, Figure 5-29).

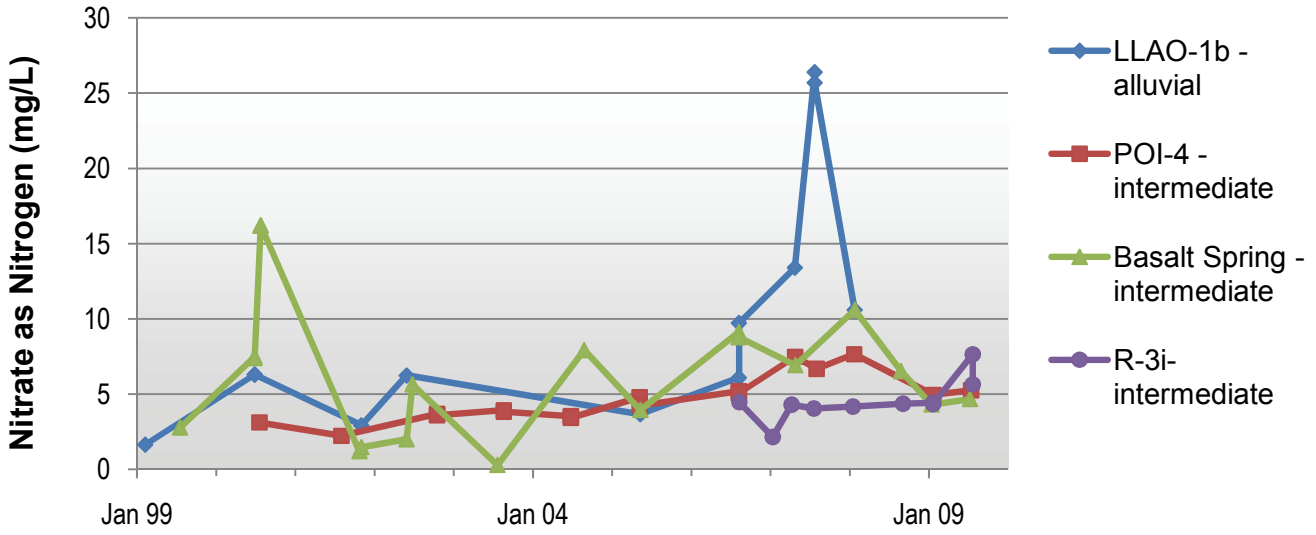


Figure 5-24. **Nitrate (as nitrogen) in Pueblo and lower Los Alamos Canyon alluvial and intermediate groundwater. The NM groundwater standard is 10 mg/L. Many of the values including the 2007 higher results in LLAO-1b are estimated due to analytical quality issues.**

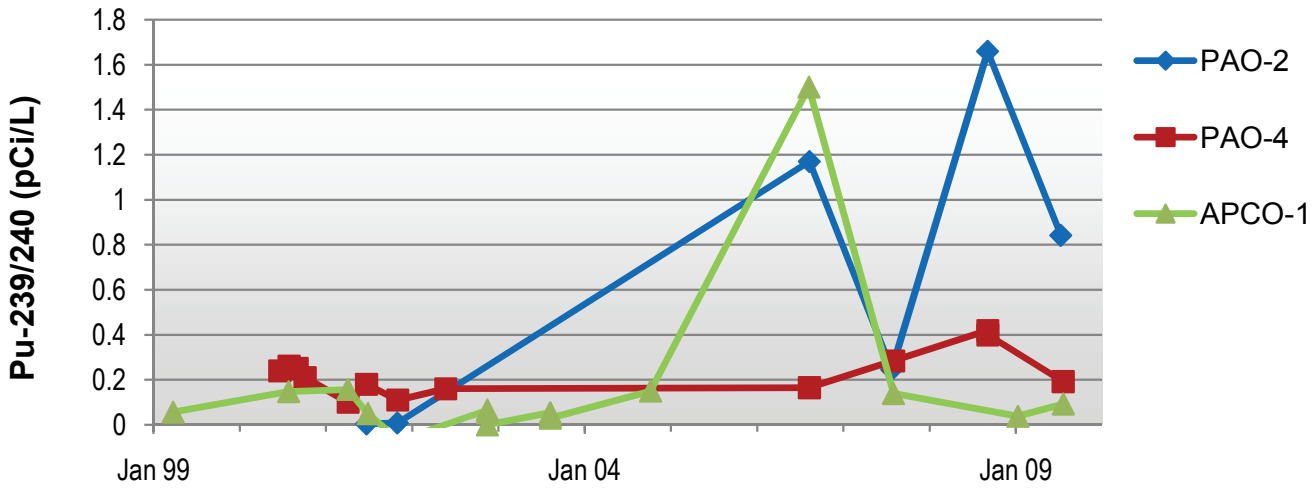


Figure 5-25. **Total plutonium-239/240 activity in Pueblo Canyon alluvial groundwater. The 4 mrem/yr DOE DCG screening level is 1.2 pCi/L. Variation in turbidity (not shown) coincides with variation in total plutonium.**

The perchlorate concentration in the deeper intermediate port at R-9i increased since late 2008 to 2.4 µg/L (Figure 5-30). At Basalt Spring, fed by intermediate groundwater in lower Los Alamos Canyon on Pueblo de San Ildefonso land, perchlorate concentrations since late 2008 have been near or above the NMED screening level of 4 µg/L.

Los Alamos Spring is near Basalt Spring on Pueblo de San Ildefonso land; both are fed by intermediate groundwater. One 2008 nitrate (as nitrogen) result from Basalt Spring was above the NM groundwater standard of 10 mg/L (Figure 5-24). For 2009 the nitrate (as nitrogen) concentrations at the two springs ranged from 2.8 mg/L to 4.7 mg/L. The source of nitrate may be releases into Pueblo Canyon from the present and former Los Alamos County sanitary treatment plants.

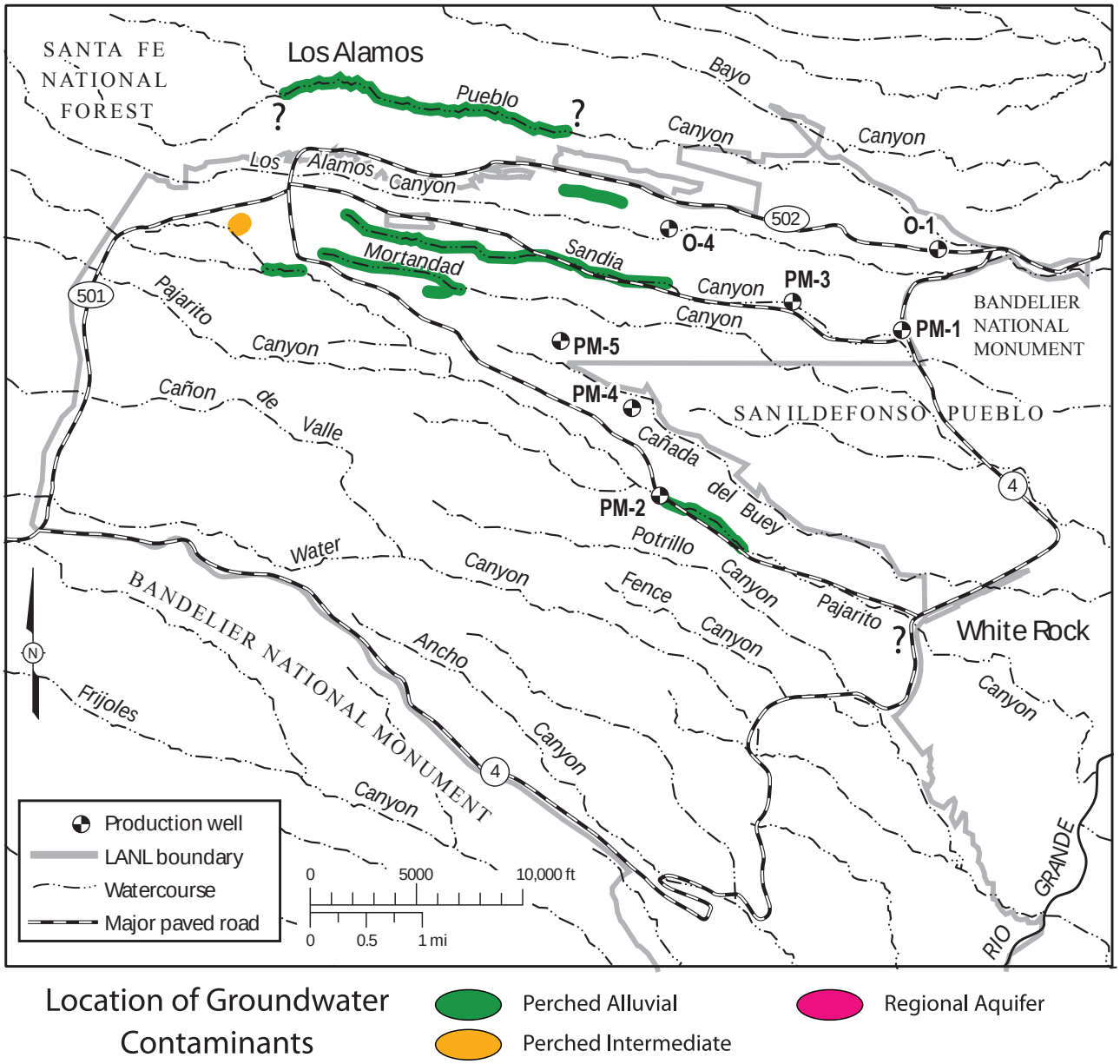


Figure 5-26. Location of groundwater containing chloride above one half of the 250 mg/L NM groundwater standard. Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage.

Alluvial groundwater in DP and Los Alamos Canyons continues to show high activities of strontium-90; the values range up to and above the 8 pCi/L EPA MCL screening level (Figures 5-17 and 5-31). Results from filtered and unfiltered samples from the same date are usually similar so both are shown in Figure 5-31. Fluoride is also present in samples as a result of past effluent release but at concentrations below the NM groundwater standard of 1.6 mg/L. In 2009 fluoride concentrations in four alluvial wells and a spring in DP and Los Alamos Canyons ranged from 0.53 mg/L to 0.76 mg/L.

In Los Alamos Canyon, molybdenum in LAO-2 and LAO-3a has dropped to 21% of the NM groundwater standard of 1,000 µg/L, which is for irrigation use. The molybdenum came from cooling towers at TA-53 (LANSCE). Use of sodium molybdate was discontinued in June 2002. Molybdenum concentrations in Los Alamos Canyon alluvial groundwater have been quite variable in recent years.

Table 5-12
Groundwater Quality in Los Alamos Canyon (includes DP Canyon)

Chemical	Location	Result	Trends
Tritium	Four intermediate wells	710 pCi/L to 3,880 pCi/L, below EPA MCL screening level of 20,000 pCi/L	Highest activities in R-6i, decreasing in LAOI-3.2 and LAOI-3.2a
Nitrate (as N)	Intermediate wells R-6i, LAOI-3.2, LAOI-3.2a	1.8 mg/L to 4.6 mg/L, below NM groundwater standard of 10 mg/L	Highest in R-6i, decreasing in other wells
Perchlorate	Intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, R-9i	2.1 µg/L to 7.0 µg/L, above Consent Order screening level of 4 µg/L	Highest in R-6i, lowest but increasing for 1 year in R-9i, decreasing in other wells
Bis(2-ethylhexyl)phthalate	Intermediate well TA-53i	2.2 µg/L to 16.3 µg/L, above EPA MCL screening level of 6 µg/L	Steady decline over three sampling events
Strontium-90	One alluvial spring and four alluvial wells	5.7 pCi/L to 49 pCi/L, above 8 pCi/L EPA MCL screening level and 40 pCi/L 4-mrem/yr DOE DCG screening level	Decreased since cessation of discharges in 1986, remains high due to retention on sediments
Gross Beta	One alluvial spring and three alluvial wells	25 pCi/L to 101 pCi/L, above 50 pCi/L EPA drinking water system screening level	Due to strontium-90; decreased since cessation of discharges in 1986, remains high due to retention on sediments
Chloride	Alluvial well LAUZ-1	159 mg/L, below NM groundwater standard of 250 mg/L	Similar but variable results over 11 years of monitoring, above standard twice; seasonal variation not clear
Molybdenum	Alluvial wells LAO-2, LAO-3a	170 µg/L to 211 µg/L, below NM groundwater standard of 1,000 µg/L	Last above standard in 2004; concentrations decreasing due to effluent quality improvement
Nitrate (as N)	Intermediate Basalt and Los Alamos Springs (Pueblo de San Ildefonso)	2.8 mg/L to 4.7 mg/L, below NM groundwater standard of 10 mg/L	Apparent result of discharge from Bayo Sanitary Treatment Plant, above standard in past years
Perchlorate	Intermediate Basalt Spring (Pueblo de San Ildefonso)	3.8 µg/L to 4.4 µg/L, above Consent Order screening level of 4 µg/L	Similar levels since August 2008; about 1 µg/L for prior four years
Fluoride	Intermediate Los Alamos Spring (Pueblo de San Ildefonso)	0.96 mg/L, below NM groundwater standard of 1.6 mg/L	Similar levels since 1961

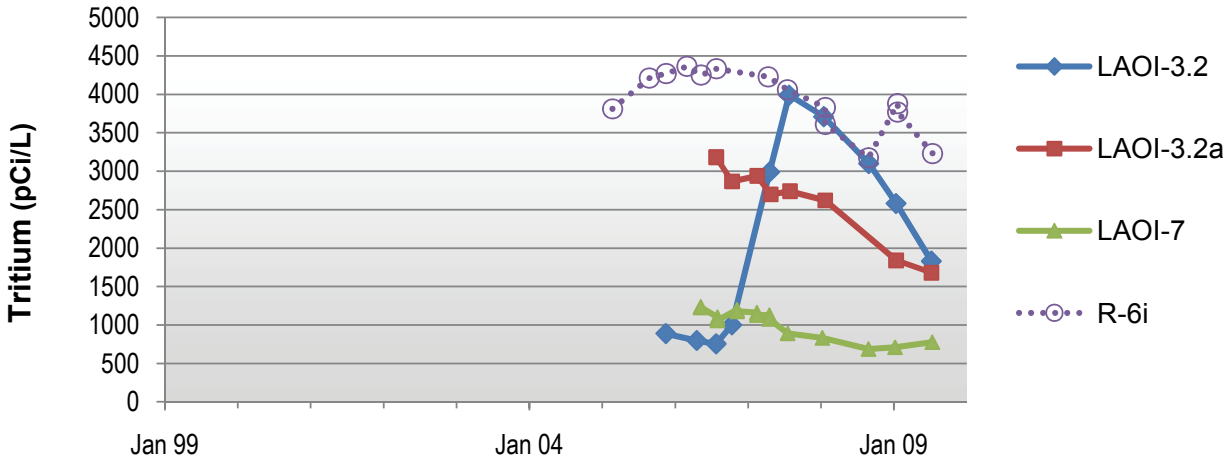


Figure 5-27. **Tritium in Los Alamos Canyon intermediate groundwater. For comparison purposes, the EPA MCL screening level is 20,000 pCi/L.**

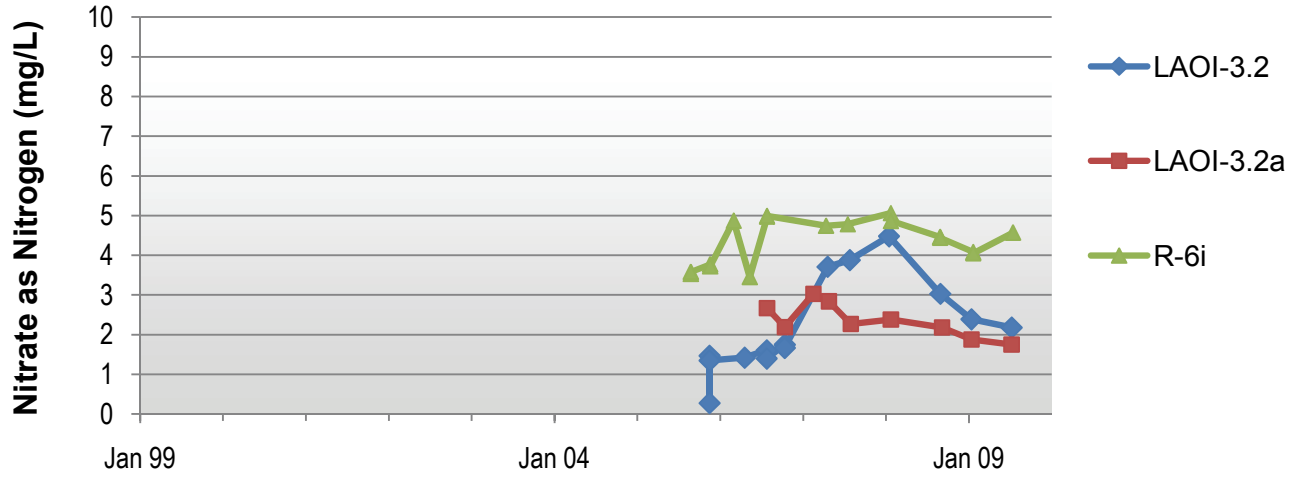


Figure 5-28. **Nitrate (as nitrogen) in Los Alamos Canyon intermediate groundwater. The NM groundwater standard is 10 mg/L.**

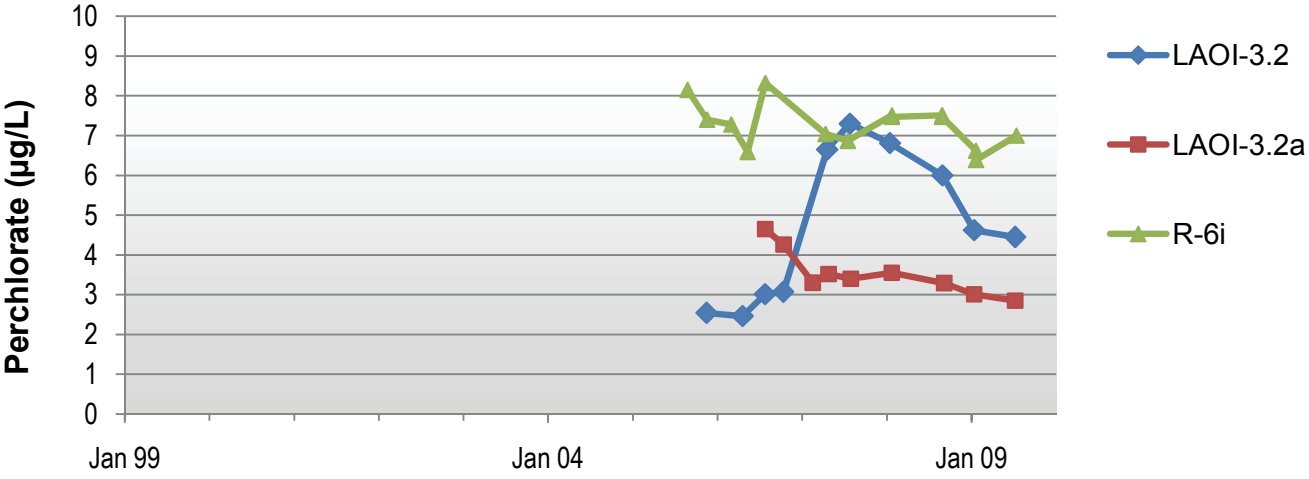


Figure 5-29. **Perchlorate in Los Alamos Canyon intermediate groundwater. The Consent Order screening level is 4 µg/L.**

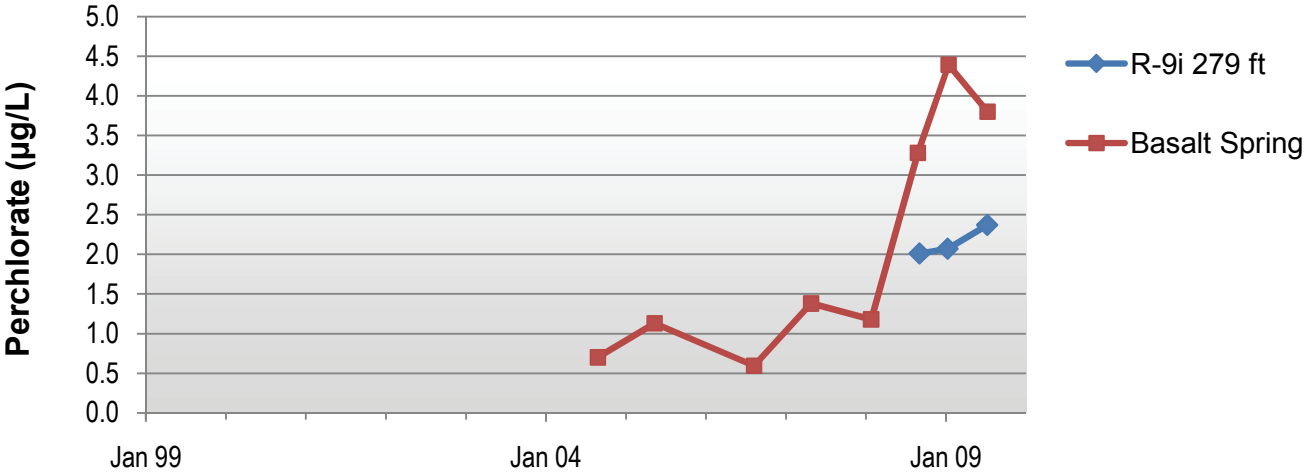


Figure 5-30. **Perchlorate in Los Alamos Canyon intermediate groundwater. The Consent Order screening level is 4 µg/L.**

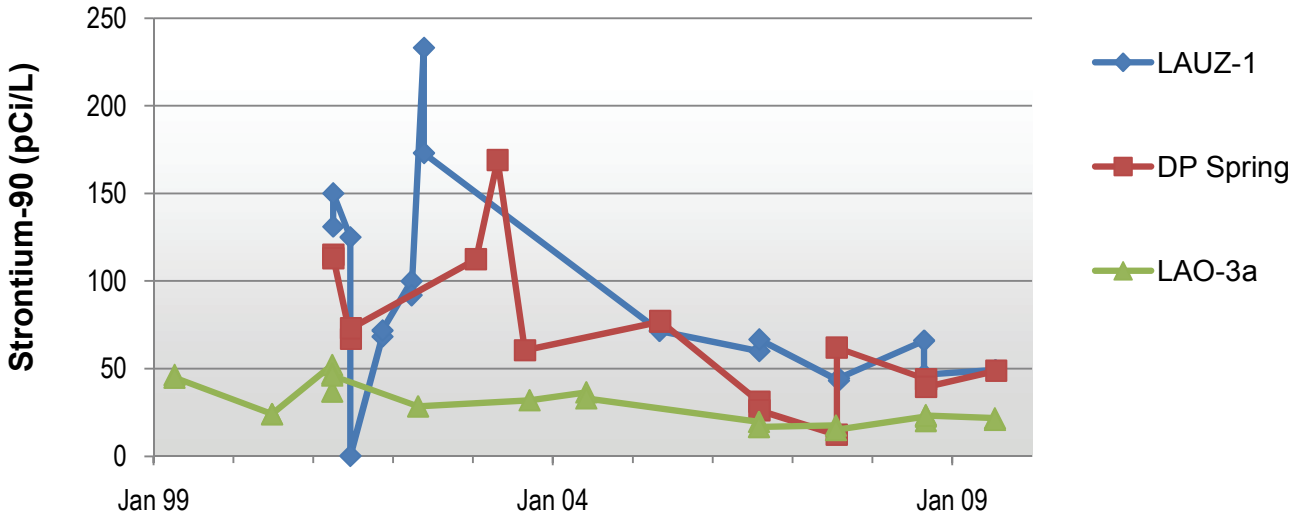


Figure 5-31. Strontium-90 in Los Alamos Canyon alluvial groundwater, showing both filtered and unfiltered results. For comparison purposes, the EPA MCL screening level is 8 pCi/L.

3. Sandia Canyon

Sandia Canyon has a small drainage area that heads at TA-3. The canyon receives the largest liquid discharges of any canyon at the Laboratory, from the cooling tower at the TA-3 power plant (Table 5-13). Treated effluents from the TA-46 SWWS Plant have been routed to Sandia Canyon since 1992. Chromate was used to treat cooling water at the power plant until 1972 (ESP 1973). These earlier discharges are identified as the source for hexavalent chromium concentrations discovered in intermediate groundwater and the regional aquifer beneath Sandia and Mortandad Canyons that are above the 50 µg/L NM groundwater standard (Figure 5-32). This standard applies to dissolved chromium (regardless of the chemical form). Sandia and Mortandad Canyons lie close together, and water percolating downward beneath Sandia Canyon may have been diverted to the south by southwesterly dipping basalts prior to reaching the regional aquifer (ERSP 2006, LANL 2008b).

Table 5-13
Summary of Groundwater Contamination in Sandia Canyon

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Sandia Canyon	Multiple liquid discharges	Chloride at 54%, fluoride at 66%, and TDS at 58% of NM groundwater standard; perchlorate at 67% of Consent Order screening level; total chromium at 60% and arsenic at 100% of EPA MCL screening levels	Chromium 13 times above NM groundwater standard; one cyanide result four times above EPA MCL screening level	Chromium at 40%, fluoride at 50%, and nitrate at 61% of NM groundwater standard; arsenic at 74% of and bis(2-ethylhexyl)phthalate 4.2 times above EPA MCL screening level

In 2009, chromium concentrations in samples from regional aquifer well R-11 in Sandia Canyon were up to 20 µg/L or 40% of the groundwater standard (Table 5-14, Figure 5-33); other analyses show the chromium is in the hexavalent form. Nitrate (as nitrogen) in R-11 and regional aquifer well R-43 were up to 61% of the NM groundwater standard, due to past Laboratory sanitary effluent releases (Figure 5-23, Figure 5-34).

Intermediate well SCI-2 had chromium at concentrations up to 13 times the NM groundwater standard (Table 5-14, Figure 5-33). The nitrate concentration in this well was 44% of the NM groundwater standard (Figure 5-17, Figure 5-34). SCI-2 also had a total cyanide result above the EPA MCL screening level but this single high measurement was about 80 times the results of four other measurements at the well.

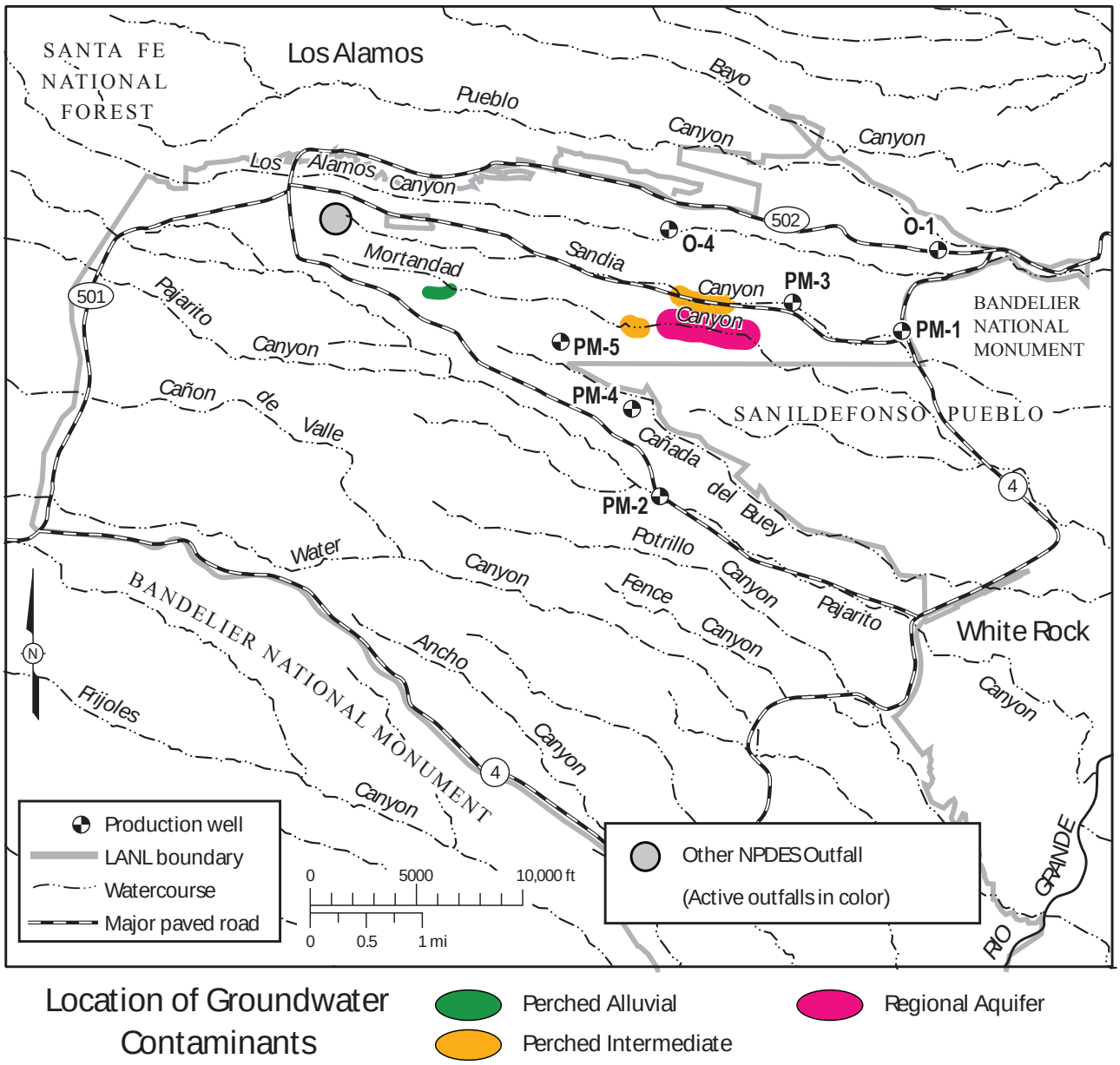


Figure 5-32. Location of groundwater containing dissolved or hexavalent chromium above one half of the 50 µg/L NM groundwater standard. Different colors indicate the affected groundwater zones.

Alluvial wells SCA-4 and SCA-5 had fluoride concentrations up to 66% of the NM groundwater standard (Figure 5- 35). Fluoride concentrations in most of the wells have increased during the past four years of sampling. Perchlorate concentrations in Sandia Canyon surface water and alluvial groundwater samples since 2007 show an annual cycle (Figures 5-36 and 5-37). The locations of surface water monitoring stations are shown in Chapter 6. At the surface water location named Sandia right fork at Power Plant, the perchlorate concentration on November 2, 2009 was 5.0 µg/L, above the Consent Order screening level of 4 µg/L. The concentration on November 3, 2009, in alluvial well SCA-2 reached 2.7 µg/L, or 67% of the screening level. At two surface water locations farther downstream, unusually high concentrations of perchlorate were seen at the same time. The perchlorate concentration was 5.2 µg/L on November 23, 2009 in a sample taken from the Power Plant outfall (EPA NPDES outfall 1) by the NMED Oversight Bureau. This suggests that variation in downstream surface and groundwater concentrations is caused by effluent perchlorate concentration variation.

Table 5-14
Groundwater Quality in Sandia Canyon

Chemical	Location	Result	Trends
Chromium	Regional aquifer monitoring well R-11	14.5 µg/L to 20 µg/L, below NM groundwater standard of 50 µg/L	Rose to 35 µg/L over four years of sampling, now decreasing
Nitrate (as N)	Regional aquifer monitoring wells R-11, R-43	5.0 mg/L to 6.0 mg/L, below NM groundwater standard of 10 mg/L	Some fluctuation over four years of sampling, recent range is 5 mg/L to 6 mg/L
Fluoride	Regional aquifer monitoring well R-36	0.55 mg/L to 0.80 mg/L, below NM groundwater standard of 1.6 mg/L	Rising during two years of samples
Arsenic	Regional aquifer monitoring wells R-11, R-35a	5.1 µg/L to 7.4 µg/L, below EPA MCL screening level of 10 µg/L, below NM groundwater standard of 100 µg/L	Most results have been nondetects, below 5 µg/L MDL
Bis(2-ethylhexyl)phthalate	Regional aquifer monitoring wells R-12, R-36, R-43	4.1 µg/L to 25.1 µg/L, above EPA MCL screening level of 6 µg/L	Only one detection in R-12; steady decline in R-36; only found in one sample event at R-43, nondetects since then
Chromium	Intermediate well SCI-2	502 µg/L to 658 µg/L, above NM groundwater standard of 50 µg/L	Some fluctuation over one year of sampling
Nitrate (as N)	Intermediate well SCI-2	2.9 mg/L to 4.4 mg/L, below NM groundwater standard of 10 mg/L	Some fluctuation over one year of sampling, recent range is mainly 4 mg/L to 5 mg/L
Total Cyanide	Intermediate well SCI-2	0.80 mg/L, above EPA MCL screening level of 0.2 mg/L	Four prior sample results between 0.007 mg/L and 0.010 mg/L
Chloride	Alluvial wells SCA-1, SCA-1-DP, and SCA-2	62 mg/L to 134 mg/L, below NM groundwater standard of 250 mg/L	Variable results over three years, high in winter/spring and low in summer/fall
TDS	Alluvial wells SCA-1, SCA-1-DP, and SCA-2	371 mg/L to 583 mg/L, below NM groundwater standard of 1,000 mg/L	In SCA-1 and nearby SCA-1-DP, somewhat steady for three years, in SCA-2 high in winter/spring and low in summer/fall
Fluoride	Alluvial wells SCA-4 and SCA-5	0.83 mg/L to 1.06 mg/L, below NM groundwater standard of 1.6 mg/L	High but variable for three years
Perchlorate	Alluvial well SCA-2	0.13 µg/L to 2.7 µg/L, below Consent Order screening level of 4 µg/L	Often between 0.4 µg/L and 0.7 µg/L for three years
Total Chromium	Alluvial well SCA-4	Unfiltered concentrations of 17.6 µg/L to 60 µg/L, below EPA MCL screening level of 100 µg/L	Variable results for three years; higher results related to higher turbidity
Arsenic	Alluvial wells SCA-4 and SCA-5	Filtered/unfiltered results of 5.9 µg/L to 10.1 µg/L, above EPA MCL screening level of 10 µg/L, below NM groundwater standard of 100 µg/L	Variable over three years at SCA-4, first detects at SCA-5; filtered and unfiltered results similar

Three alluvial wells, SCA-1, SCA-1-DP (a substitute for SCA-1), and SCA-2, had results for chloride and TDS that approached NM groundwater standards. Data from these wells and more frequent data from adjacent surface water monitoring locations indicate seasonal variation in chloride concentrations, with highest values in winter (Figure 5-26, 5-38, and 5-39). The surface water locations show peaks in chloride concentrations in early winter, evidently the result of road salt runoff. Similar trends occur in sodium concentrations and TDS (not shown). Although alluvial groundwater data are less frequent, they support the pattern of high concentrations of chloride, sodium, and TDS in winter. At SCA-4, the well located farthest downstream, the chloride concentration peaks appear to be delayed and have lower amplitude.

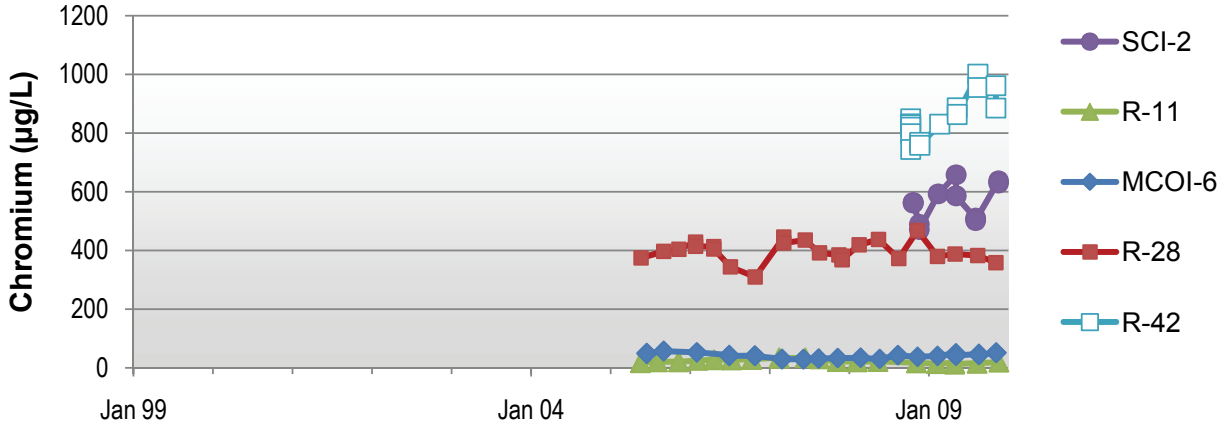


Figure 5-33. Filtered chromium in Sandia and Mortandad Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 50 µg/L.

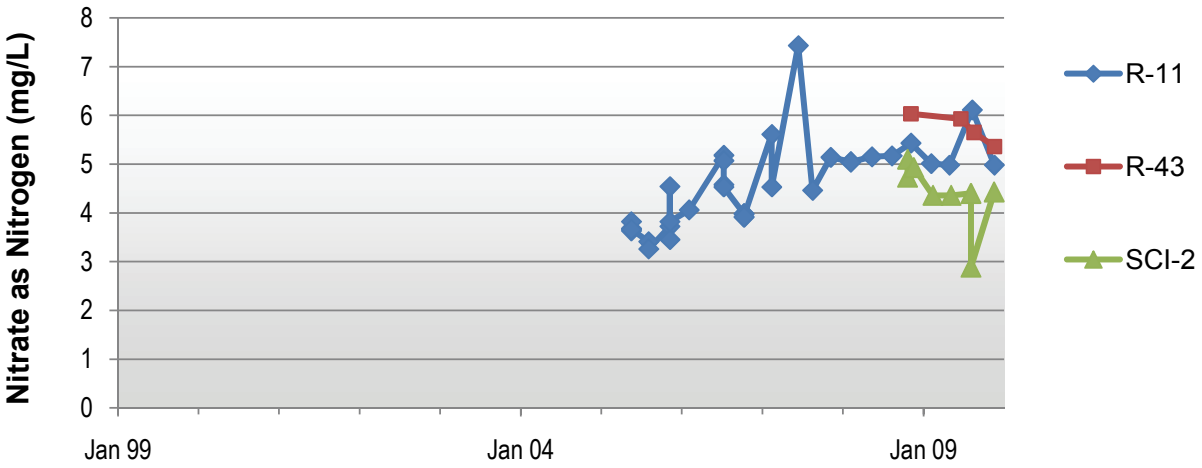


Figure 5-34. Nitrate (as nitrogen) in Sandia Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 10 mg/L. Many of the results in 2007 and 2008 are estimated due to analytical quality issues.



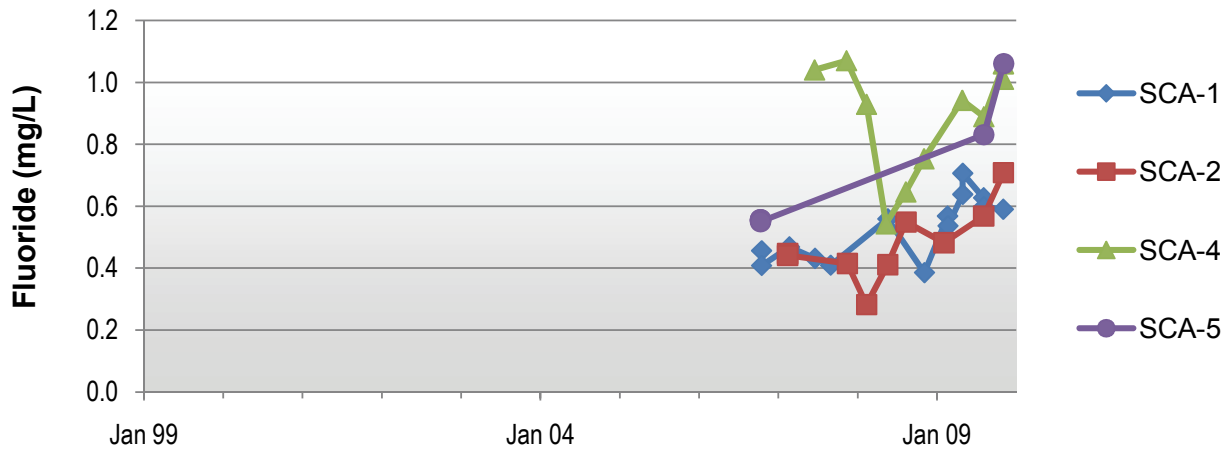


Figure 5-35. Fluoride in Sandia Canyon alluvial groundwater. The NM groundwater standard is 1.6 mg/L.

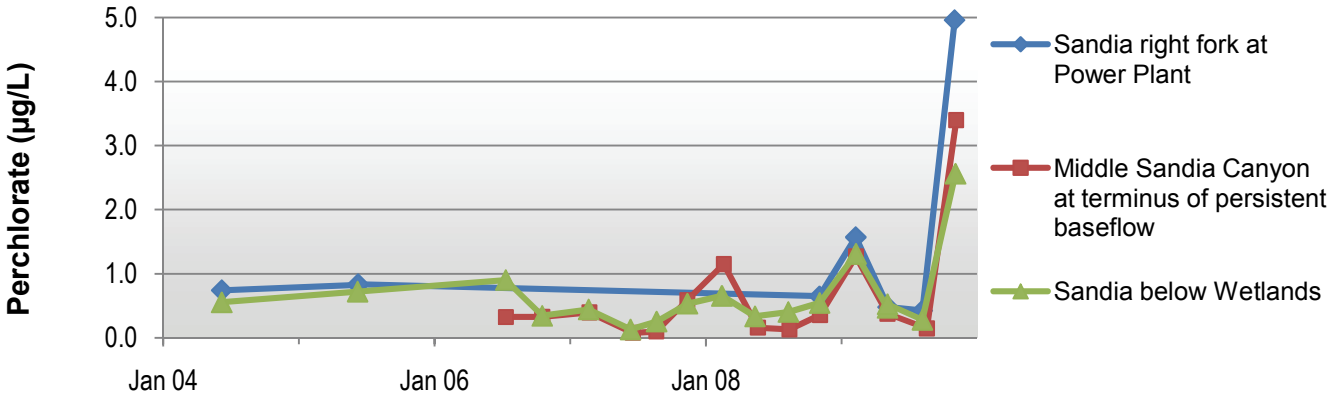


Figure 5-36. Perchlorate in Sandia Canyon surface water. The Consent Order screening level is 4 µg/L.

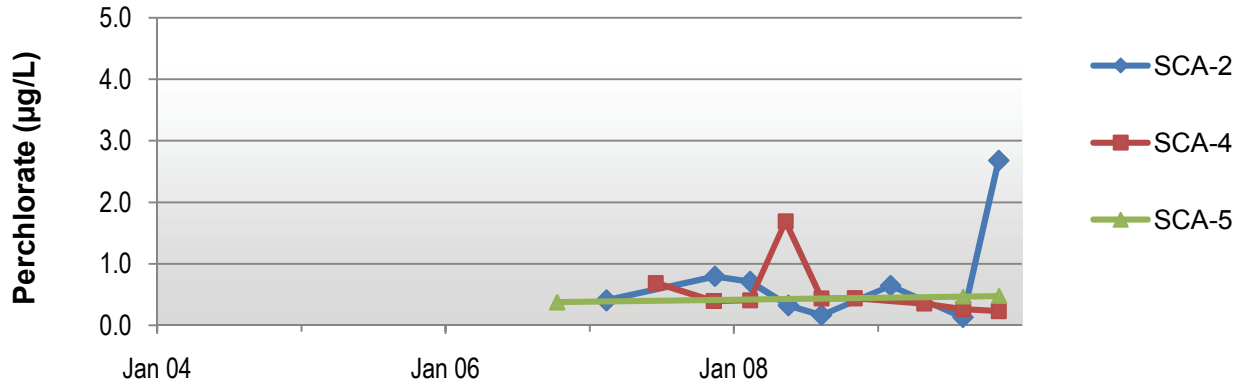


Figure 5-37. Perchlorate in Sandia Canyon alluvial groundwater. The Consent Order screening level is 4 µg/L.

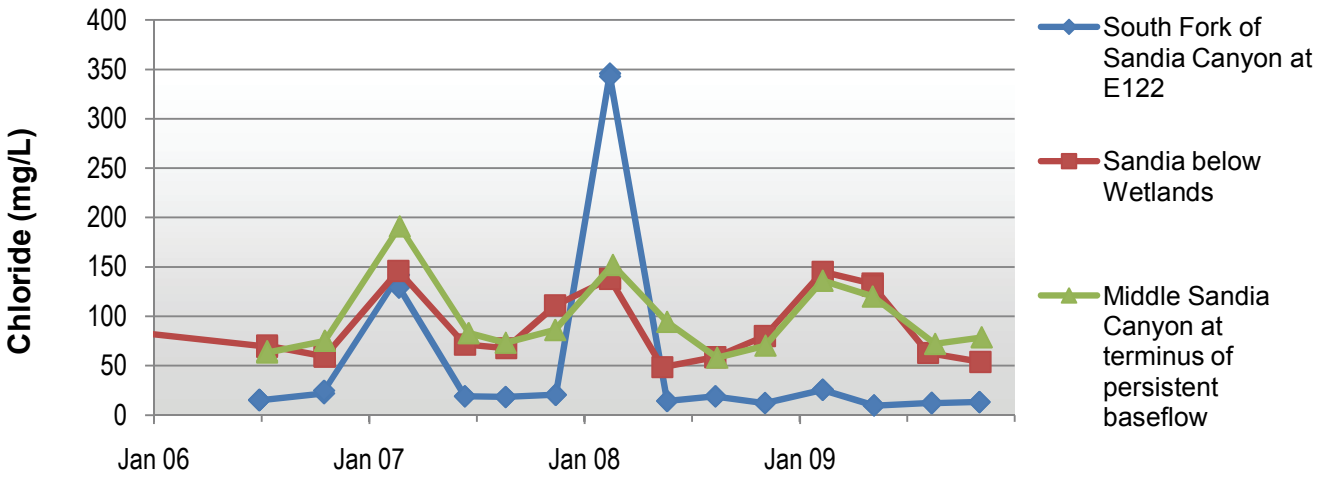


Figure 5-38. Chloride in Sandia Canyon surface water. The NM groundwater standard is 250 mg/L.

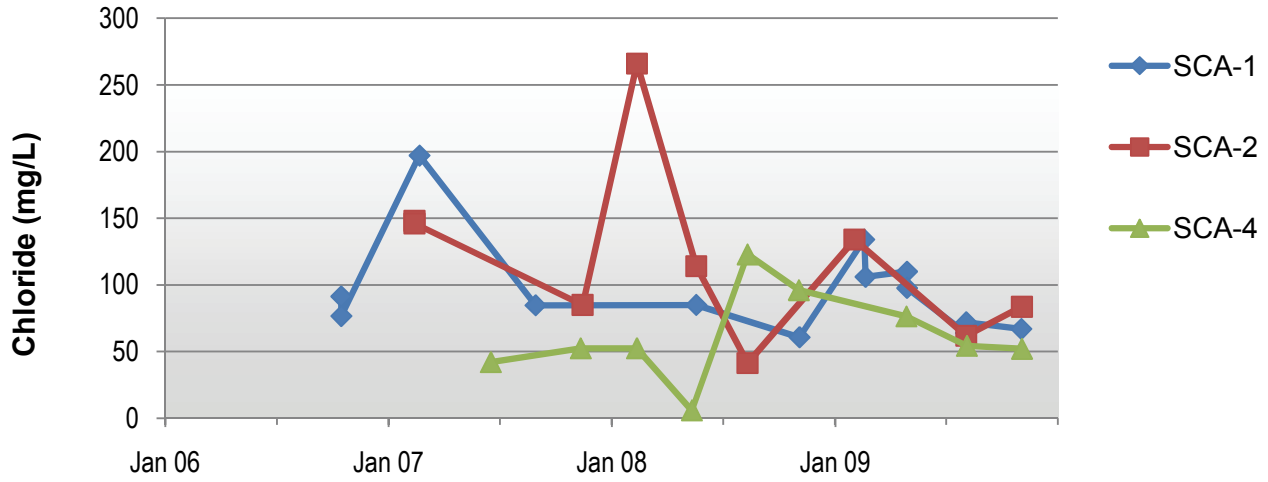


Figure 5-39. Chloride in Sandia Canyon alluvial groundwater. Because they are substitute monitoring locations, data for SCA-1 and SCA-1-DP are shown together. The NM groundwater standard is 250 mg/L.

4. Mortandad Canyon (includes Ten Site Canyon and Cañada del Buey)

Mortandad Canyon has a small drainage area that heads at TA-3. This drainage area receives inflow from natural precipitation and a number of National Pollutant Discharge Elimination System (NPDES) outfalls, including one from the Radioactive Liquid Waste Treatment Facility (RLWTF) at TA-50 (Table 5-15). Past discharges into tributary Ten Site Canyon included a previous radioactive effluent treatment plant at TA-35. These discharges have affected groundwater quality in the canyons (Table 5-16).

Table 5-15
Summary of Groundwater Contamination in Mortandad Canyon
(includes Ten Site Canyon and Cañada del Buey)

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Mortandad and Ten Site Canyons	Multiple past and current effluent discharges	Chloride 1.8 times above, fluoride at 88%, and TDS at 93% of NM groundwater standards; strontium-90 5.6 times above, arsenic at 87% of EPA MCL screening levels; perchlorate 5.5 times above Consent Order screening level; plutonium and americium 3.3 times above 4-mrem DCG screening levels	Nitrate at 150%, hexavalent chromium at 104% and uranium at 100%, fluoride at 60%, and TDS at 58% of NM groundwater standards; tritium at 48% of EPA MCL screening level; dioxane[1,4-] at 56% of EPA Human Health tap water screening level; perchlorate at 26 times above Consent Order screening level	Hexavalent chromium 18 times above and nitrate at 70% of NM groundwater standards; perchlorate 1.9 times above Consent Order screening level; benzene and bis(2-ethylhexyl)phthalate 16 times above and arsenic at 61% of EPA MCL screening levels
Cañada del Buey	Major dry, minor liquid sources	None, little alluvial groundwater	No intermediate groundwater	None

Table 5-16
Groundwater Quality in Mortandad Canyon
(includes Ten Site Canyon and Cañada del Buey)

Chemical	Location	Result	Trends
Chromium	Regional aquifer monitoring wells R-28 and R-42	Average of 377 µg/L at R-28 and 911 µg/L at R-42, above NM groundwater standard of 50 µg/L	Increasing over two years of samples at R-42; results at R-28 in this range for five years of sampling
Nitrate (as N)	Regional aquifer monitoring wells R-42, R-28, and R-15	1.9 mg/L to 7.0 mg/L, below NM groundwater standard of 10 mg/L	Higher values in R-42 and lowest in R-15, results in this range in R-28 and R-15 for five years of sampling
Perchlorate	Regional aquifer monitoring well R-15	6.4 µg/L to 7.4 µg/L, above Consent Order screening level of 4 µg/L	Results in this range for six years of sampling
Bis(2-ethylhexyl) phthalate	Regional aquifer monitoring wells R-38, R-46	3.3 µg/L to 96 µg/L, above EPA MCL screening level of 6 µg/L	Declining concentrations after first sample rounds
Benzene	Regional aquifer monitoring well R-38	24 µg/L, above EPA MCL screening level of 5 µg/L	Found mainly in first two of first five sample events; concentrations dropped to 2 µg/L in second sampling
Tritium	Intermediate wells MCOI-4, MCOI-5, MCOI-6	3070 to 9520 pCi/L, below EPA MCL screening level of 20,000 pCi/L	Values decreasing over five years of sampling; wells sample separate isolated perched zones
Nitrate (as N)	Intermediate wells MCOI-4, MCOI-5, MCOI-6	3.6 mg/L to 15 mg/L, above NM groundwater standard of 10 mg/L	Results decreasing in MCOI-6 for two years, in MCOI-4 for four years; wells sample separate isolated perched zones
Perchlorate	Intermediate wells MCOI-4, MCOI-5, MCOI-6	61 µg/L to 104 µg/L, above Consent Order screening level of 4 µg/L	Results decreasing in MCOI-6 for two years, decreasing in MCOI-4 for four years
Chromium	Intermediate well MCOI-6	41 µg/L to 52 µg/L, above NM groundwater standard of 50 µg/L	Increasing for three years following two-year decrease

Table 5-16 (continued)

Chemical	Location	Result	Trends
Dioxane[1,4-]	Intermediate wells MCOI-4, MCOI-5, MCOI-6	Semivolatile results are 5 µg/L to 34 µg/L, below EPA Human Health tap water screening level of 61 µg/L	Results at each location fairly steady over three years; many estimated results
Uranium	Intermediate Pine Rock Spring (Pueblo de San Ildefonso)	30 µg/L, at NM groundwater standard of 30 µg/L	Steady over four years, may be leached from bedrock by percolation of sanitary effluent used to irrigate Overlook Park athletic fields
Nitrate (as N)	Intermediate Pine Rock Spring (Pueblo de San Ildefonso)	8.2 mg/L, below NM groundwater standard of 10 mg/L; one higher value due to field preservation error	Values range from 3.6 mg/L to 14.4 mg/L over four years; from percolation of sanitary effluent used to irrigate Overlook Park athletic fields
Fluoride	Intermediate Pine Rock Spring (Pueblo de San Ildefonso)	0.95 mg/L, below NM groundwater standard of 1.6 mg/L	Similar values over four years
TDS	Intermediate Pine Rock Spring (Pueblo de San Ildefonso)	582 mg/L, below NM groundwater standard of 1,000 mg/L	Similar values over four years; from percolation of sanitary effluent used to irrigate Overlook Park athletic fields
Americium-241, plutonium-238 and -239/240	Alluvial well MCO-3	All about 4 pCi/L, above 1.2 pCi/L to 1.6 pCi/L 4-mrem/yr DOE DCG screening levels; unfiltered sample	Few samples in recent years; results similar to those in 2003 and earlier
Strontium-90	Alluvial wells MCO-3, MCO-4B, MCO-5, MCO-6	13.5 pCi/L to 45 pCi/L, above EPA MCL screening level of 8 pCi/L and 40 pCi/L 4-mrem/yr DOE DCG screening level	Fairly stable between 30 pCi/L to 80 pCi/L for 10 years due to retention on sediments
Fluoride	Seven alluvial wells	0.27 mg/L to 1.4 mg/L, below NM groundwater standard of 1.6 mg/L	Results stable and generally below standard since 1999 effluent treatment upgrades
Chloride	Alluvial wells MCO-0.6, MCO-2, MCO-3	17 mg/L to 444 mg/L, above NM groundwater standard of 250 mg/L	Caused by road salt runoff; peaks in mid-winter; generally above standard for five years at MCO-0.6 and MCO-2
TDS	Alluvial wells MCO-0.6, MCO-2	205 mg/L to 927 mg/L, below NM groundwater standard of 1,000 mg/L	Caused by road salt runoff; often above standard for five years at MCO-0.6
Perchlorate	Six alluvial wells	4.7 µg/L to 22 µg/L, above Consent Order screening level of 4 µg/L	Results substantially decreasing since 2002 effluent treatment upgrades
Arsenic	Alluvial well MCO-2	Filtered concentrations 8.3 µg/L, below EPA MCL screening level of 10 µg/L	Results variable, few prior sampling events, may be naturally occurring

Cañada del Buey, a tributary to Mortandad Canyon, contains a shallow perched alluvial groundwater system of limited extent, and only two wells have ever contained water. Because treated effluent from the Laboratory's SWWS facility may at some time be discharged into the Cañada del Buey drainage system, a network of five shallow groundwater monitoring wells and two moisture-monitoring holes was installed during 1992 within the upper and middle reaches of the drainage. Past discharges included accidental releases from experimental reactors and laboratories at TA-46.

a. 2009 Radioactive Liquid Waste Treatment Facility Discharges

Data on the RLWTF's yearly radionuclide discharge into Mortandad Canyon from 2007 through 2009 appear in Supplemental Data Table S5-13. Table S5-13 shows mean annual levels in effluent for each radionuclide and the ratio of each of these to the 100-mrem/yr DOE DCG for public dose. Figures 5-40 and 5-41 show RLWTF average annual radionuclide activities in discharges compared to DOE DCGs and the fluoride and nitrate concentrations relative to NM groundwater standards since 1996.

Beginning in 1999, LANL made significant upgrades to the RLWTF treatment system. As a result, activities of radionuclides in the effluent have dropped one or more orders of magnitude and several can no longer be detected in samples. For the last nine years, including 2009, the RLWTF has met all DOE radiological discharge standards. Concentrations of nitrate, fluoride, and TDS in the effluent decreased substantially. A system for removing perchlorate from the RLWTF effluent became operational on March 26, 2002. Since then, perchlorate was detected in effluent samples only for five weeks in 2008.

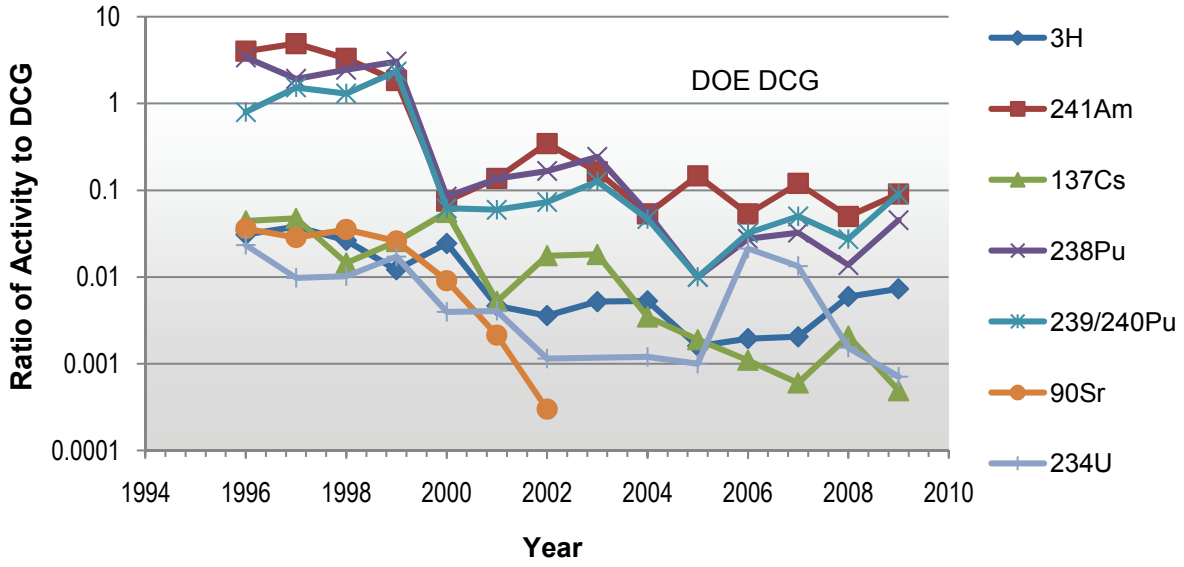


Figure 5-40. Ratio of 1996–2009 average annual radionuclide activity in RLWTF discharges to the 100-mrem/yr public dose DOE DCGs, which are applicable to effluent releases.

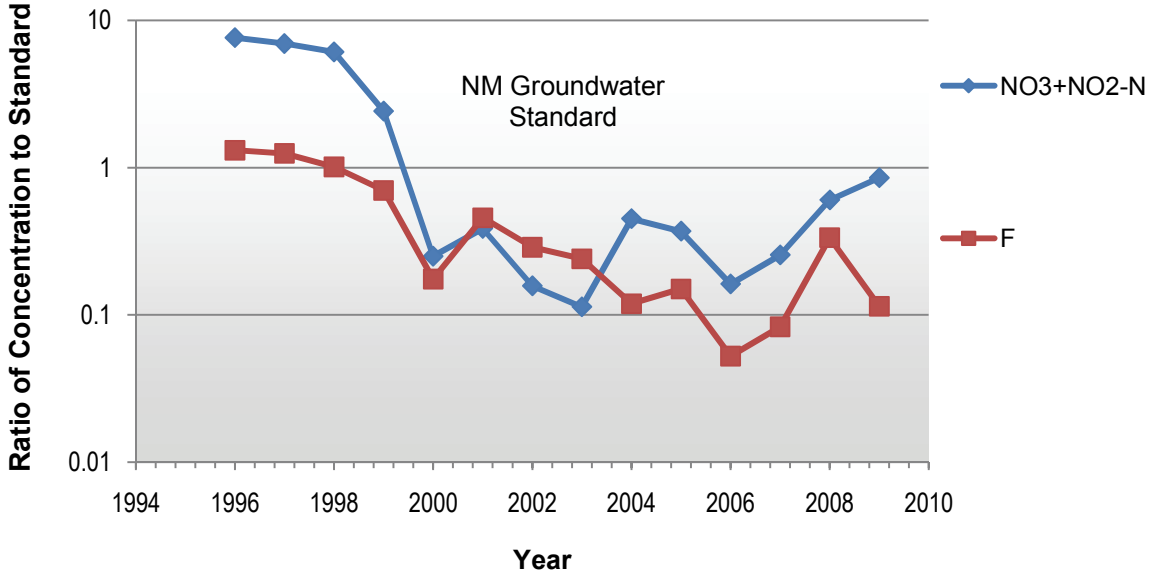


Figure 5-41. Ratio of 1996–2009 average annual nitrate plus nitrite (as nitrogen) and fluoride concentrations in RLWTF discharges to the NM groundwater standards.

During 2008 and 2009, the nitrate (as nitrogen) concentrations of all monthly analyses of effluent discharges from the RLWTF were less than the NM groundwater standard for nitrate (as nitrogen) of 10 mg/L, as has been the case since 2000. However, in some cases the nitrate + nitrite (as nitrogen) concentration of the effluent discharges was near or slightly above10 mg/L (Figure 5-42). The average 2009 effluent total nitrate + nitrite (as nitrogen) concentration was 8.54 mg/L. In 2009, the highest nitrate + nitrite (as nitrogen) concentration in a base flow grab sample collected below the outfall was 4.1 mg/L, at the surface water station Mortandad below Effluent Canyon.

The fluoride concentration in the effluent has also declined over the last few years (Figure 5-43). The 2009 effluent fluoride concentration (average value of 0.18 mg/L) was below the NM groundwater standard of 1.6 mg/L. In 2009, the highest fluoride concentration in a base flow grab sample collected below the outfall was 0.30 mg/L, at the surface water station Mortandad below Effluent Canyon.

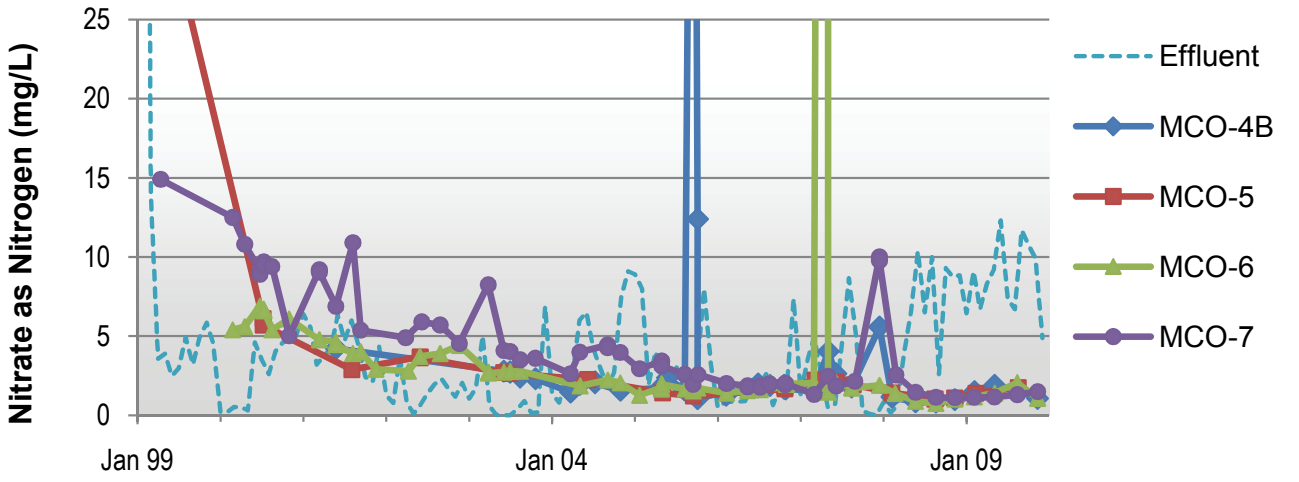


Figure 5-42. **Nitrate + nitrite (as nitrogen) in RLWTF effluent and Mortandad Canyon alluvial groundwater. The NM groundwater standard is 10 mg/L. Groundwater results above about 3 mg/L taken after 2005 reflect field preservation errors.**

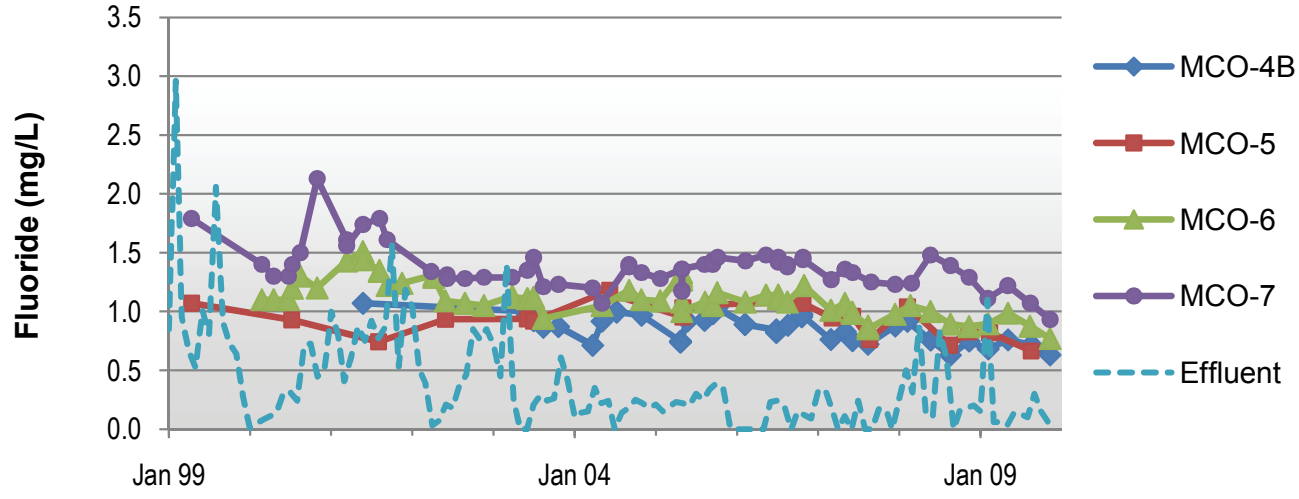


Figure 5-43. **Fluoride in RLWTF effluent and Mortandad Canyon alluvial groundwater. The NM groundwater standard is 1.6 mg/L.**

b. Mortandad Canyon Intermediate Groundwater and Regional Aquifer

The regional aquifer beneath Mortandad Canyon shows impacts from past LANL discharges; intermediate groundwater shows a generally larger effect. In 2009, sampling at two regional aquifer monitoring wells continued to show contamination by hexavalent chromium above the NM groundwater standard of 50 µg/L (which applies to any dissolved form of chromium) (Table 5-16, Figure 5-32, Figure 5-33). The concentrations found at regional aquifer monitoring well R-42 were approximately 900 µg/L, and those in R-28 were about 380 µg/L. The Laboratory is investigating this issue in cooperation with NMED and identified past cooling tower discharges in Sandia Canyon as the likely source (ERSP 2006, LANL 2008b).

The 2009 nitrate concentration in R-28 was up to 43% of the NM groundwater standard (Figure 5-44). The nitrate concentration in R-42 was up to 70% of the standard. In nearby regional aquifer monitoring well R-15, results for tritium and nitrate are higher than in unaffected wells but are below standards or screening levels. Nitrate concentrations in 2009 in R-15 ranged up to 24% of the NM groundwater standard and the 880 ft. port of R-45 had concentrations up to 19% of the standard (Figure 5-44). The perchlorate concentration in R-15 was above the Consent Order screening level of 4 µg/L (Figure 5-45). Samples taken from R-15 since June 2004 have perchlorate concentrations between 5.3 µg/L and 7.4 µg/L.

In 2009, bis(2-ethylhexyl)phthalate was detected in samples from new regional aquifer wells R-38 and R-46 at concentrations above the 6 µg/L EPA MCL screening level. The concentrations ranged from 3.3 µg/L to 96 µg/L and are declining with time (Figures 5-13 and 5-15). Benzene was found in R-38 at concentrations up to 24 µg/L, above EPA MCL screening level of 5 µg/L. Benzene was found mainly in the first two of the five sample events; concentrations dropped to 2 µg/L in the second sample event.

Contaminants found in Mortandad Canyon intermediate groundwater indicate an impact by LANL effluents, with some concentrations near or exceeding regulatory standards or screening levels. MCOI-6, an intermediate groundwater well in Mortandad Canyon, consistently shows chromium in filtered samples at concentrations near the NM groundwater standard (Figure 5-33). Nitrate (Figures 5-23, 5-46, 5-47), dioxane[1,4-] (Figure 5-48), and perchlorate (Figures 5-19 and 5-49) are consistently near or above standards or screening levels in some of these intermediate groundwater monitoring wells.

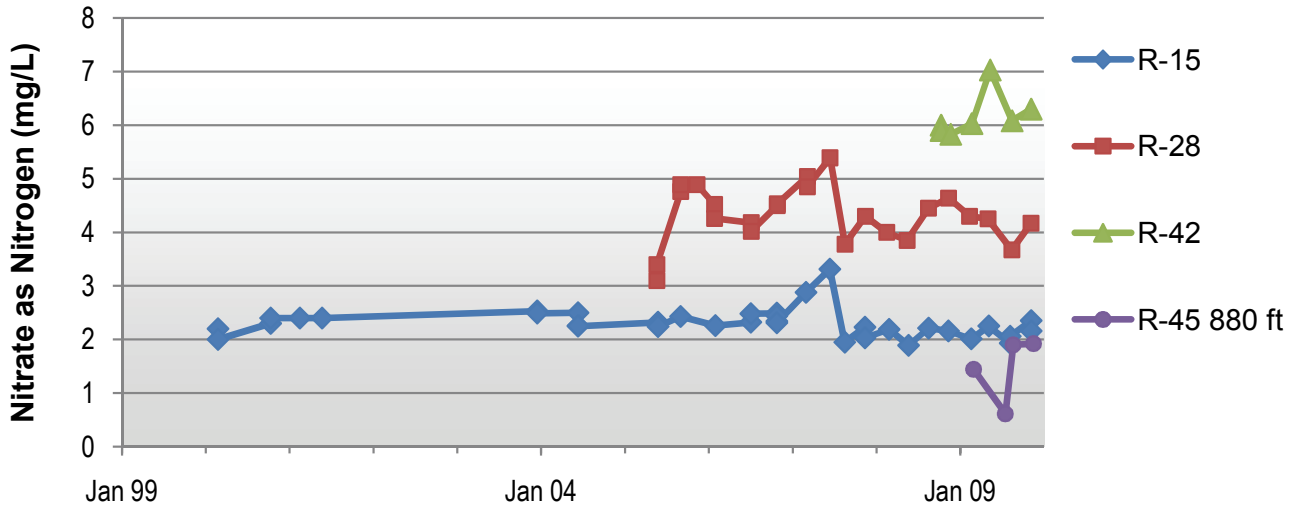


Figure 5-44. Nitrate (as nitrogen) in Mortandad Canyon regional aquifer groundwater The NM groundwater standard is 10 mg/L. Most of the 2007 and some 2009 results are estimated due to analytical quality issues.

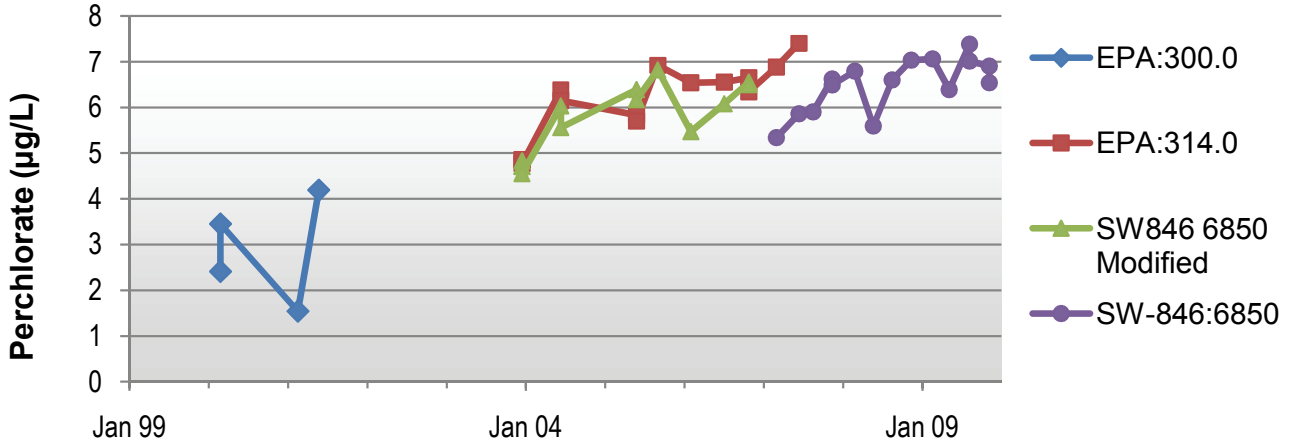


Figure 5-45. **Perchlorate in Mortandad Canyon regional aquifer well R-15; the Consent Order screening level is 4 µg/L. Data are separated by analytical method. Most results by SW846 6850 Modified are estimated due to analytical laboratory quality issues.**

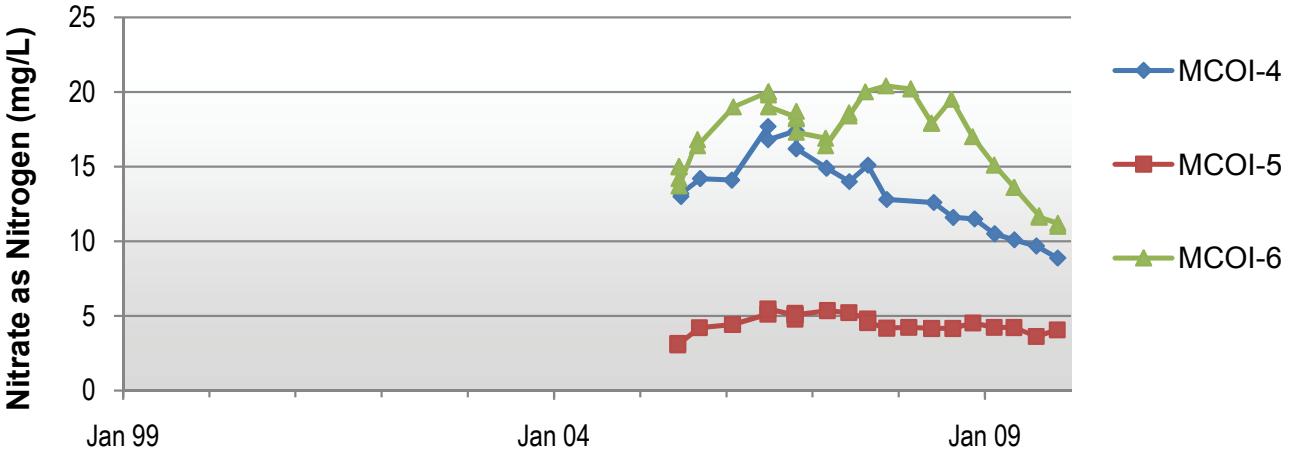


Figure 5-46. **Nitrate (as nitrogen) in Mortandad Canyon intermediate groundwater The NM groundwater standard is 10 mg/L. Many of the results, particularly in 2006, are estimated due to analytical laboratory quality issues.**

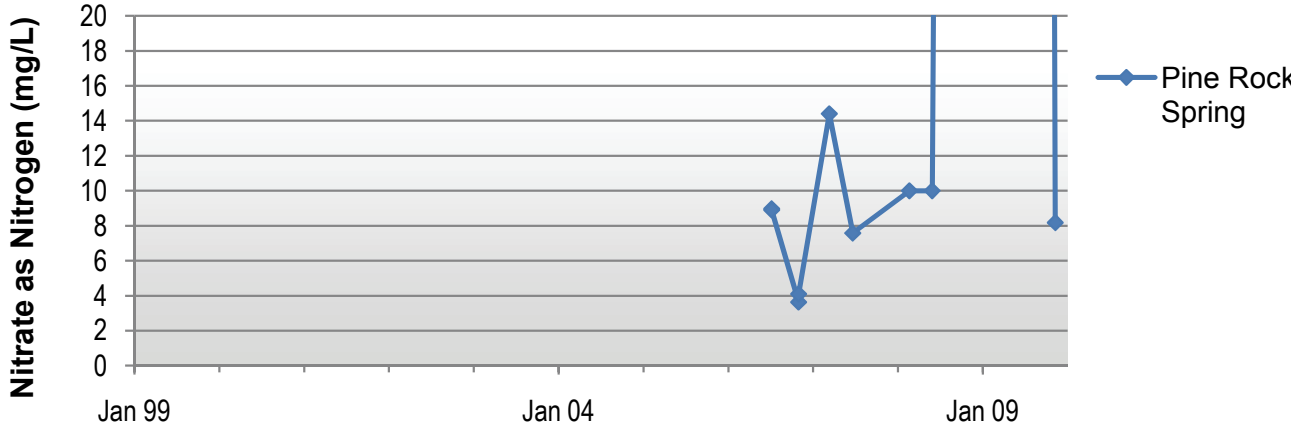


Figure 5-47. **Nitrate (as nitrogen) in Mortandad Canyon intermediate groundwater at Pine Rock Spring on Pueblo de San Ildefonso land. The NM groundwater standard is 10 mg/L. A very high May 2009 result was caused by a field preservation error.**

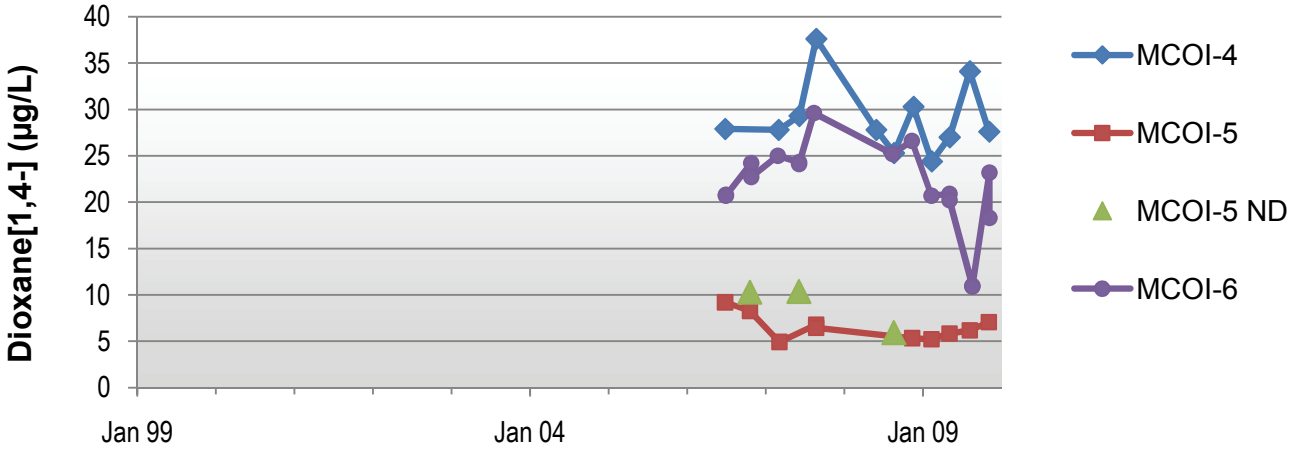


Figure 5-48. **Dioxane[1,4-] in Mortandad Canyon intermediate groundwater; the EPA Human Health tap water screening level is 61.1 µg/L. About half the results are estimated; nondetects (ND) are indicated separately for MCOI-5. The results using the semivolatile organic compound (SVOC) method are shown; earlier results using the volatile organic compound (VOC) method are higher, but that method is not suitable for this compound.**

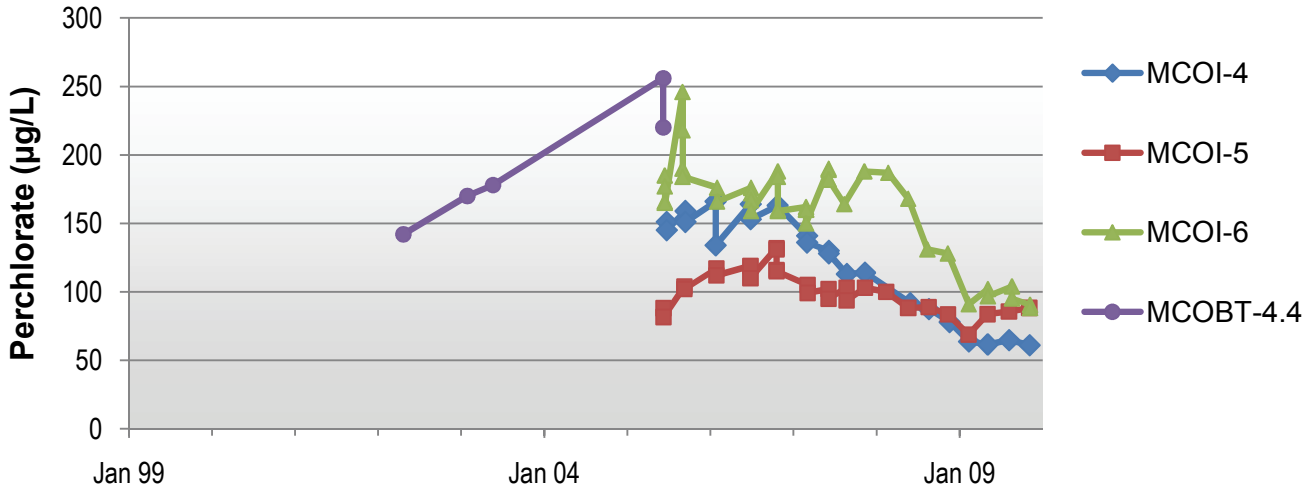


Figure 5-49. **Perchlorate in Mortandad Canyon intermediate groundwater; the Consent Order screening level is 4 µg/L.**

Three intermediate wells in Mortandad Canyon (MCOI-4, MCOI-5, and MCOI-6) had tritium activities that ranged from 15% to 48% of the EPA MCL screening level of 20,000 pCi/L (Figure 5-50). Tritium activities in these wells have decreased over the past two to three years. Another intermediate well, MCOBT-4.4, was installed in 2001 and had construction problems that caused groundwater to leak from the perched zone it sampled; it was plugged and abandoned in 2009 (LANL 2009h). The Laboratory drilled nearby MCOI-4 as a replacement.

Pine Rock Spring on Pueblo de San Ildefonso land had uranium concentrations equal to and nitrate concentrations (Figure 5-47) below the NM groundwater standards. Fluoride and TDS were also near the NM groundwater standards. The uranium values may be caused by dissolution of uranium from the bedrock by sanitary effluent used to water athletic fields at nearby Overlook Park (Teerlink 2007). The nitrate, fluoride, and TDS concentrations also appear to be caused by the contribution of effluent to spring flow.

In 2005, we measured and detected dioxane[1,4-] for the first time in two intermediate wells in Mortandad Canyon. Dioxane[1,4-] has been detected since 2006 in MCOI-4, MCOI-5, and MCOI-6 using the semivolatile organic compound method SW-846:8270C (Figure 5-48). The dioxane[1,4-] EPA Human Health tap water screening level is 61 µg/L. In 2009, the highest result of 34 µg/L was in MCOI-4, at 56% of the screening level. Earlier results using the volatile organic compound method SW-846:8260B were higher, but results lack accuracy as the method is not suitable for this compound.

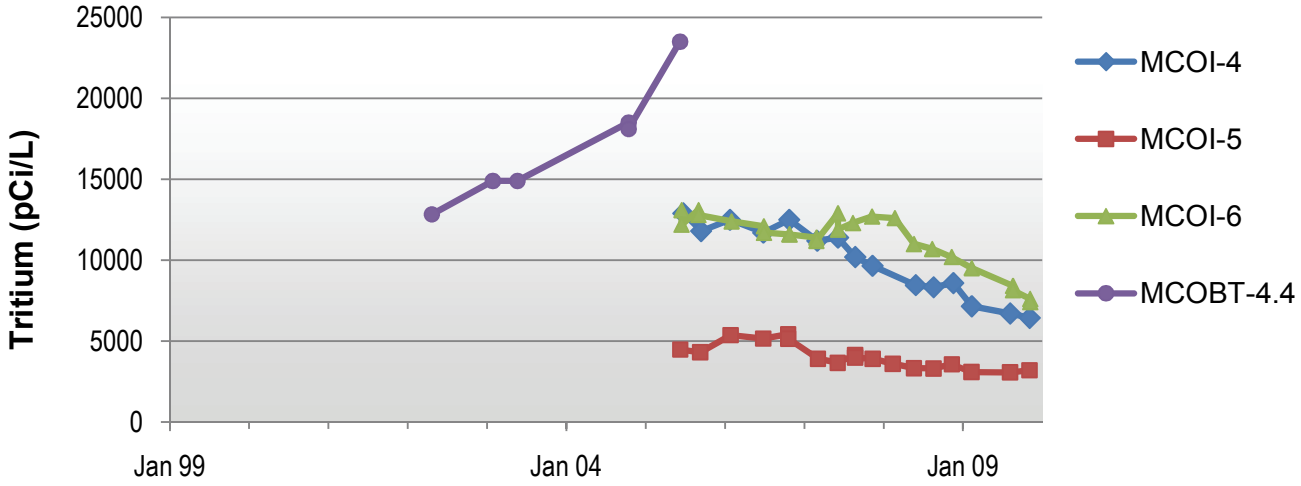


Figure 5-50. Tritium in Mortandad Canyon intermediate groundwater. For comparison purposes, the EPA MCL screening level is 20,000 pCi/L.

c. Alluvial Groundwater

Radionuclide levels in Mortandad Canyon alluvial groundwater are, in general, highest just below the TA-50 RLWTF outfall at wells MCO-3, MCA-5, or MCO-4B and decrease down the canyon. Most radionuclides adsorb to sediment closer to the outfall and subsequently move with sediment rather than in groundwater. Since the early 1990s, radionuclide levels in alluvial groundwater samples have not exceeded the 100-mrem/yr public dose DOE DCG screening levels (applicable to effluent discharges).

In 2009, total LANL-derived radioactivity exceeded the 4-mrem/yr DOE DCG screening level in Mortandad Canyon alluvial groundwater samples from wells MCO-3, MCO-4B, MCO-5, and MCO-6 (Figure 5-18). Except for MCO-3, strontium-90 was the dominant contributor to dose in these samples. The 2009 results for strontium-90 were close to or exceeded the 4-mrem/yr DOE DCG screening level (40 pCi/L) and the EPA MCL screening level (8 pCi/L) in all four wells (Figure 5-17, Figure 5-51).

Variable americium-241, plutonium-238, and plutonium-239/240 results in some Mortandad Canyon alluvial wells have occasionally exceeded the 4-mrem/yr DOE DCG screening levels in the last decade. In a 2009 sample at MCO-3, americium-241, plutonium-238, and plutonium-239/240 activities were all above the 4-mrem DCGs.



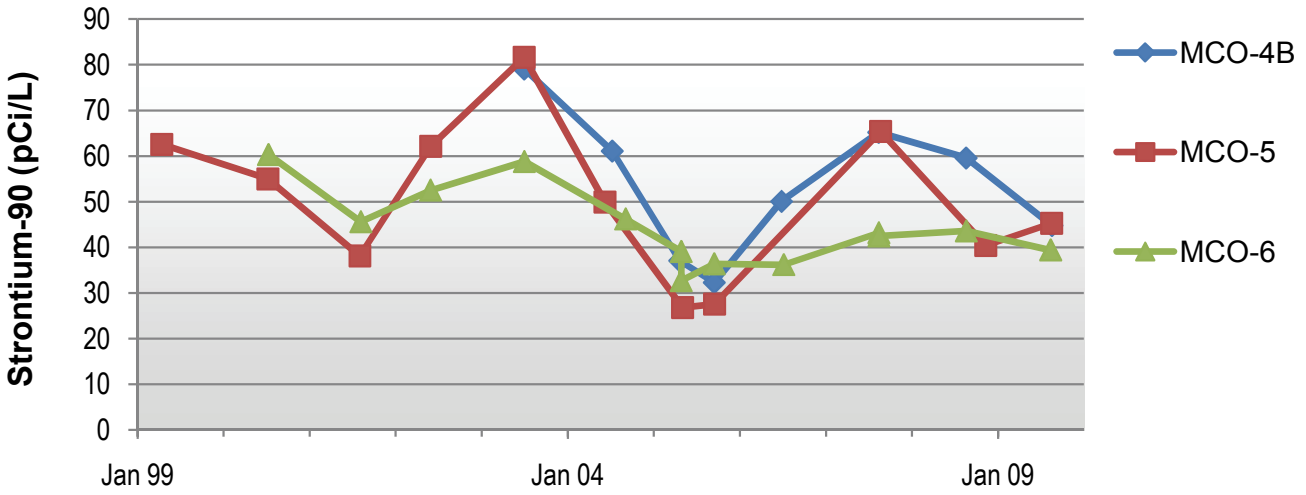


Figure 5-51. Strontium-90 in Mortandad Canyon alluvial groundwater. For comparison purposes, the EPA MCL screening level is 8 pCi/L.

The strontium-90 activity in the RLWTF effluent has been below detection since 2003 (Figure 5-40). The inventory of strontium-90 in the alluvium is gradually declining, since discharge amounts have decreased and the half-life of strontium-90 is 28.8 years. Strontium-90 continues to be found in groundwater samples because it has been retained by cation exchange on sediment within the upstream portion of the alluvium.

Three alluvial wells, MCO-0.6, MCO-2, and MCO-3, had results for chloride and TDS that approached or exceeded NM groundwater standards. MCO-0.6 is in Mortandad Canyon upstream of Effluent Canyon, a tributary of Mortandad Canyon, and MCO-2 is in Effluent Canyon. For the past three years, more frequent data from these wells and from adjacent surface water monitoring locations show seasonal variation in chloride concentrations, with highest values beginning in winter (Figure 5-26, Figures 5-52 and 5-53). The locations of surface water monitoring stations are shown in Chapter 6. These locations show peaks in chloride concentrations in early winter, evidently the result of runoff affected by road salting. Similar trends occur in sodium concentrations and TDS (not shown).

The highest surface water chloride concentrations were seen at location M-1W (Figure 5-53) in February of 2007, 2008, and 2009 (up to 1,540 mg/L, above the 250 mg/L NM groundwater standard). This station is in upper Mortandad Canyon in the Laboratory's main technical area, just east of Diamond Drive, below a large area of roads and parking lots. Since September 2005, the chloride concentration at alluvial well MCO-0.6, located farther down the canyon, ranged from 155 mg/L to 759 mg/L. The highest values at MCO-0.6 occurred in August of 2006 and 2008; the cause of this timing is unclear.

Surface water locations in Effluent Canyon show similar chloride concentrations pattern (Figure 5-52). The chloride concentration at E-1FW in February 2008 was 265 mg/L. Although alluvial groundwater data at MCO-2 (in the middle of Effluent Canyon) are less frequent, they support the pattern of high concentrations of chloride and sodium in winter. High chloride concentrations occurred at MCO-2 in February 2008 (2180 mg/L) and February 2009 (444 mg/L). These two monitoring locations are upstream of the RLWTF outfall in Effluent Canyon. The canyon receives runoff from a large area of roads and parking lots.

At surface water location Mortandad below Effluent Canyon, located downstream of these monitoring sites and the RLWTF outfall, chloride concentrations also have peaked in February of 2007, 2008, and 2009 (up to 132 mg/L, below the 250 mg/L NM groundwater standard). At nearby alluvial well MCO-3, chloride values were highest in February through May of 2008 and 2009, up to 144 mg/L. MCO-3 has been sampled since 1963. With the exception of a few chloride results in about 1971 and 1990, the recent chloride concentrations at MCO-3 are the highest measured at the well over its monitoring history.

The chloride concentrations at MCO-3 and downstream alluvial groundwater wells have risen since 2003 and are now higher than most previous values (Figure 5-54). The volume of RLWTF effluent discharge and the total chloride mass discharged have decreased since 1990. The annual average effluent chloride concentration has also decreased. As the RLWTF effluent is now contributing less volume to stream flow in Mortandad Canyon and less chloride mass, this is not likely to be the cause of the increasing chloride concentration in downstream alluvial groundwater samples. These results suggest that increased application of road salt during the past few years has a greater impact on groundwater chloride concentrations than the past RLWTF effluent discharges did.

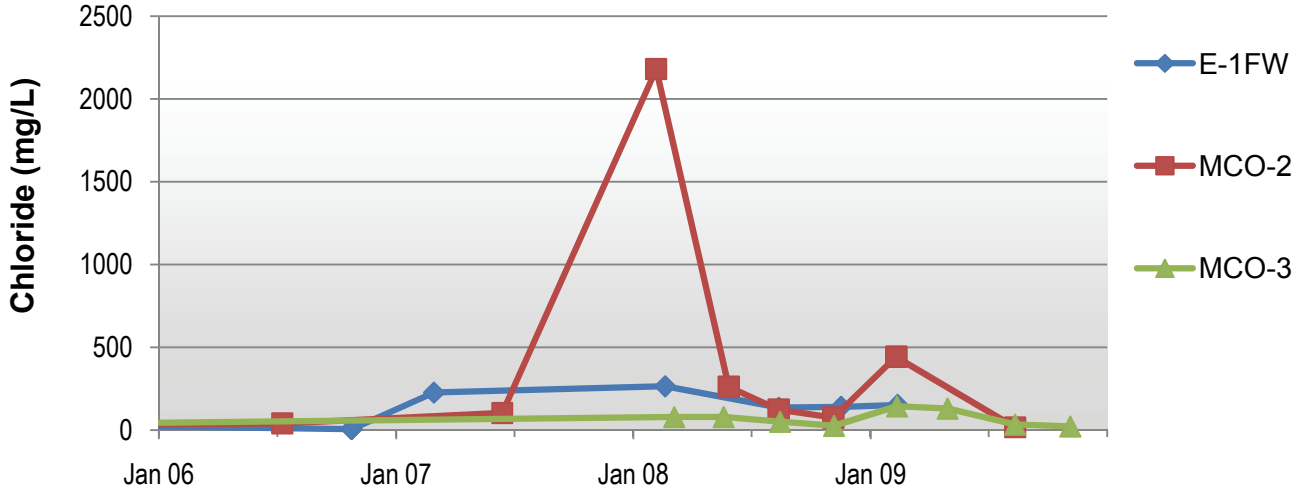


Figure 5-52. Chloride in Mortandad Canyon surface water and alluvial groundwater. The NM groundwater standard is 250 mg/L. Surface water location E-1FW and alluvial well MCO-2 are in Effluent Canyon, a tributary of Mortandad Canyon.

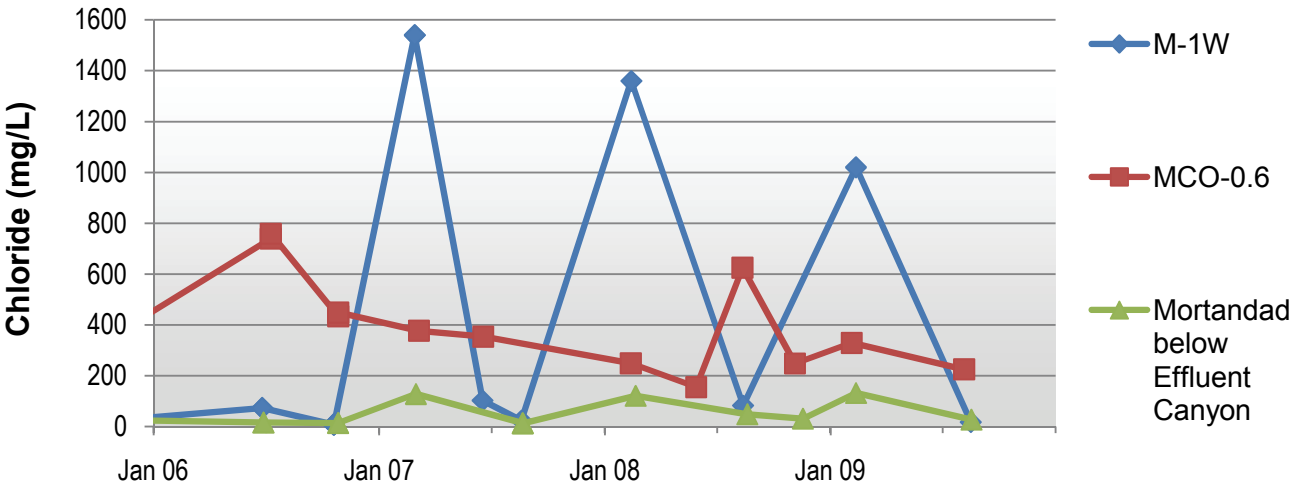


Figure 5-53. Chloride in Mortandad Canyon surface water and alluvial groundwater. The NM groundwater standard is 250 mg/L. Surface water location M-1W and alluvial well MCO 0.6 are in Mortandad Canyon, upstream of Effluent Canyon, a tributary. Mortandad below Effluent Canyon is a surface water monitoring location.

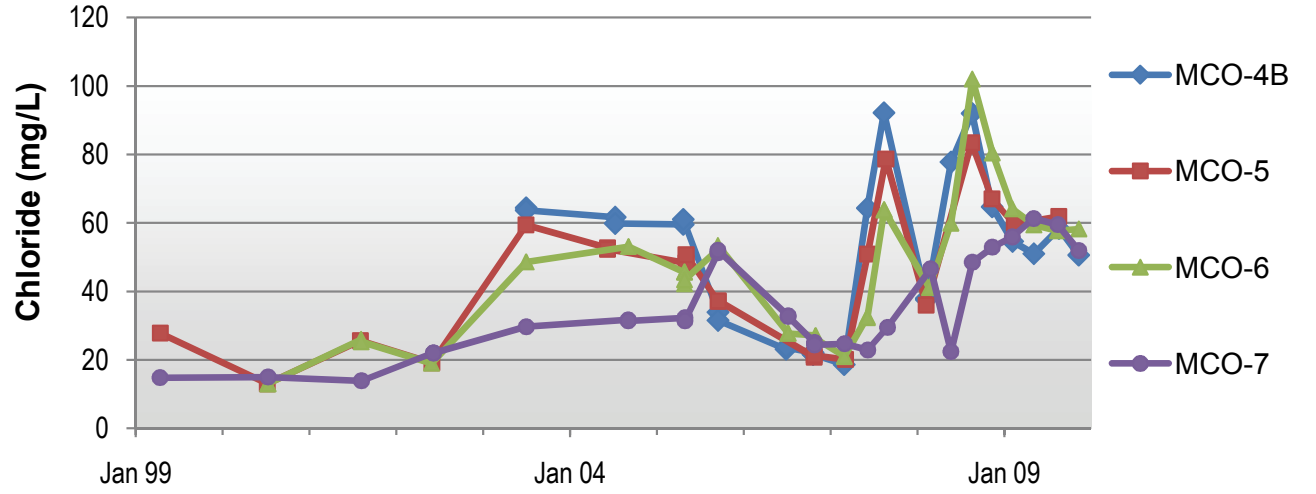


Figure 5-54. Chloride histories for Mortandad Canyon alluvial groundwater. The NM groundwater standard is 250 mg/L.

As shown in Figures 5-42 and 5-43, the nitrate + nitrite (as nitrogen) and fluoride concentrations of effluent discharge from the RLWTF after March 1999 have generally been below the NM groundwater standards. As mentioned above, in some cases the combined nitrate + nitrite (as nitrogen) concentration of the effluent discharges was near or slightly above 10 mg/L. Under the groundwater discharge plan application for the RLWTF, the Laboratory collected additional quarterly samples for nitrate, fluoride, perchlorate, and TDS during 2009 from four alluvial monitoring wells below the outfall in Mortandad Canyon: MCA-5 (or MCO-3), MCO-4B, MCO-6, and MCO-7.

The nitrate (as nitrogen) concentrations in these wells were below the NM groundwater standard of 10 mg/L (Figure 5-42), and fluoride concentrations were below the NM groundwater standard of 1.6 mg/L (Figure 5-43). Many alluvial groundwater samples collected below the RLWTF outfall had fluoride concentrations above 50% of the NM groundwater standard (Figures 5-22 and 5-43).

Mortandad Canyon alluvial groundwater samples from wells downstream of the RLWTF outfall had high perchlorate concentrations (Figures 5-19 and 5-55). The 2009 concentrations at five alluvial wells were above the Consent Order screening level of 4 µg/L. Alluvial groundwater concentrations of perchlorate have dropped, especially near the outfall, following the removal of perchlorate from RLWTF effluent in March 2002.

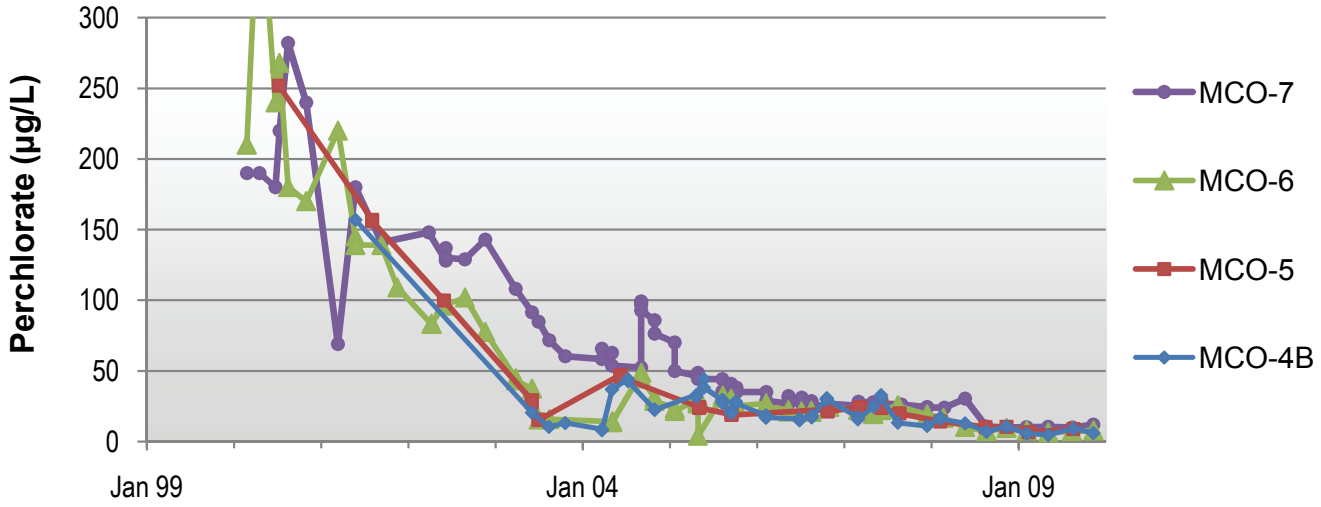


Figure 5-55. Perchlorate in Mortandad Canyon alluvial groundwater; the Consent Order screening level is 4 µg/L.

d. Cañada del Buey

Alluvial well CDBO-6 in Cañada del Buey was sampled four times and CDBO-7 twice in 2009. There were no results measured near regulatory standards or screening levels.

5. Pajarito Canyon (includes Twomile and Threemile Canyons)

Pajarito Canyon has a drainage that extends into the Sierra de los Valles, west of the Laboratory. Saturated alluvium occurs in lower Pajarito Canyon near the eastern Laboratory boundary, but does not extend beyond the boundary. In the past, the Laboratory released small amounts of wastewater into tributaries of Pajarito Canyon from several HE-processing sites at TA-9 (Table 5-17). Some firing sites border portions of tributaries Twomile and Threemile canyons. A nuclear materials experimental facility occupied the floor of Pajarito Canyon at TA-18. Waste management areas at TA-54, used for disposal of organic chemicals and low-level radioactive waste, occupy the mesa north of the lower part of the canyon. A small contaminated body of shallow intermediate groundwater occurs behind a former Laboratory warehouse location at TA-3, where the Laboratory disposed of waste materials. The main water quality impacts are from organic chemicals released at the TA-3 warehouse and from HE (Table 5-18).

Table 5-17
Summary of Groundwater Contamination in Pajarito Canyon (includes Twomile and Threemile Canyons)

		Groundwater Contaminants		
Canyon	Contaminant Sources	Alluvial	Intermediate	Regional
Pajarito, Twomile, and Threemile Canyons	Major non-effluent sources; liquid sources major in past but minor currently	Barium 2.6 times, chloride 4 times, and TDS 2.1 times above; cobalt at 52% of NM groundwater standards; total lead at 71% of EPA MCL screening level	Dichloroethene[1,1-] 2 times and trichloroethane[1,1,1-] 2.9 times above and chloride at 66% of NM groundwater standards; total lead 1.2 times above EPA MCL screening level; dioxane[1,4-] at 96% and RDX at 90% of EPA Human Health tap water screening levels; trichloroethene at 41% of EPA MCL screening level	Trichloroethene at 61% of EPA MCL screening level; trace RDX

Table 5-18
Groundwater Quality in Pajarito Canyon (includes Twomile and Threemile Canyons)

Chemical	Location	Result	Trends
RDX	Regional aquifer well R-18	0.45 µg/L to 0.62 µg/L, below EPA Human Health tap water screening level of 6.1 µg/L	Found in all sample events since August 2006; values increasing
Trichloroethene	Regional aquifer well R-20	0.42 µg/L to 3.0 µg/L, below EPA MCL screening level of 5 µg/L	Found in five consecutive sample events; concentration increasing
Bis(2-ethylhexyl) phthalate	Regional aquifer monitoring wells R-32 and R-40	One detection of 4.9 µg/L at R-40, up to 3.5 µg/L at R-32, below EPA MCL screening level of 6 µg/L	Found in one sample event in each well; values decreased to ND in R-32
Chloride	Intermediate wells 03-B-10, 03-B-13	18 mg/L to 166 mg/L, below NM groundwater standard of 250 mg/L	From road salt; previously above standard; highest results during March and December for four years of sampling

Table 5-18 (continued)

Chemical	Location	Result	Trends
Total Lead	Intermediate wells 03-B-10, 03-B-13	5 µg/L to 18 µg/L, above EPA drinking water system screening level of 15 µg/L; filtered lead up to 11.7 µg/L	Detected in nearly every sample for four years; variable concentrations
Dichloroethene [1,1-]	Intermediate wells 03-B-10, 03-B-13	0.9 µg/L to 9.9 µg/L, above NM groundwater standard of 5 µg/L	Detected in every sample for four years; seasonally variable with highest concentrations in 2008
Trichloroethane [1,1,1-]	Intermediate wells 03-B-10, 03-B-13	60 µg/L to 173 µg/L, above NM groundwater standard of 60 µg/L	Detected in every sample for four years; seasonally variable with highest concentrations in 2006
Trichloroethene	Intermediate wells 03-B-10, 03-B-13	0.6 µg/L to 2.1 µg/L, below EPA MCL screening level of 5 µg/L	Detected in every sample for four years; seasonally variable with highest concentrations in 2006
Dioxane[1,4-]	Intermediate wells 03-B-10, 03-B-13	14 µg/L to 59 µg/L, below EPA Human Health tap water screening level of 61 µg/L	Detected for four years; seasonally variable with highest concentrations in July 2007 and March 2008
RDX	Intermediate Bulldog Spring	0.11 µg/L to 5.5 µg/L, below EPA Human Health tap water screening level of 6.1 µg/L	Found in every sample at Bulldog Spring; sampled since 2004; values fluctuate
Chloride	Alluvial wells 18-MW-18, PCAO-7a, PCAO-7b2, alluvial TW-1.72 Spring	46 mg/L to 994 mg/L, above NM groundwater standard of 250 mg/L	Concentrations peak in summer, possibly delayed movement of road salt plume
TDS	Alluvial wells 18-MW-18, PCAO-7b2	637 mg/L to 2,140 mg/L, above NM groundwater standard of 1,000 mg/L	Concentrations peak in summer, possibly delayed movement of road salt plume
Barium	Alluvial wells PCAO-5, PCAO-7b2	354 µg/L to 2580 µg/L, above NM groundwater standard of 1,000 µg/L	Possibly due to cation exchange caused by high sodium in road salt runoff
Lead	Alluvial TW-1.72 Spring	Filtered lead concentration of 9.1 µg/L in TW-1.72 Spring, below EPA drinking water system screening level of 15 µg/L	Highest concentration of five samples since 2005, total lead previously at this level
Cobalt	Alluvial well PCAO-5	26.5 µg/L, below NM groundwater standard of 50 µg/L	Similar results for two years of samples

Rehabilitation activities were conducted at regional aquifer well R-20 through December 2007 to improve sample quality (LANL 2008c). Beginning with a December 18, 2008 sample, trichloroethene has been detected at the 1,147 ft. regional port for five consecutive sample events (Figure 5-56). Results from the first three sample events were near the detection limit of 0.25 µg/L and were estimated. Results from the next two sample events reached 3.04 µg/L in December 2009. The EPA MCL for trichloroethene is 5 µg/L. Sample events in May, September, and December 2009 included field duplicate samples that had similar concentrations of trichloroethene. Trichloroethene has not been detected at the shallower 904 ft regional port and was not detected at R-20 prior to rehabilitation. A source for trichloroethene has not been determined at this time, and additional wells are being drilled to investigate water quality in the area.

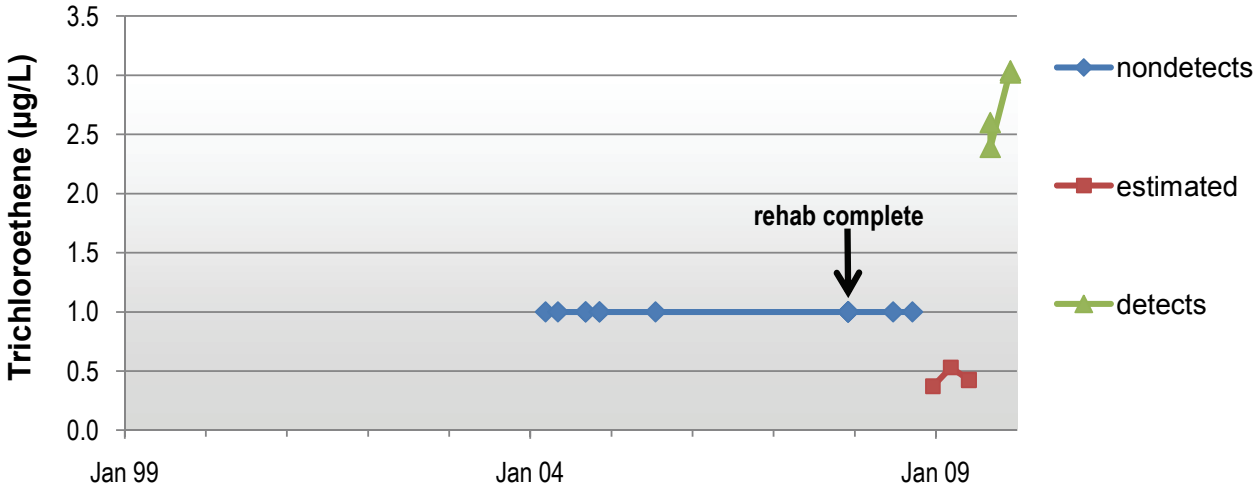


Figure 5-56. Trichloroethene in Pajarito Canyon regional aquifer well R-20. The EPA MCL is 5 µg/L. Nondetects are reported at the PQL of 1 µg/L; the MDL is 0.25 µg/L. The well underwent rehabilitation in 2007.

RDX was detected at Pajarito Canyon regional well R-18 at a concentration that is at 10% of the EPA Human Health tap water screening level. RDX has been detected at this well since August 2006 in every sample at increasing concentrations.

Samples from several of the intermediate groundwater springs in upper Pajarito Canyon contained RDX, HMX, and other HE compounds as in prior years. One RDX result from Bulldog Spring was just below the EPA Human Health tap water screening level (Figures 5-57 and 5-58).

SWMU 03-010(a) is the outfall area from a former vacuum repair shop and is currently under investigation (LANL 2005b). The outfall area is located on a steep slope on the rim of Twomile Canyon about 30 ft west of a general warehouse (Building 03-30). Technicians working at the vacuum repair shop discarded vacuum pump oil at this site in the 1950s. The oil contained radionuclides, rinse solvents, and mercury. A small zone of shallow intermediate perched groundwater is apparently recharged by runoff from the parking lot and building roofs; the groundwater becomes contaminated through contact with the soil.

This perched groundwater is tapped by three wells. Water quality results from samples taken in two wells, 03-B-10 and 03-B-13, are similar. Another well, 03-B-09, rarely contained water. Two of the wells, 03-B-09 and 03-B-10, were plugged and abandoned in 2009 because they were installed in vaults flush with the roadway, subject to flooding from the roadway and to damage by snow removal equipment (LANL 2009i).

Samples from wells 03-B-10 and 03-B-13 during 2009 had chloride (Figure 5-26, Figure 5-59) and TDS (not shown) results that were high but below groundwater standards. The seasonal pattern of sodium (not shown) and chloride concentrations, with high values in winter, suggest that road salting is the source of this variation. Samples from these wells also contained several organic chemicals including four chlorinated solvents (Table 5-18). Several organic chemicals were at concentrations exceeding NM groundwater standards. Compounds found in well samples included dichloroethane[1,1-], dichloroethene[1,1-], trichloroethene, trichloroethane[1,1,1-], and dioxane[1,4-].

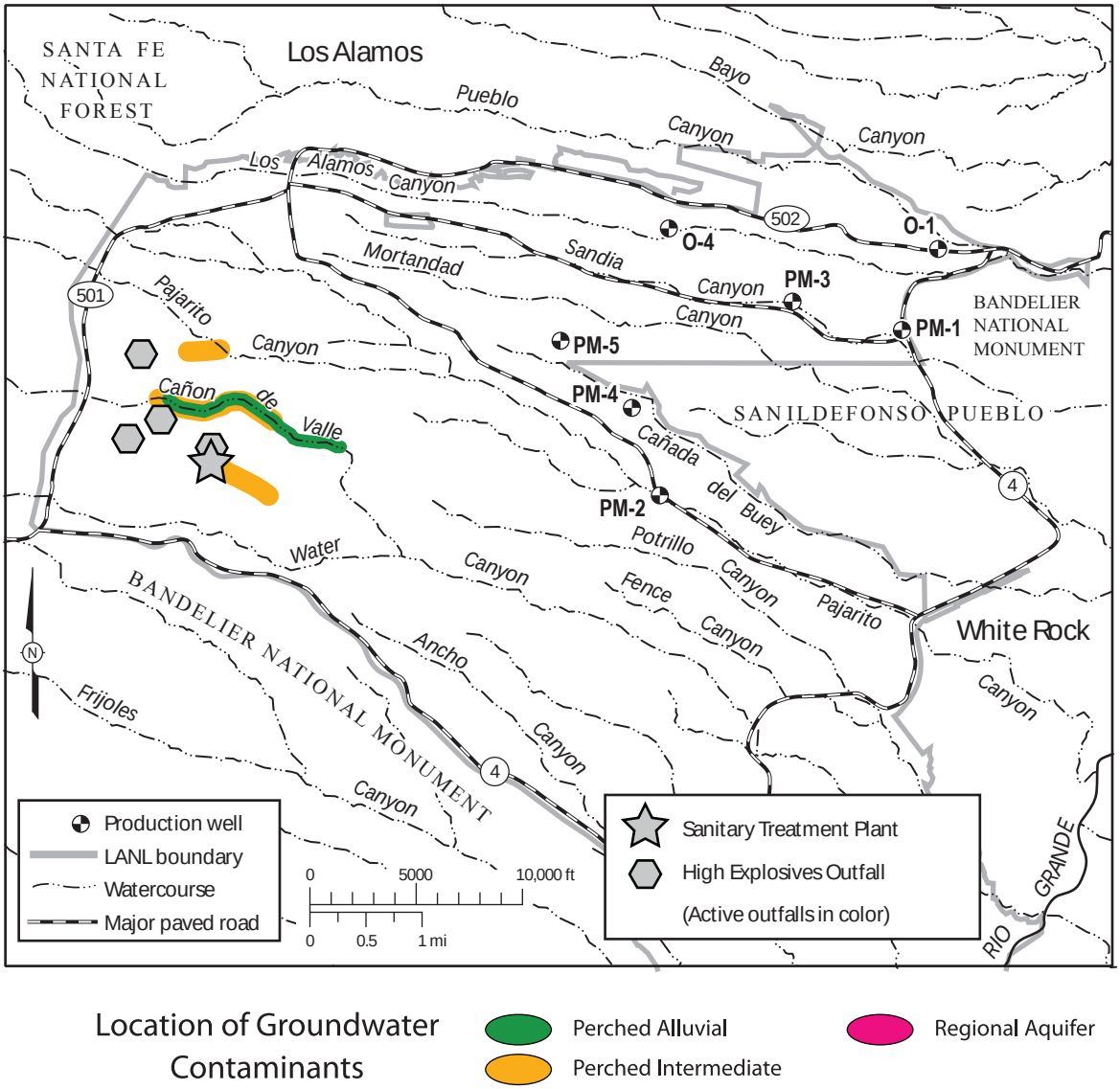


Figure 5-57. Location of groundwater containing RDX above one half of the EPA Human Health tap water screening level of 6.1 µg/L. Different colors indicate the affected groundwater zones.

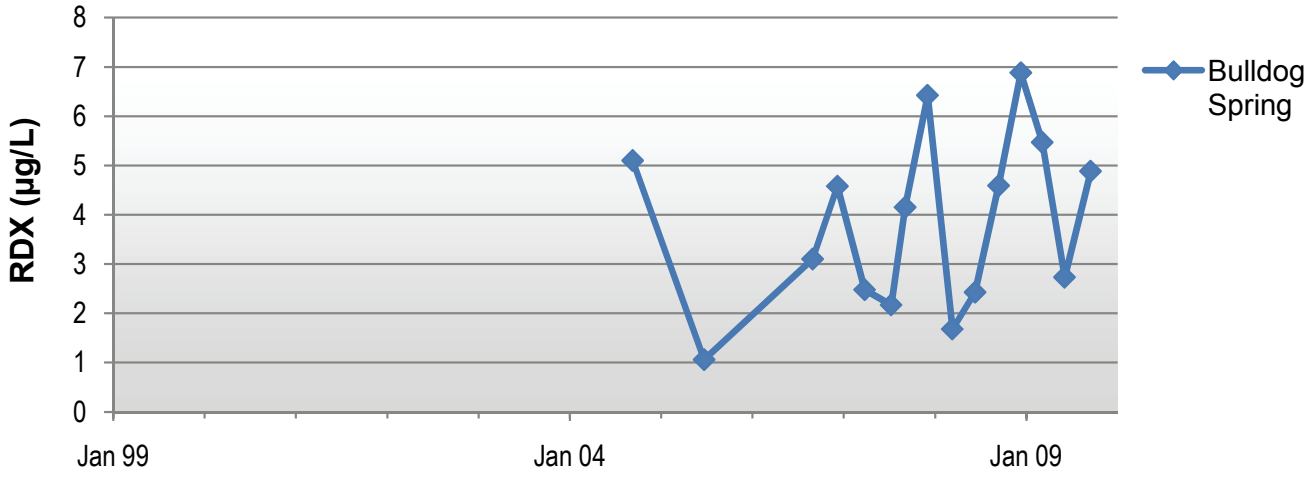


Figure 5-58. RDX in Pajarito Canyon intermediate groundwater at Bulldog Spring; the EPA tap water screening level is 6.1 µg/L.

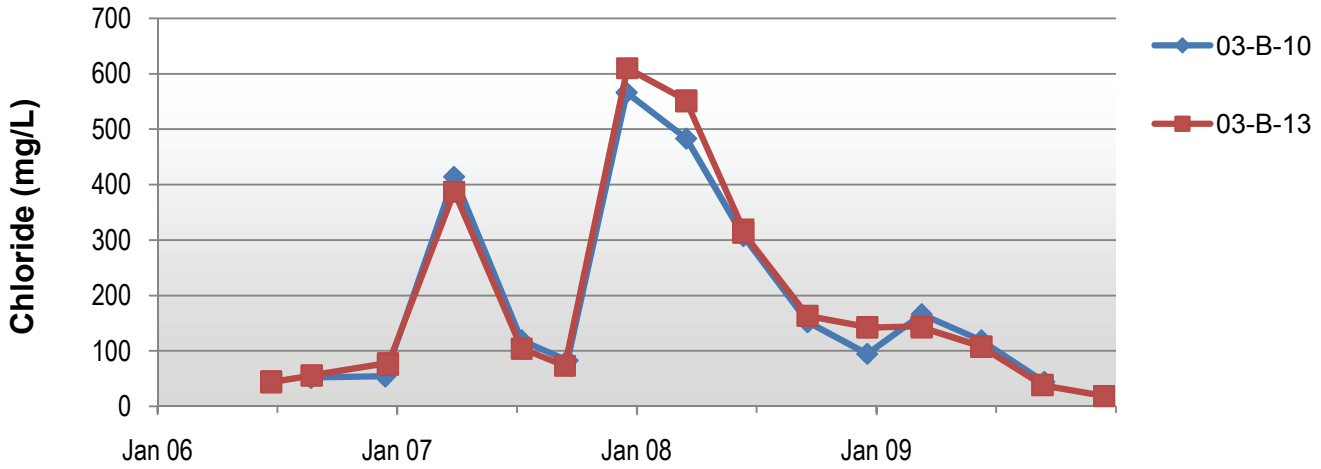


Figure 5-59. Histories for chloride in Pajarito Canyon intermediate groundwater at TA-3 wells 03-B-10 and 03-B-13. The NM groundwater standard is 250 mg/L.

Seasonal variation is shown by several other field parameters and chemical compounds measured in water samples from wells 03-B-10 and 03-B-13 (LANL 2009j). Variation in ORP (oxidation-reduction potential) and TOC (total organic carbon) indicate changes in reducing conditions. Changes in oxidation-reduction potential lead to observed seasonal changes in turbidity and concentrations of dissolved iron and manganese; under more reducing conditions iron and manganese are more soluble.

Figures 5-60 and 5-61 show dichloroethene[1,1-] and trichloroethane[1,1,1-] histories for wells 03-B-10 and 03-B-13. For some solvents, their retention on solid surfaces is lower in higher ionic strength solutions. Thus, the increasing concentration of dichloroethene[1,1-] and trichloroethane[1,1,1-] could possibly result from the increasing concentration of sodium and chloride, which releases these compounds from the aquifer matrix. For example, the high chloride (Figure 5-59) and TDS observed in the groundwater in December 2007 might cause release of trichloroethane[1,1,1-] during the following months (Figure 5-61).

Several alluvial groundwater wells along Pajarito Road showed high chloride (Figure 5-26, Figure 5-62) and TDS concentrations during 2009. More frequent sampling in recent years shows a seasonal pattern of winter increase in concentrations of chloride, sodium, and TDS. Runoff related to road salting is the apparent cause. The highest chloride concentrations are at PCAO-7b2, above the NM groundwater standard of 250 mg/L. Chloride and TDS concentrations at these locations peak in the summer, possibly due to slow movement of the chloride plume. An alluvial spring, TW-1.27 Spring in upper Pajarito Canyon, also shows high winter chloride concentrations. In March 2009 the chloride concentration at TW-1.72 Spring was 170 mg/L, below the NM groundwater standard.

Barium concentrations are elevated in several alluvial wells and above the NM groundwater standard of 1,000 µg/L in PCAO-7b2 (Figures 5-63 and 5-64). Barium concentrations show seasonal fluctuations; high sodium concentrations in road salt runoff lead to cation exchange replacement by sodium of barium bound to sediments, increasing the groundwater barium concentration.

Samples from alluvial well PCAO-5 had the highest 2009 filtered manganese values of any groundwater samples, up to 14,000 µg/L, above the 200 µg/L NM groundwater standard. Filtered iron values were also high: up to 20,800 µg/L, above the 1,000 µg/L NM groundwater standard. Turbidity values were below 2 nephelometric turbidity units. A sample from this well also gave the highest 2009 groundwater filtered cobalt values: up to 26.5 µg/L, but below the 50 µg/L NM groundwater standard. This well is located in a wetland. Based on high TOC values, the groundwater is under reducing conditions. These reducing conditions would increase solubility of iron, manganese, and other metals. Alternatively, the metals could be present in groundwater as organic-metal colloids.

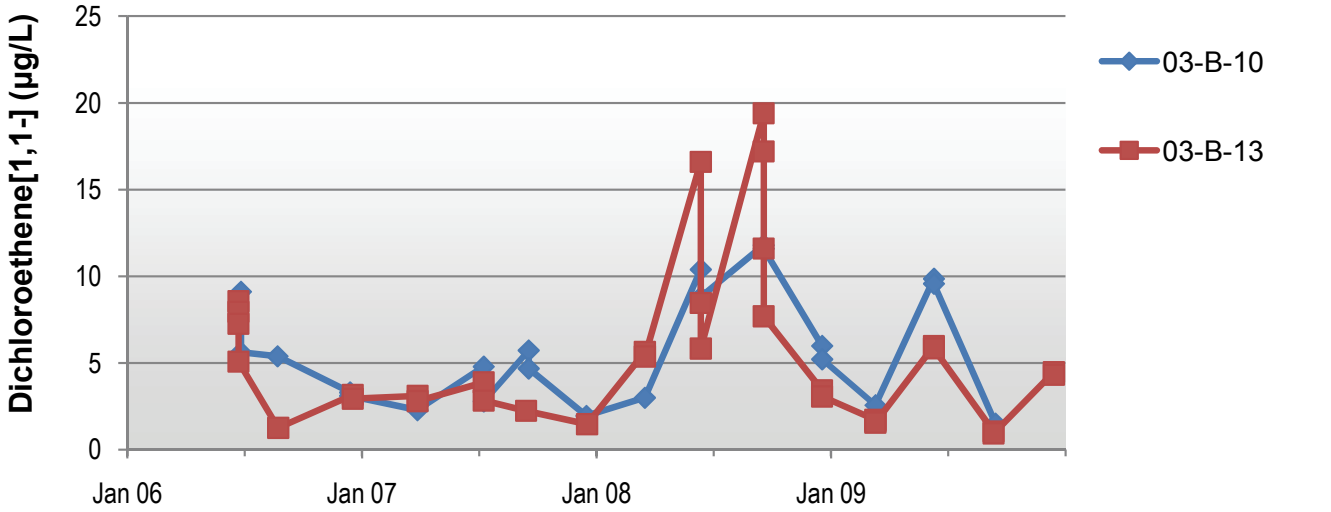


Figure 5-60. **Histories at wells 03-B-10 and 03-B-13 for dichloroethene[1,1-]. The NM groundwater standard is 5 µg/L.**

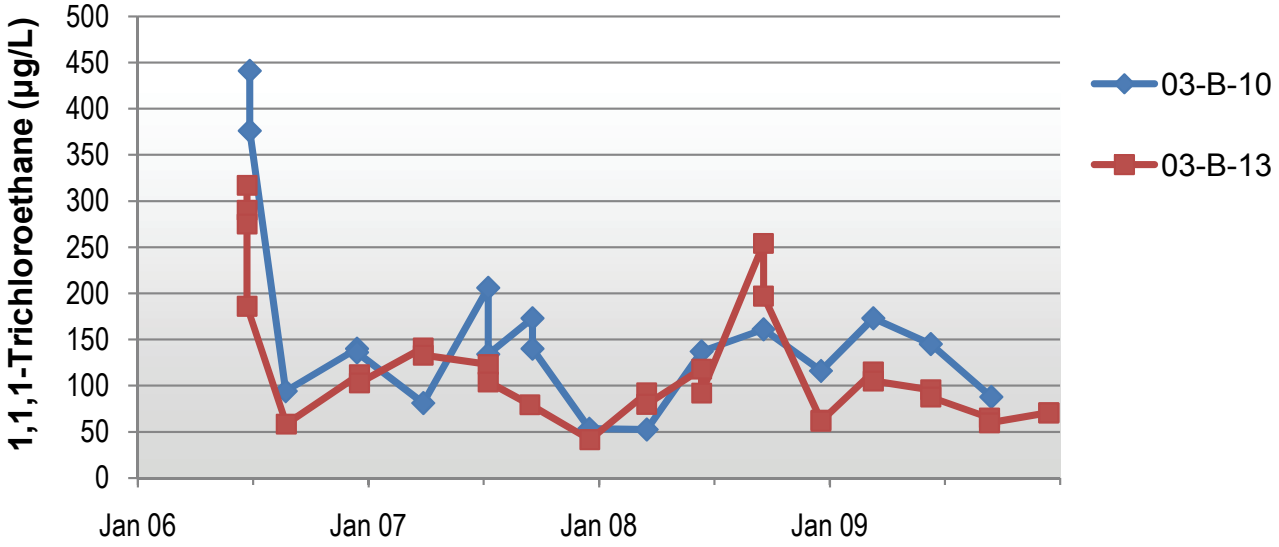


Figure 5-61. **Histories at wells 03-B-10 and 03-B-13 for 1,1,1–trichloroethane. The NM groundwater standard is 60 µg/L.**

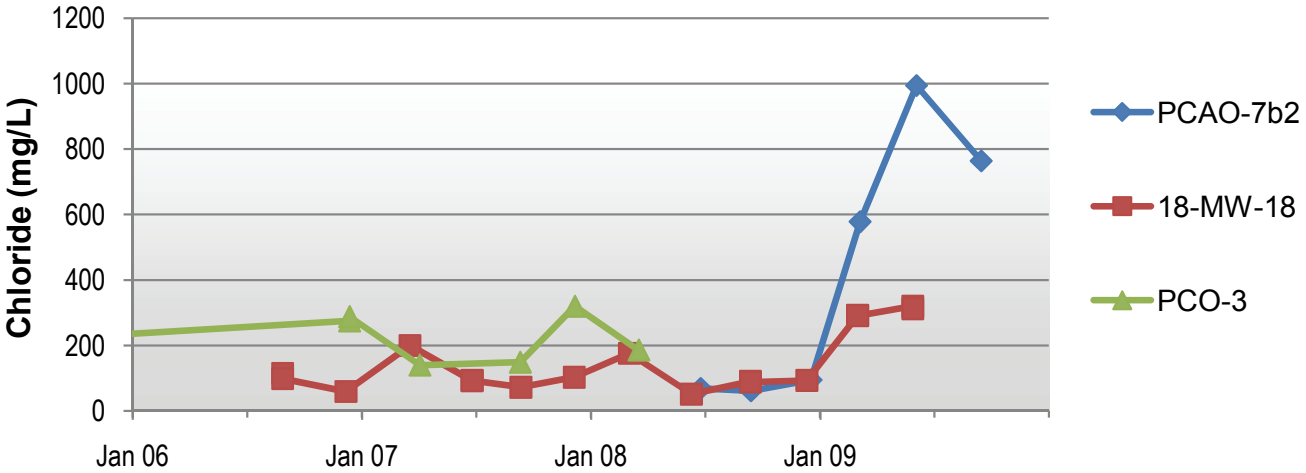


Figure 5-62. **Histories for chloride in Pajarito Canyon alluvial groundwater. The NM groundwater standard is 250 mg/L.**

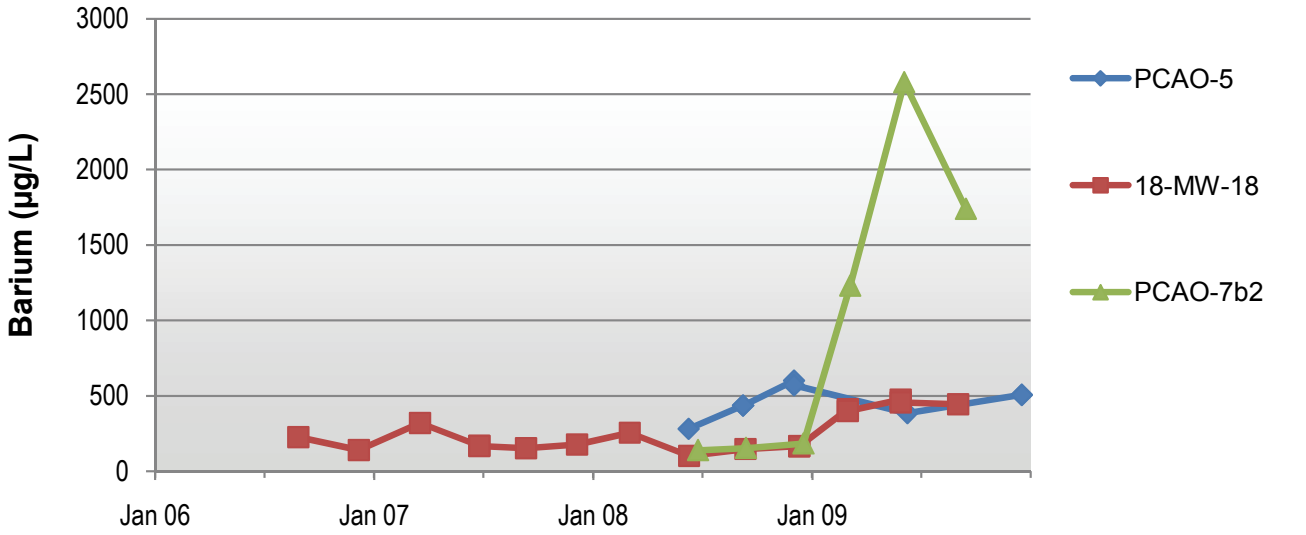


Figure 5-63. Histories for barium in Pajarito Canyon alluvial groundwater. The NM groundwater standard is 1,000 µg/L.

6. Water Canyon (includes Cañon de Valle, Potrillo, Fence, and Indio Canyons)

Water Canyon and Cañon de Valle (a tributary) traverse the southern portion of LANL where the Laboratory conducts explosives development and testing. In the past, the Laboratory released wastewater into both canyons from several HE processing sites in TA-16 and TA-9 (Table 5-19). In 1997, the Laboratory consolidated these individual NPDES outfalls into one outfall from the High Explosives Wastewater Treatment Facility. This outfall discharges a much smaller amount of water that generally meets NPDES permit requirements. Alluvial groundwater in Cañon de Valle shows barium above 1,000 µg/L, the NM groundwater standard (Table 5-20, Figure 5-64), and RDX above the EPA Human Health tap water screening level of 6.1 µg/L (Figure 5-57). Intermediate perched groundwater in this area also shows RDX at concentrations above 6.1 µg/L. The Potrillo, Fence, and Indio canyon watersheds contain several open-burning/open-detonation and firing sites used for testing of weapons system components. These three small canyons have surface water only in response to precipitation events and no known alluvial or intermediate groundwater.

Table 5-19
Summary of Groundwater Contamination in Water Canyon
(includes Cañon de Valle, Potrillo, Fence, and Indio Canyons)

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Cañon de Valle	Multiple dry and past effluent sources	Barium above, boron at 90%, and TDS at 51% of NM groundwater standards; tetrachloroethene, trichloroethene, and total lead above and total beryllium at 60% of EPA MCL screening levels; and RDX above EPA Human Health tap water screening level	Boron and nickel above and arsenic at 54% of NM groundwater standards; total chromium at 75%, total lead at 75%, tetrachloroethene at 31%, and trichloroethene at 36% of EPA MCL screening levels; RDX above EPA Human Health tap water screening level	Trace tetrachloroethene, trace RDX
Water Canyon	Multiple dry and past effluent sources	None, little alluvial groundwater	No intermediate groundwater	None
Potrillo, Fence, and Indio Canyons	Minor non-effluent sources	No alluvial groundwater	No intermediate groundwater	None

Table 5-20
Groundwater Quality in Water Canyon (includes Cañon de Valle, Potrillo, Fence, and Indio Canyons)

Chemical	Location	Result	Trends
RDX	Regional aquifer well R-25	0.38 µg/L, below EPA Human Health tap water screening level of 6.1 µg/L	Perhaps present due to well construction delays in 2000; levels have decreased; present in two regional ports in 2009
Tetrachloroethene	Regional aquifer well R-25	0.33 µg/L, below EPA MCL screening level of 5 µg/L	Present for three years of sampling at shallowest regional port
Boron	Intermediate Martin Spring	1270 µg/L to 1380 µg/L, above NM groundwater standard (for irrigation use) of 750 µg/L	Consistent with results collected over 19-year period; approximate 40% decrease since 2003
Nickel	Intermediate well R-25	731 µg/L, above NM groundwater standard of 200 µg/L	Similar results in shallowest port since 2001
Total chromium	Intermediate well R-25	75 µg/L, below EPA MCL screening level of 100 µg/L	High total results in shallowest port since 2004
Arsenic	Intermediate well R-25b	5.4 µg/L, below EPA MCL screening level of 10 µg/L	Three sample events in 2009, two with detections
Total lead	Fish Ladder Spring	11.3 µg/L, below EPA drinking water system screening level of 15 µg/L	Variable concentrations, often this high for 12 years of sampling
RDX	Three intermediate springs, six wells or well ports	Up to 79 µg/L, above EPA Human Health tap water screening level of 6.1 µg/L	Present for 14 years of sampling at springs, during several years of sampling of wells
Tetrachloroethene	Three intermediate springs, six wells or well ports	0.34 µg/L to 1.6 µg/L, below EPA MCL screening level of 5 µg/L	Present for 14 years of sampling at springs, during several years of sampling of wells
Trichloroethene	Three intermediate springs, two wells or well ports	0.31 µg/L to 1.8 µg/L, below EPA MCL screening level of 5 µg/L	Present for 14 years of sampling at springs, during several years of sampling of wells
Barium	Three alluvial wells in Cañon de Valle	3,180 µg/L to 5,870 µg/L, above NM groundwater standard of 1,000 µg/L	Present at these levels for 12 years of sampling
Total beryllium	Alluvial wells FLC-16-25280 and MSC-16-06294	2.0 µg/L and 2.4 µg/L, below EPA MCL screening level of 4 µg/L	Second measurement and detect in first well, detected in about half of 10 years in second well
Boron	Martin Spring Canyon alluvial well MSC-16-06293	676 µg/L, below NM groundwater standard (for irrigation use) of 750 µg/L	At low end of concentrations in four samples since 2000
TDS	Cañon de Valle alluvial well CDV-16-02655	506 mg/L, below NM groundwater standard of 1,000 mg/L	Lowest concentration since 1998, previously up to 1,000 mg/L
RDX	Three alluvial wells in Cañon de Valle	3.6 µg/L to 50 µg/L, above EPA Human Health tap water screening level of 6.1 µg/L	Present at these levels for 12 years
Tetrachloroethene	Fish Ladder Canyon alluvial well FLC-16-25280	200 µg/L, above EPA MCL screening level of 5 µg/L	Third sample in four years, similar concentrations for two years
Trichloroethene	Fish Ladder Canyon alluvial well FLC-16-25280	10.9 µg/L, above EPA MCL screening level of 5 µg/L	Third sample in four years, similar concentrations for two years
Total Lead	FLC-16-25279, FLC-16-25280, MSC-16-06294	9.4 µg/L to 18.6 µg/L, above EPA drinking water system screening level of 15 µg/L	Similar results for two to three years in Fish Ladder Canyon wells, many detections in Martin Spring Canyon well

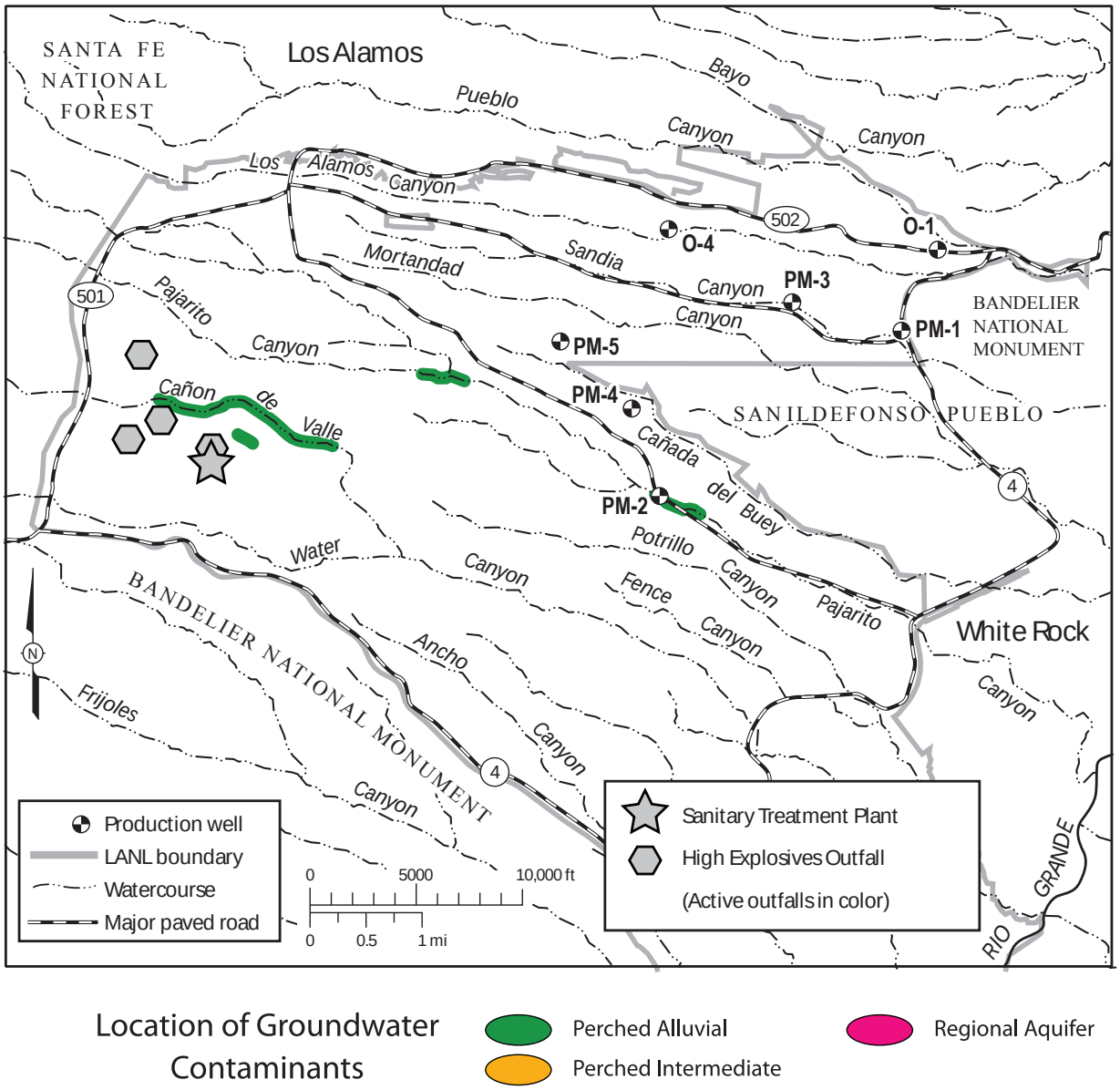


Figure 5-64. Location of groundwater containing barium above one half of the NM groundwater standard of 1,000 µg/L. Different colors indicate the affected groundwater zones.

Boron was found in samples from intermediate Martin Spring at concentrations above the NM groundwater standard for irrigation use, a reflection of past effluents (Figure 5-65). This spring is not used for irrigation. Boron is also present at high levels in downstream alluvial wells (Figure 5-66).

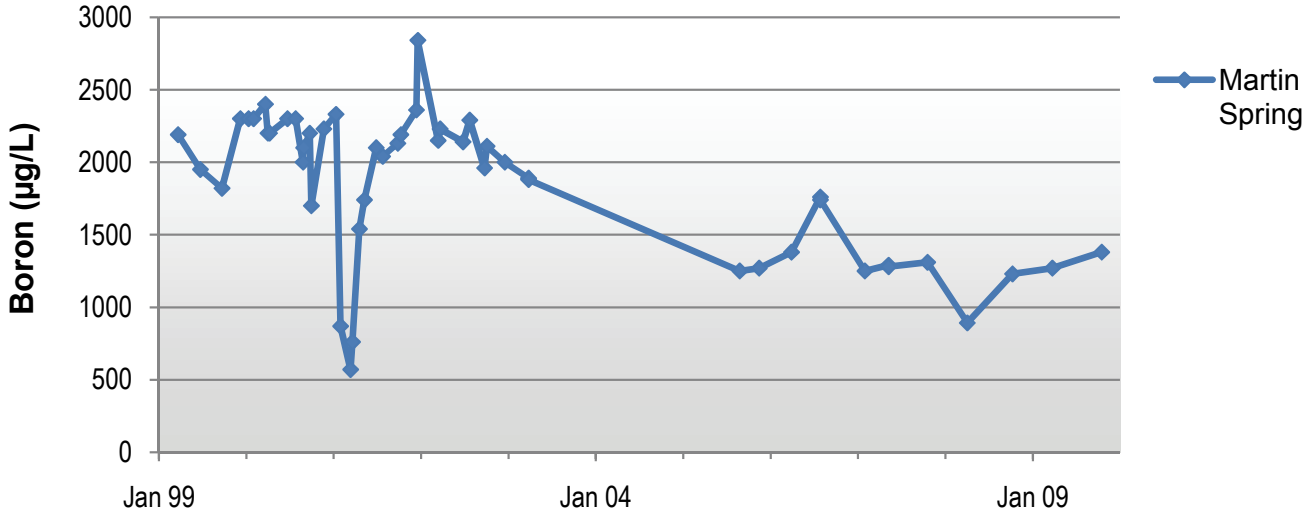


Figure 5-65. Boron in Cañon de Valle tributary Martin Spring Canyon intermediate groundwater at Martin Spring. The NM groundwater standard (for irrigation use) is 750 µg/L.

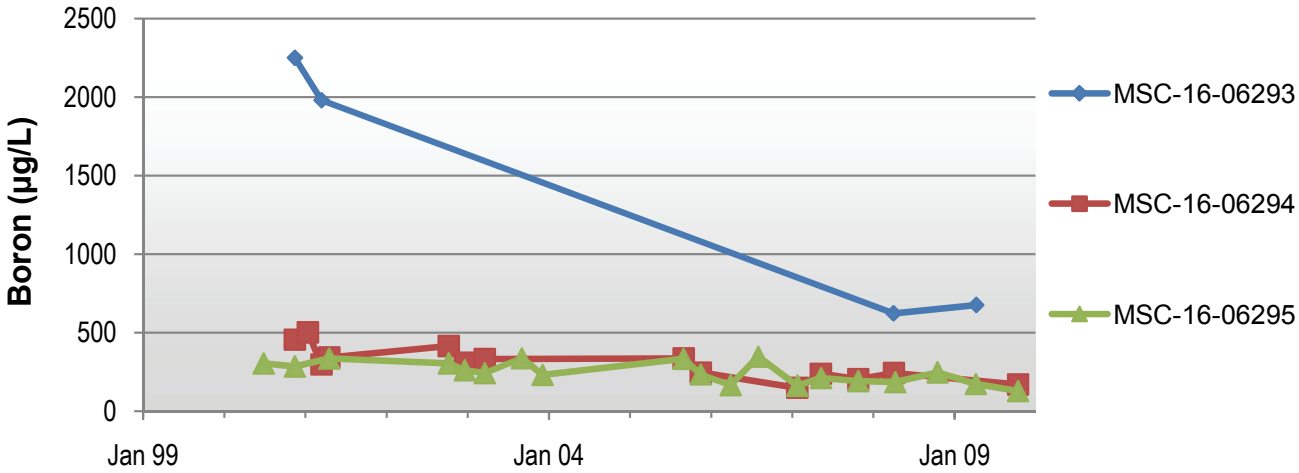


Figure 5-66. Boron in Cañon de Valle (tributary Martin Spring Canyon) alluvial groundwater. The NM groundwater standard (for irrigation use) is 750 µg/L.

The shallowest two screens at well R-25 (which sample intermediate groundwater) have shown high concentrations of metals such as nickel and chromium for several years. These screens were damaged during drilling of the well. In 2008 new wells were drilled to replace some of the upper R-25 screens.

Intermediate perched zone well and spring samples contained several HE compounds. Of these compounds, RDX was present at the highest concentrations compared to screening levels, above the 6.1 µg/L EPA Human Health tap water screening level (Figures 5-57, 5-67, 5-68, 5-69). The RDX levels have been fairly steady at most of these monitoring sites. The concentrations show some seasonal fluctuation, for example, at Martin Spring (Figure 5-69).

As seen in Figure 5-68, samples from the shallowest two screens at well R-25, which sample intermediate groundwater, show variability that may be due to switching of samples or drilling of new nearby wells (LANL 2009j).

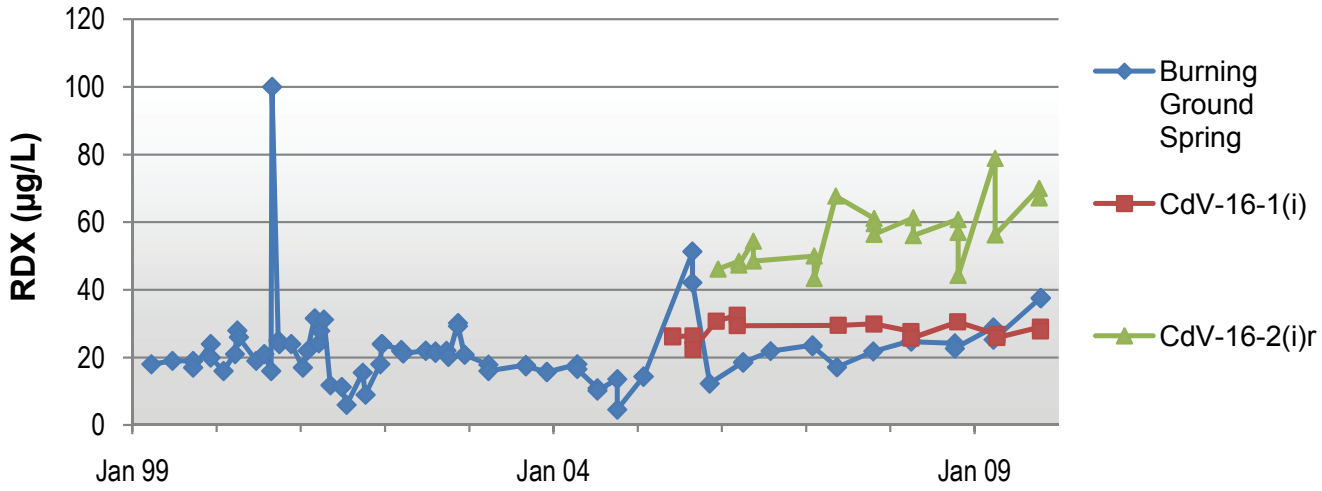


Figure 5-67. **RDX in Cañon de Valle intermediate groundwater. The EPA Human Health tap water screening level is 6.1 µg/L.**

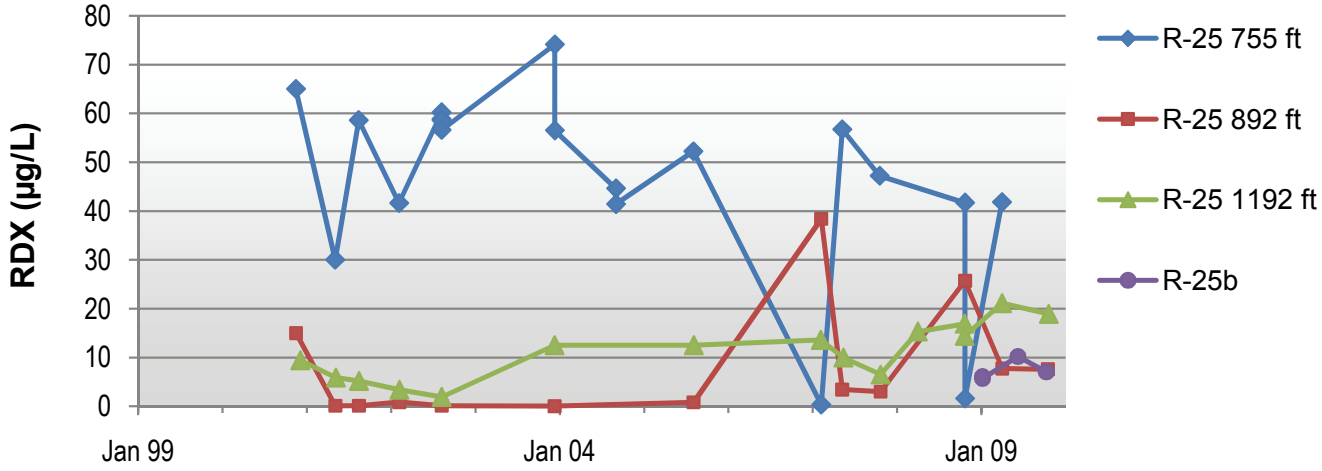


Figure 5-68. **RDX in Cañon de Valle intermediate groundwater. The EPA Human Health tap water screening level is 6.1 µg/L.**

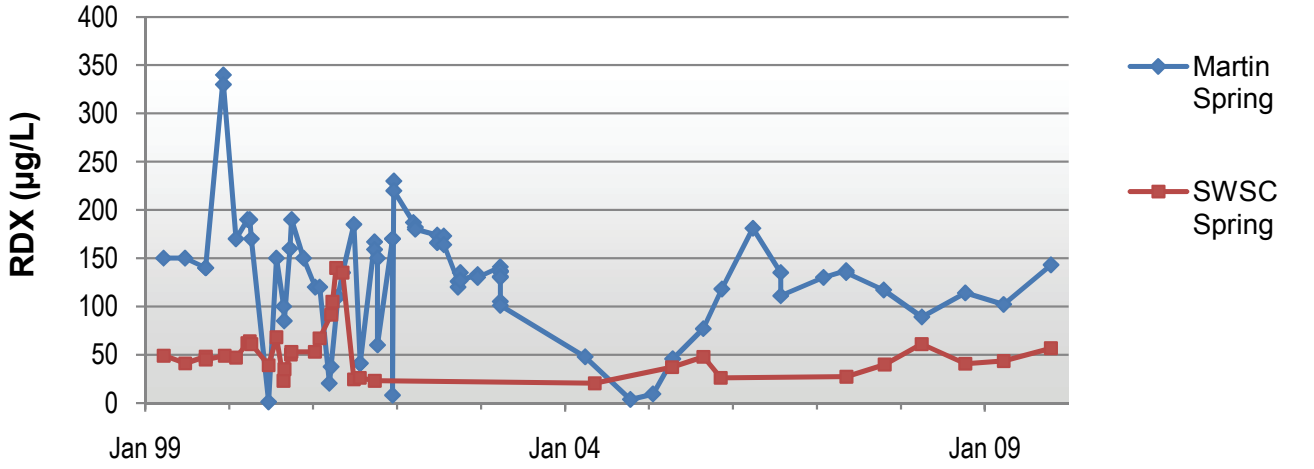


Figure 5-69. **RDX in Cañon de Valle intermediate groundwater. The EPA Human Health tap water screening level is 6.1 µg/L.**

The chlorinated solvents tetrachloroethene and trichloroethene continue to be found in several intermediate wells and springs (Table 5-20).

Barium, present due to past HE wastewater discharges, exceeded the NM groundwater standard in several alluvial wells in Cañon de Valle (Figures 5-64, 5-70). These alluvial well samples also contained several HE compounds. As with intermediate perched groundwater, RDX was the HE compound present at the highest concentrations compared to risk levels, with some sample results above the 6.1 µg/L EPA Human Health tap water screening level (Figures 5-57 and 5-71).

The 2009 sample from alluvial well FLC-16-25280 in Fish Ladder Canyon contained high concentrations of tetrachloroethene (200 µg/L) and trichloroethene (10.9 µg/L), above the respective EPA MCL screening levels of 5 µg/L (Figures 5-72 and 5-73). This is the third sample at this well; the first sample was collected in 2006. Similarly high tetrachloroethene concentrations of about 40 µg/L have also been found in past samples from nearby Fish Ladder Spring. Otherwise, the tetrachloroethene concentration measured at FLC-16-25280 is the highest in groundwater samples at LANL, by nearly two orders of magnitude. The trichloroethene concentration measured at FLC-16-25280 is also among the highest measured. Both compounds are found in other groundwater samples in this part of LANL.

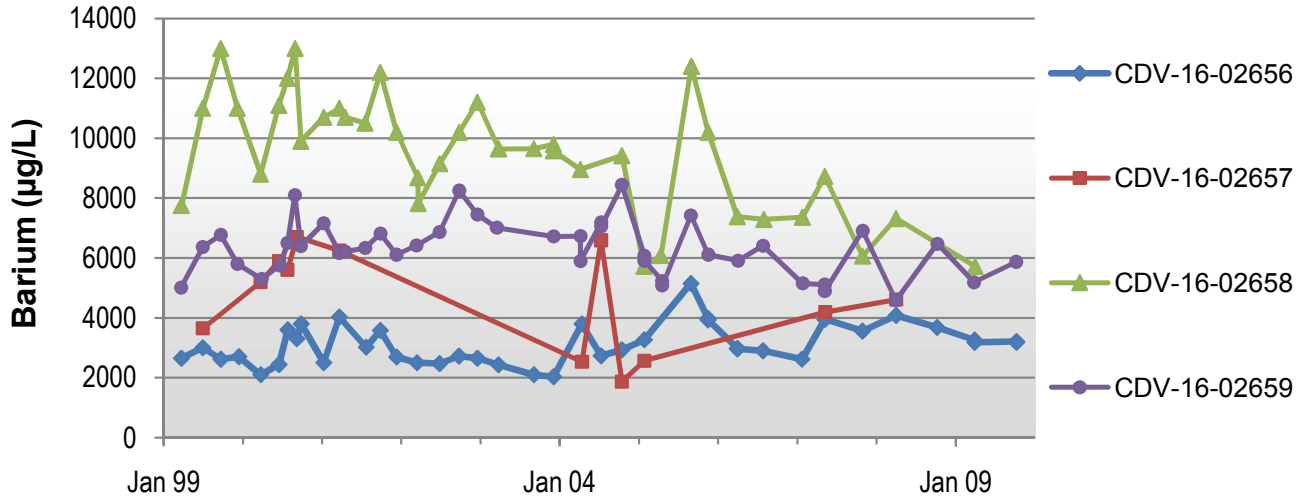


Figure 5-70. Barium in Cañon de Valle alluvial groundwater. The NM groundwater standard is 1,000 µg/L.

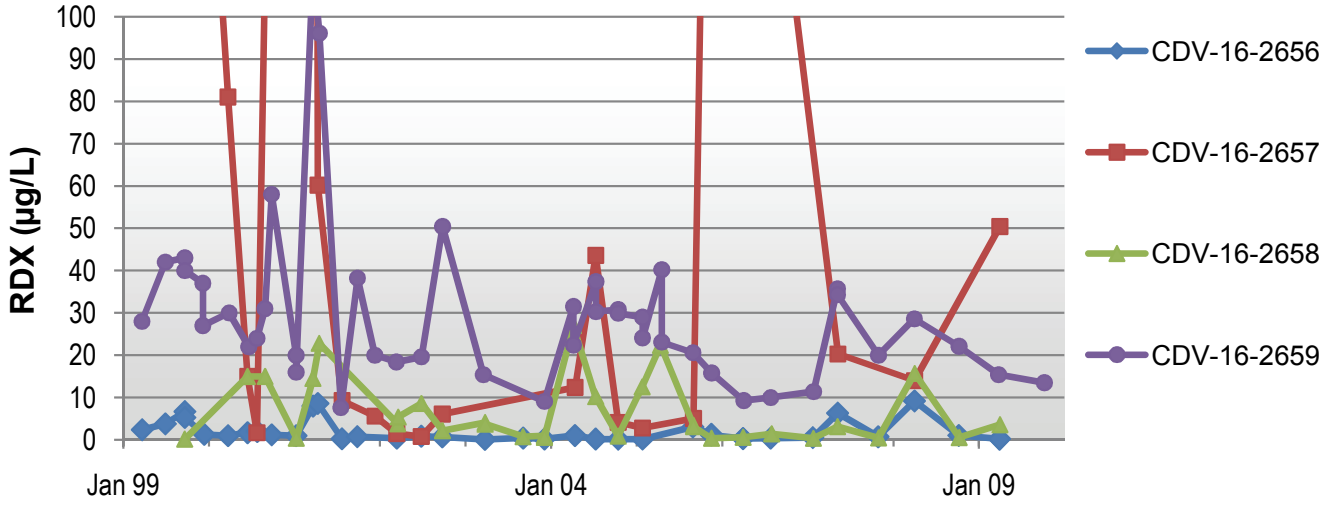


Figure 5-71. RDX in Cañon de Valle alluvial groundwater. The EPA Human Health tap water screening level is 6.1 µg/L.

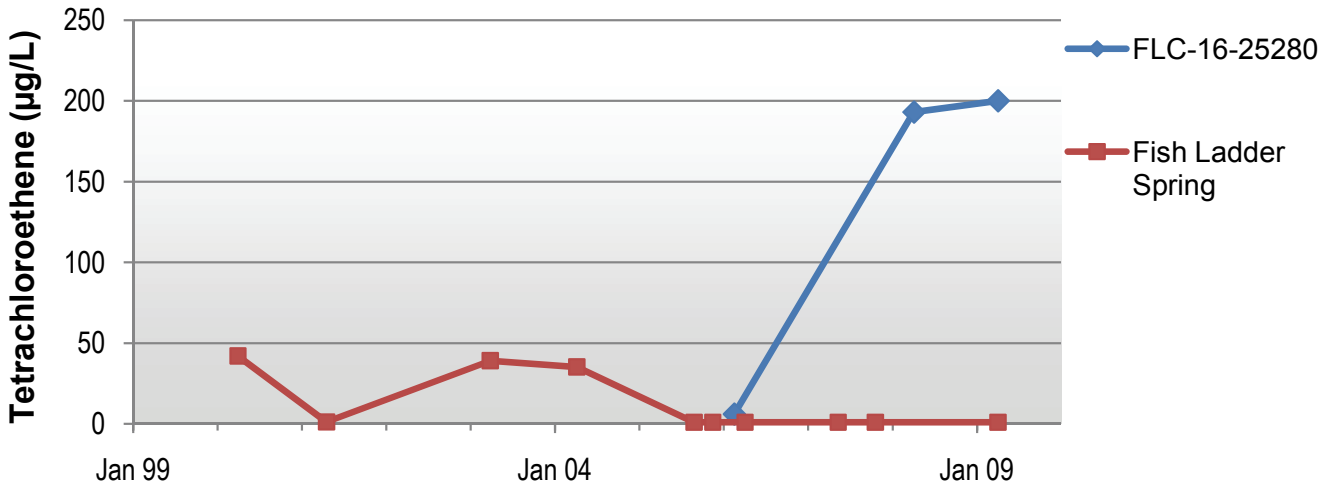


Figure 5-72. **Tetrachloroethene in Cañon de Valle alluvial and intermediate groundwater; the EPA MCL is 5 µg/L. Recent results at Fish Ladder Spring are nondetects reported at the PQL of 1 µg/L; the MDL is 0.25 µg/L.**

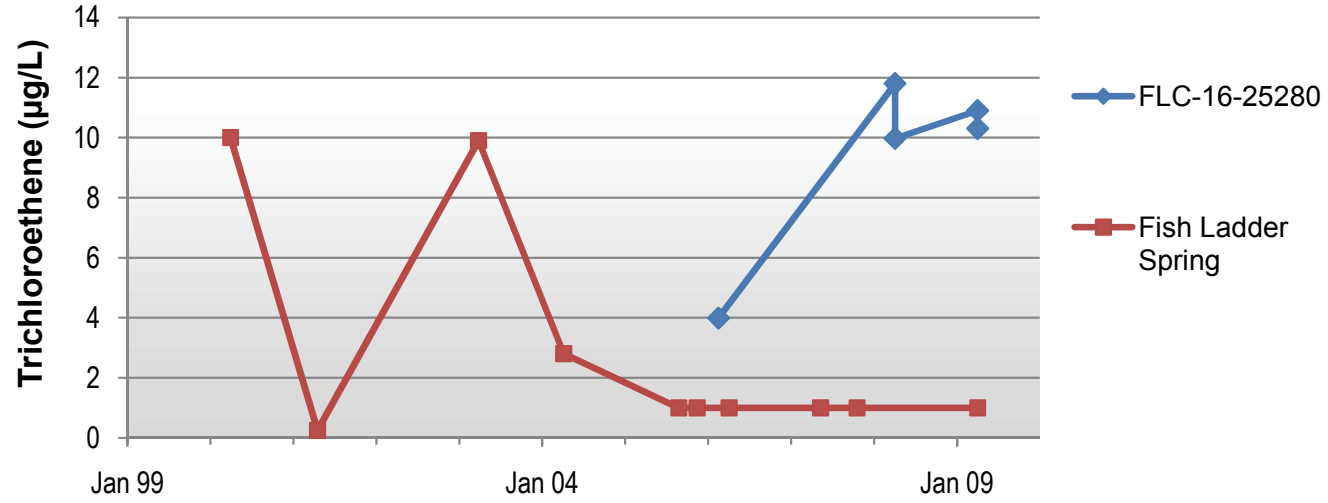


Figure 5-73. **Trichloroethene in Cañon de Valle alluvial and intermediate groundwater; the EPA MCL is 5 µg/L. Recent results at Fish Ladder Spring are nondetects reported at the PQL of 1 µg/L; the MDL is 0.25 µg/L.**

7. Ancho Canyon

Area AB at TA-49 was the site of underground nuclear weapons component testing from 1959 to 1961 (Purtymun and Stoker 1987; ESP 1988). The tests involved insufficient HEs and fissionable material to produce a nuclear reaction. The canyons in the watershed are mainly dry with little alluvial and no known intermediate groundwater. In 1960, the US Geological Survey drilled three deep wells (Test Wells DT-5A, DT-9, and DT-10) to monitor regional aquifer water quality. Another regional aquifer well, R-31, lies downstream from firing sites at TA-39. No contaminants were found in these wells at concentrations near or above standards (Table 5-21). As with other wells installed during that period, samples from these three test wells have shown high metals concentrations related to corrosion or flaking of well components.

Table 5-21
Summary of Groundwater Contamination in Ancho Canyon

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Ancho Canyon	Minor non-effluent sources and past effluent sources	Little or no alluvial groundwater	No intermediate groundwater	None

8. White Rock Canyon Springs

The springs that issue along the Rio Grande in White Rock Canyon represent a principal discharge of regional aquifer groundwater that flows underneath the Laboratory (Purtymun et al., 1980). The White Rock Canyon springs serve as boundary monitoring points for evaluating the Laboratory's impact on the regional aquifer and the Rio Grande (Table 5-22). A few springs such as Spring 2B (near Spring 2 on Fig. 5-8) appear to represent discharge of intermediate perched groundwater; that spring is supplied by percolation of municipal sanitary effluent discharge or irrigation with effluent from athletic fields near White Rock. Other springs may be a mixture of regional aquifer groundwater, intermediate perched groundwater, and percolation of recent precipitation (Longmire et al., 2007).

Table 5-22
Summary of Groundwater Contamination in White Rock Canyon Springs

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
White Rock Canyon: Springs	Sources in tributary canyons	No alluvial groundwater	Little intermediate groundwater	Natural fluoride, arsenic, uranium

The tritium values in the White Rock Canyon springs are similar to results measured during the last decade. Tritium was not detected in most of the springs. The highest results have been found at the Spring 4 group of springs. Tritium activities in samples from these springs have decreased since 2002 and are now about 8 pCi/L at Spring 4 and Spring 4C and 23 pCi/L at Spring 4B. These springs discharge within a hundred yards of each other near the Rio Grande. Other than tritium, the only radionuclide detection of note in White Rock Canyon springs was natural uranium in La Mesita Spring (Table 5-23). Naturally occurring uranium is commonly detected in this spring and a few other nearby wells and springs.

Table 5-23
Groundwater Quality in White Rock Canyon Springs

Chemical	Location	Result	Trends
Uranium	Regional aquifer La Mesita Spring, east of Rio Grande (Pueblo de San Ildefonso)	10.5 µg/L, below NM groundwater standard of 30 µg/L	Naturally occurring
Arsenic	Regional aquifer Spring 2 (Pueblo de San Ildefonso)	Up to 14.4 µg/L, above EPA MCL screening level of 10 µg/L; NM groundwater standard is 100 µg/L	Naturally occurring

Results for White Rock Canyon spring perchlorate samples collected in 2009 are consistent with prior data; concentrations are below background levels observed in sampling of NM groundwater by Plummer et al. (2006). The highest perchlorate value occurs east of the Rio Grande at La Mesita Spring on Pueblo de San Ildefonso land at a concentration of 0.83 µg/L. This spring also shows high nitrate and uranium values; it is not located near any apparent sources of contamination. Several of the springs in the Spring 4 series had perchlorate values of 0.5 to 0.7 µg/L, the highest concentrations for springs along the west side of the Rio Grande.

Spring 2 samples had fluoride concentrations at 0.73 mg/L, below the NM groundwater standard of 1.6 mg/L. The fluoride in this and nearby springs occurs naturally in groundwater near the Rio Grande and in the Española Basin.

9. Pueblo de San Ildefonso

This section covers results from Pueblo de San Ildefonso supply wells that lie near and east of the Rio Grande (Table 5-24). Other Pueblo de San Ildefonso wells and springs were covered in prior sections. The groundwater data for these wells and springs indicate the widespread presence of naturally occurring uranium at levels below the NM groundwater standard of 30 µg/L (Table 5-25). These measurements are consistent with previous samples. Naturally occurring uranium concentrations near or exceeding the NM groundwater standard are prevalent in well water throughout the Pojoaque area and Pueblo de San Ildefonso lands.

Table 5-24
Summary of Groundwater Contamination in White Rock Canyon Wells

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
White Rock Canyon: San Ildefonso Pueblo and Buckman Well Field	None	No alluvial groundwater	No intermediate groundwater	Natural fluoride, arsenic, and uranium

Table 5-25
Groundwater Quality in White Rock Canyon Wells

Chemical	Location	Result	Trends
Uranium	Pueblo de San Ildefonso and Buckman regional aquifer supply wells	Up to 18 µg/L at Pueblo de San Ildefonso and 21 µg/L at Buckman Well field, below NM groundwater standard of 30 µg/L	Naturally occurring
Fluoride	Supply well Pajarito Well Pump 1 (Pueblo de San Ildefonso)	Up to 1.0 mg/L, below NM groundwater standard of 1.6 mg/L	Naturally occurring
Arsenic	Pueblo de San Ildefonso and Buckman regional aquifer supply wells	Up to 21 µg/L at Pueblo de San Ildefonso and 15 µg/L at Buckman Well field, above EPA MCL of 10 µg/L	Naturally occurring

10. Buckman Well Field

In 2009, we sampled three wells in the City of Santa Fe's Buckman Well Field (Tables 5-24 and 5-25). As in past samples, these wells contain natural uranium below the NM groundwater standard of 30 µg/L.

The water in some of these wells has high TDS, so concentrations of several chemicals including chloride are near or above NM groundwater standards or EPA health advisory levels. Naturally occurring metals such as arsenic and boron are also high in some wells.

H. QUALITY ASSURANCE OF GROUNDWATER, SURFACE WATER, AND SEDIMENT ANALYSES

The 2009 environmental sampling incorporates a graded approach to quality assurance (QA) in accordance with DOE Order 414.1C, which determines the scope, depth, and rigor of implementing the QA criteria for a specific activity. To maximize effective resource use, this process promotes the selective application of QA and management controls based on the quality requirements, risk, and hazards associated with each activity.

All sampling, data reviews, and data package validations are conducted using standard operating procedures (SOPs), which are part of a comprehensive QA program. The LANL quality program and SOPs may be viewed at http://www.lanl.gov/environment/all/qa.shtml. Completed chain-of-custody forms serve as the analytical request form and include the requester or owner, sample number, program code, date and time of sample collection, total number of bottles, list of analytes to be measured, bottle sizes, and preservatives for each analysis requested.

All analytical laboratory results undergo validation following the guidelines in the National Nuclear Security Administration (NNSA) Model Data Validation Procedure (NNSA 2006a) and US EPA Contract Laboratory Program National Functional Guidelines for Data Review (EPA CLP 2004, EPA CLP 2005, and EPA CLP 2008). This process includes review of the data quality and the documentation's correctness and completeness. An independent DOE contractor, Analytical Quality Associates, Inc. (AQA), in Albuquerque, NM, performs the data validation and applies data qualifiers to the data according to LANL validation SOPs.

Field QA procedures and the quality plan documents were followed during 2009 sampling. Together, these plans and procedures describe or prescribe all the planned and systematic activities necessary to provide adequate confidence that processes perform satisfactorily.

The LANL water data are available as part of the RACER database (http://racernm.com/) which contains all the surface water, sediment, and groundwater analytical data received from our analytical laboratories. None of the data are censored or removed. If analytical results are inconsistent with prior data, LANL investigates the laboratory records, and the sample may be reanalyzed or the location resampled. Both the initial sample and the follow-up sample analyses are kept in the database and are available to the public. In some cases, comments are appended to the records to indicate existence of recognized analytical issues. The primary documentation of analytical issues for data from a given year is provided in this report.

See Supplemental Tables S5-14, S5-15, and S5-16 for the analytes, analytical methods, and detection limits used for analysis of surface water, sediment, and groundwater samples, respectively, during 2009.

1. Quality Control for Samples, Data Validation, and Analytical Results Review

All samples are analyzed at analytical laboratories authorized by the LANL Analytical Services Statement of Work (SOW) for general inorganic, organic, radiochemical, and asbestos analytical laboratory service (LANL 2000). LANL requires all laboratories to produce legally defensible data packages, which include the following types of quality control (QC) samples and data: instrument raw data, initial and continuing calibration verifications, method blanks, internal standards, laboratory duplicates, laboratory control samples (LCS), surrogate samples, tracers, and matrix spike (MS) samples. The results from the laboratory QC samples are used to check the accuracy and precision of the analytical data. Field QC samples are also submitted along with environmental samples so that field and analytical laboratory contamination could be tracked and analytical laboratory performance can be assessed. Field QC samples collected include equipment blanks, field blanks, field duplicates, field trip blanks, and performance evaluation blanks.

LANL verifies and validates all analytical data used to support monitoring activities to ensure they are defensible and of known quality. Analytical data packages sent to LANL by the analytical laboratories undergo a secondary validation review by AQA. When documentation or contract-compliance problems are identified during data validation, the analytical laboratory is contacted and attempts to resolve or clarify the related issues are established in Validation Corrective Action Reports submitted by AQA to LANL. The analytical laboratory reissues the corrected, modified documentation for re-validation. The majority of the issues of concern involve minor documentation and typographical errors, missing pages, and clarification of data results. Associated sample results are generally not affected. All 2009 Validation Corrective Action Reports are addressed and resolved appropriately by the analytical laboratory. AQA validated all of the 2009 data packages. Tables S5-5, S5-6, and S5-7 include the qualifiers and validation reason codes used to qualify the 2009 data.

After data validation by AQA, approximately 98% of all results are of good quality and are usable. Overall, approximately 13% of the accepted results are qualified during data validation based on data quality issues such as surrogate, LCS, tracer, and MS recoveries that do not meet specification; laboratory duplicates or holding times no met; or calibrations and internal standards that have expired. The analytical laboratory J-qualified approximately 2% of the data. AQA R-qualified (rejected) approximately 2% of the 2009 data. Less than 1% of the 2009 data are qualified as not detected (U) based on method blank and/or field blank contamination. The percentage of data qualified based on AQA's secondary data validation of laboratory QC samples is shown in Tables 5-26 and 5-27.

Table 5-26
Secondary Data Validation Summary for Estimated Data

QC Sample Type	Number of Analytes Qualified as Estimated (J)	Percent of 2009 Data
Blanks	755	0.24
Holding Times	960	0.30
Initial Calibration Verifications or Continuing Calibration Verifications	248	0.078
Interference Check Samples	50	0.016
Internal Standards or Surrogates	169	0.053
Laboratory Control Samples	37	0.012
Laboratory Duplicates	82	0.026
Matrix Spike Samples	746	0.24
Analyte Detected Between the Method Detection Limit and Practical Quantitation Limit	6361	2.01
Serial Dilutions	23	0.007
Tracers (rad only)	50	0.012

Total of 3% of 2009 Data qualified as Estimated Detect (J).

Table 5-27
Secondary Data Validation Summary for Rejected Data

QC Sample Type	Number of Analytes Qualified as Rejected (R)	Percent of 2009 Data
Holding Times	14	0.004
Initial Calibration Verifications or Continuing Calibration Verifications	5276	1.67
Internal Standards or Surrogates	791	0.25
Laboratory Control Samples	218	0.07
Laboratory Duplicates	1	0
Matrix Spike Samples	19	0.006

Total of 2% of 2009 Data qualified as Rejected (R).

In addition to data validation, LANL performs data review of analytical results to assess and identify issues with data quality that require action to determine the overall quality of the reported results. The data quality issues identified and addressed in 2009 include the following:

- During 2009, several strontium-90 detections were reported in samples from locations that usually have none. Reanalysis of these samples produced nondetect results for strontium-90 in several cases. Upon investigation, the analytical laboratory found that using several counting systems with differing sensitivity gave inconsistent results and resulted in apparent detections. The counting system with lower sensitivity has been replaced and all future data will be analyzed on the same types of counting systems.
- There were also a large number of fluoride results that were the highest measured at several monitoring locations. After investigation, the fluoride values appeared to be the integration of a signal for the water pulse rather than integration of the fluoride peak. Currently, data are being re-examined and the appropriate data quality qualifier is being applied in the database. A section was added to the contract laboratory SOW to ensure all fluoride detections are reviewed by a qualified analyst to prevent this occurrence.

- Sample bottles for volatile organic compounds and distilled water blanks were contaminated with chloromethane prior to use. During the investigation of this problem, it was identified that the preservative used by the bottle vendor was contaminated with chloromethane. The vendor has replaced its preservation vendor and upgraded to a higher purity acid. All acids are analyzed and checked for purity before being introduced into the bottles for purchase.

2. Qualification and Performance Assessment of Analytical Laboratories

The Laboratory is responsible for acquiring analytical services that support monitoring activities. The SOW for analytical services follows the DOE NNSA Service Center Model Statement of Work for Analytical Laboratories (NNSA 2006b). The SOW provides the contract analytical laboratories with the general QA guidelines, which includes specific requirements and guidelines for analyzing surface water, groundwater, and sediment samples.

Analytical laboratories undergo a pre-award assessment to evaluate their ability to perform the needed analyses. The laboratories must be certified under the National Environmental Laboratory Accreditation Program (NELAP) for the analytical methods needed for the programs.

LANL requires most analytical laboratories to participate in independent national performance evaluation programs. These programs measure each laboratory's performance as they analyze analytes in different media. The laboratories participate in the Mixed Analyte Performance Evaluation Program (MAPEP) and other pertinent programs as available for the analytical methods they conduct for LANL.

In 2009, General Environmental Laboratories (GEL), LLC, of Charleston, South Carolina, performed the majority of the analyses. To provide access to additional laboratories and meet the requirements of the Consent Order, LANL combined the analytical laboratory contracts with the contracts within the LANL Environmental Programs (EP) Directorate under control of the Sample Management Office (SMO). Vista Analytical Laboratory in El Dorado Hills, California (used for dioxin and furans analysis) and TestAmerica, Inc. in Earth City, Missouri (used for RDX [1,3,5-trinitro-1,3,5-triazine] breakdown product analysis) were included as additional laboratories to address specific needs created by the Consent Order.

GEL participated in several different performance evaluation studies that addressed a majority of the parameters for which they conduct analyses. GEL participated in both MAPEP and proficiency testing offered by Environmental Resource Associates and state-sponsored certification programs. The vast majority of the results of these studies were within acceptance limits. Acceptance limits are the range of percent recoveries that indicate sufficient accuracy of the analyses and results in data not being qualified. If the results for an analyte or group of analytes did not pass, GEL implemented corrective actions and acceptable results are reported for 2009.

Results for the applicable 2009 performance evaluation programs at GEL are summarized in Table 5-28. All corrective actions have been addressed and resolved unless indicated otherwise and only analytes that were found deficient are listed.

Table 5-28
2009 Performance Evaluation Results at GEL

Analytical Suite Type	Analytes	Evaluation	Study Results
Organic Chemicals	Endrin Ketone	MAPEP-19	Reported as false positive due to sample degradation from holding times.
	Heptachlor	MAPEP-19	Reported below the acceptance limits.
	2,4-Dinitrotoluene	WP-168	Reported below acceptance limits due to the analyte being manually integrated.
	Dibenzo(a,h)anthracene	NY-320	Reported below acceptance limits.
	2,4,5- Trichlorophenoxyacetic acid (2,4,5-T)		

Table 5-28 (continued)

Analytical Suite Type	Analytical Suite Type	Analytical Suite Type	Analytical Suite Type
Organic Chemicals (continued)	2,4-Dichlorophenoxyacetic acid (2,4-D)	NY-320	Reported below acceptance limits.
	2,4-Dimethylphenol	MAPEP Series 20	Reported above the acceptance limits.
	Endosulfan II	NY-325	Acceptance limits are nondetect.
	Fluoranthene		
	Dinoseb	NY-325	Reported above the acceptance limits due to Co-eluting matrix interference.
	Endrin Aldehyde	MAPEP Series 21	Reported as false positive. (fourth quarter, corrective action under investigation).
	Benzo(k)fluoranthene		
	Dichlorodifluoromethane	NY-327	Reported above acceptance limits. (fourth quarter, corrective action under investigation).
Inorganic Chemicals	Mercury	MAPEP-19	Reported above acceptance limits; however, the duplicate passed.
	Thallium	NY-317	Reported below acceptance limits; however, the duplicate passed.
	Cyanide	WP09-1	Reported above acceptance limits.
	Ammonia	NY-320; NY-322	Reported below acceptance limits due to sample dilution.
	Silver	NY-320	
	Vanadium	NY-320; WS09-3-11	
	Chlorate	WS09-3-11	Reported above acceptance limits.
	Zinc	WS09-3-11	Reported below acceptance limits due to random statistical fail rate.
	Iron	WS09-3-11; DMRQA-29	Reported above acceptance limits.
	Molybdenum	WS09-3-11	Reported above acceptance limits.
	Silver		
	Nitrate as Nitrogen	NY-327	Reported below acceptance limits. (fourth quarter, corrective action under investigation).
Radiochemistry	Cesium-137	RAD-75	Reported above acceptance limits; however, the duplicates passed.
	Radium-226	RAD-75; RAD-78	Reported above the acceptance limits due to Ra-224 also present in sample.
	Cesium-134	NY-322	Reported below the acceptance limits.
	Strontium-90		
	Strontium-89	NY-322	Reported above the acceptance limits due to QC issue.
	Technetium-99	MAPEP Series 20	Reported below the acceptance limits.
	Iodine-131	RAD-78	Reported above the acceptance limits due to QC issue.
	Tritium	NY-327	Reported above acceptance limits. (fourth quarter, corrective action under investigation).

GEL performance evaluation studies, investigation reports, and correction action plans are on file at the analytical laboratory and available for review during on-site assessments. They are also available in the quarterly progress reports provided in conformance with the requirements of the NNSA Service Center's SOW for analytical laboratories and available through AQA.

There are no performance evaluation programs for the specialty analyses conducted at Vista Analytical Laboratory and TestAmerica, Inc. Therefore, performance on samples at Vista Analytical Laboratory and TestAmerica was not assessed through performance evaluation programs.

In addition, each laboratory conducts internal audits of their procedures, instrumentation and reporting practices on a regular basis. Issues found are documented and corrective actions performed and recorded. Copies of internal audits are maintained on file at the analytical laboratory and available for review during on-site assessments.

3. Department of Energy Contract Analytical Program Audits

The DOE Office of Environmental Management mandates participation in the DOE Contract Analytical Program (DOECAP). DOECAP is a consolidated, uniform program for conducting annual audits of commercial laboratories to eliminate audit redundancy by involving all DOE program line organizations and field elements, providing a pool of trained auditors sufficient to support consolidated audits, standardizing terms and conditions of existing and proposed contracts to allow acceptance of consolidated audit results, and interfacing with state and federal regulatory agencies and other industry standard-setting groups, such as the National Environmental Laboratory Accreditation Conference. LANL requires participation in DOECAP for all major analytical providers.

In 2009, DOECAP audits were conducted at four laboratory facilities that provide water and sediment data to the EP Directorate: Paragon Analytics; TestAmerica, Inc.; GEL, LLC; and American Radiation Services, Inc.

DOECAP audits result in findings and observations when there are items of concern that need to be addressed in the audit report. DOECAP audits found that the laboratories meet established requirements necessary to produce data of acceptable and documented quality through analytical operations that follow approved and technically sound methods. The corrective action plans for all four audits listed below have been approved and are available from the DOECAP website at https://doecap.oro.doe.gov/.

- Paragon Analytics, Fort Collins, Colorado, March 24 26, 2009. There were eight findings and 12 minor observations identified. All eight findings were addressed and resolved.
- TestAmerica, Inc., Earth City Missouri, March 17 19, 2009. There were 14 findings and 10 minor observations identified. All 14 findings were addressed and resolved.
- GEL, LLC, Charleston, South Carolina, April 21 23, 2009. There were nine findings and 12 minor observations identified. All nine findings were addressed and resolved.
- American Radiation Services, Port Allen, Louisiana, July 28 29, 2009. There were five findings and seven minor observations identified. All five findings were addressed and resolved.



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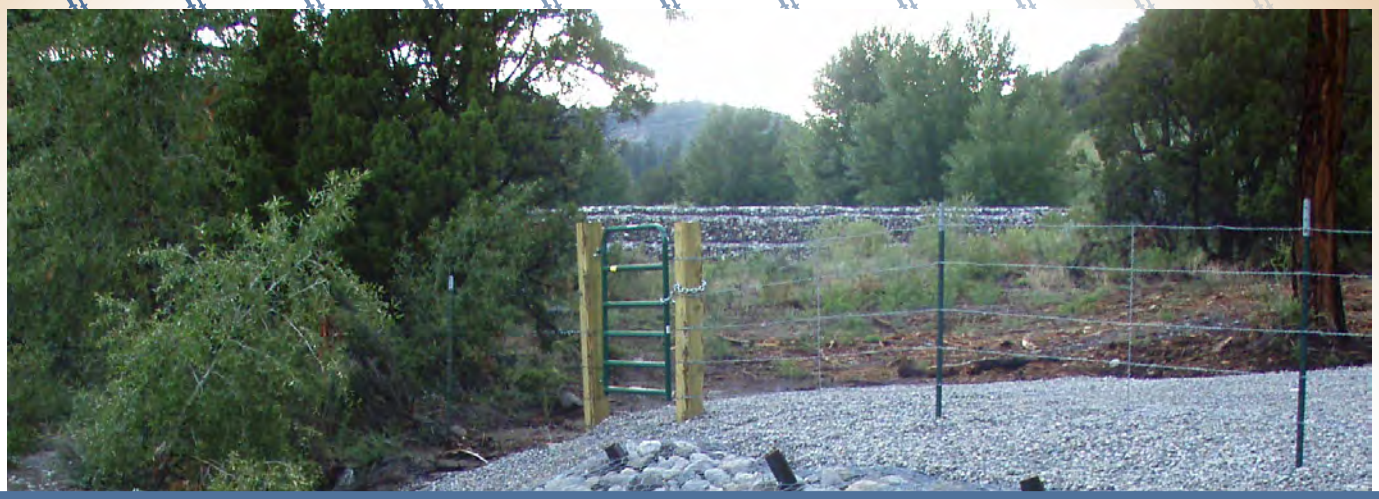
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6. Watershed Monitoring



contributing authors:
Steven L. Reneau, Paul G. Drakos, Armand R. Groffman, Jenifer Linville, Randall T. Ryti, Kelly B. Schilling, Emily S. Schultz-Fellenz, Wendy L. Swanson, Steven J. Veenis

To Read About **Turn to Page**

Introduction 207
Hydrologic Setting 207
Surface Water and Sediment Standards and Screening Levels 210
Sampling Locations and Data Analysis Methods 214
Sampling Results by Constituents 217
Canyon-Specific Results 228
Potential Impacts to the Rio Grande 242
Quality Assurance 249
References 250

A. INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) monitors the quality of surface water, including storm water, and stream sediment in northern New Mexico to evaluate the potential environmental effects of Laboratory operations on affected watersheds. The Laboratory collects and analyzes samples for a variety of constituents, including radionuclides and inorganic and organic chemicals. In this chapter, the effects of Laboratory operations on surface water and stream sediment are evaluated geographically and over time. Additionally, the sampling results are compared with screening criteria established to protect human health and the aquatic environment.

Annual monitoring of sediment sampled from selected locations at and near LANL has occurred since 1969, as part of the US Department of Energy (DOE) Environmental Protection Program (DOE 2008). This currently includes sampling of active stream channels, overbank sediment on floodplains, and other settings. Monitoring in 2009 occurred following the annual summer monsoon season, and this work is described in a sampling and analysis plan (LANL 2009a).

Surface water monitoring and assessments at the Laboratory in 2009 occurred under several tasks. The annual Interim Facility-Wide Groundwater Monitoring Plan (LANL 2009b) includes monitoring of base flow or persistent surface water in main drainages and some tributary channels for an extensive list of constituents. This plan was prepared following the March 1, 2005, Compliance Order on Consent (the Consent Order) with the New Mexico Environment Department (NMED). Sampling of base flow along the Rio Grande at two locations occurred under an agreement with the City and County of Santa Fe and the Buckman Direct Diversion (BDD) Project. Storm water sampling at gaging stations occurred as part of the Laboratory's environmental surveillance activities. Storm water sampling at other locations near facilities occurred under the Multi-Sector General Permit with the US Environmental Protection Agency (EPA). Additional storm water sampling occurred in 2009 as part of a special study to evaluate background and baseline concentrations of polychlorinated biphenyls (PCBs), metals, and gross alpha radiation in and near the Laboratory (LANL 2009c).

B. HYDROLOGIC SETTING

Laboratory lands contain parts or all of seven primary watersheds that drain directly into the Rio Grande, each defined by a master canyon (Figure 6-1). Listed from north to south, the master canyons for these watersheds are Los Alamos, Sandia, Mortandad, Pajarito, Water, Ancho, and Chaquehui canyons. Each of these watersheds includes tributary canyons of various sizes. Los Alamos, Pajarito, and Water Canyons have their headwaters west of the Laboratory in the eastern Jemez Mountains (the Sierra de los Valles), mostly within the Santa Fe National Forest, while the remainder head on the Pajarito Plateau. Only the Ancho Canyon watershed is entirely located on Laboratory land.

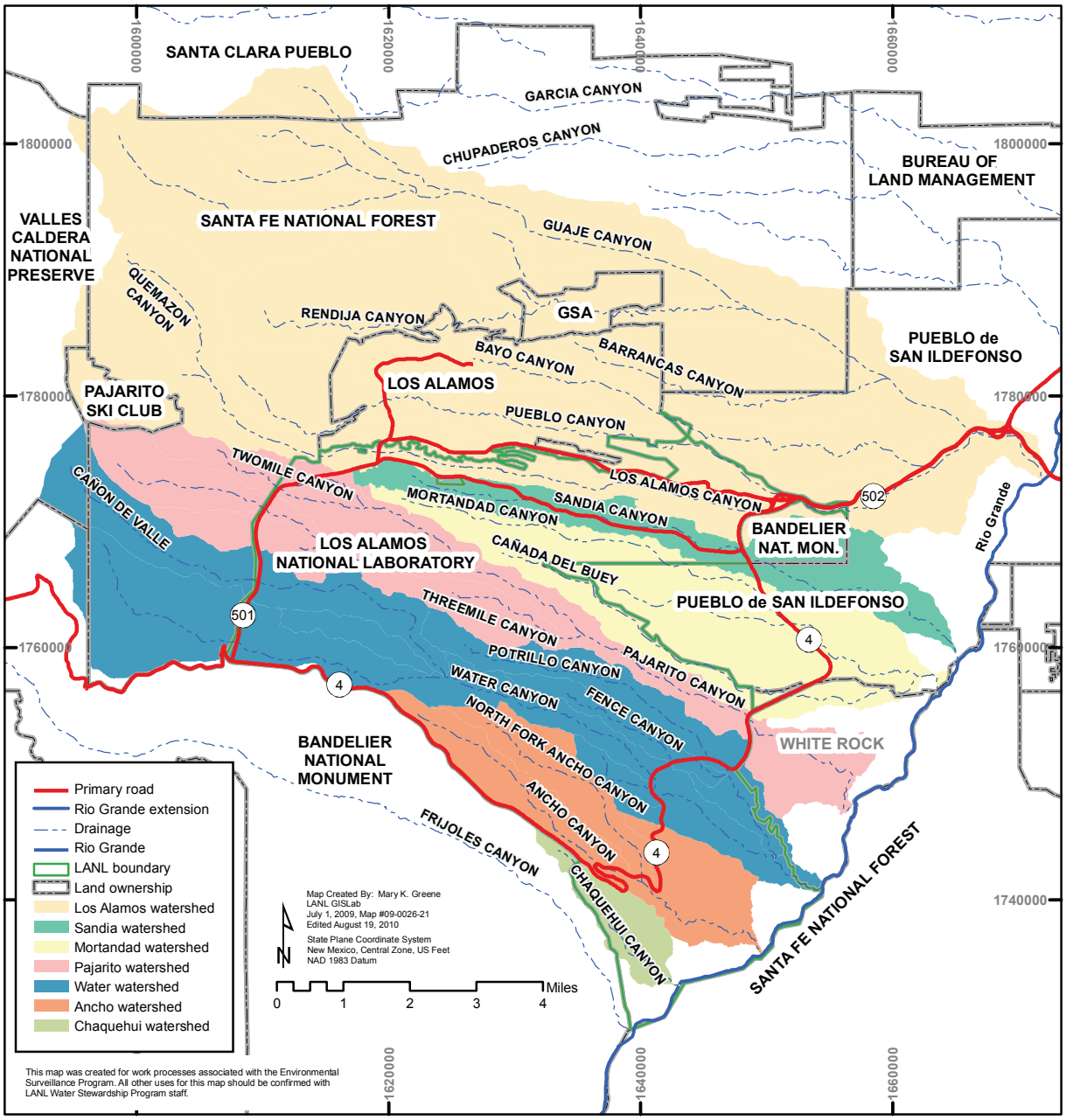


Figure 6-1. Primary watersheds at Los Alamos National Laboratory.

Canyons that drain Laboratory property are generally dry for most of the year, and no perennial surface water (i.e., water that is present all year) extends completely across Laboratory land in any canyon. Approximately three miles of canyon in the western part of the Laboratory have streams that are naturally perennial and fed by springs. These perennial segments are located in Water Canyon, Cañon de Valle (a major tributary to Water Canyon), and Pajarito Canyon and its tributaries. Approximately four miles of canyon on Laboratory land have perennial streams created by discharges of sanitary effluent from wastewater treatment plants (WWTPs) in Pueblo and Sandia Canyons. Spring-fed perennial stream segments are also located in lower Ancho and Chaquehui Canyons on Laboratory land near the Rio Grande, as well as in other canyons upstream and downstream from the Laboratory.

The remaining stream channels are dry for varying lengths of time. The driest segments flow only after local precipitation events or during snowmelt periods, and flow in these streams is ephemeral. Other stream segments sometimes have alluvial groundwater that discharges into the stream bed and/or experience extensive snowmelt runoff and are considered intermittent. Intermittent streams may flow for several weeks to a year or longer.

To aid in water quality interpretation, we consider three basic types of stream flow. At times, the flow might represent a combination of several of these flow types:

- Base flow—persistent stream flow but not necessarily perennial water. This type of flow is generally present for periods of weeks or longer. The water source may be springs, effluent discharge, or alluvial groundwater that emerges along stream beds.
- Snowmelt runoff—flowing water present because of melting snow. This type of water may be present for up to a month or more and in some years may not be present at all.
- Storm water runoff—flowing water present in response to rainfall. These flow events are generally very short-lived, with flows lasting from less than an hour to—rarely—several days.

Because base flow and snowmelt runoff can be present for extended periods of time, they may be available for potentially longer-term exposures, such as when wildlife uses them for watering. Storm water runoff may provide a short-term water source for wildlife, particularly when it collects in bedrock pools or other local depressions, although water quality will improve at these locations over time as the suspended sediment settles out. Storm water runoff in particular is capable of transporting Laboratory-derived constituents associated with sediment particles off-site and possibly into the Rio Grande.

None of the streams within the Laboratory boundary averages more than one cubic foot per second (cfs) of flow annually. It is unusual for the combined mean daily flow from all LANL canyons to be greater than 10 cfs. The largest flows in 2009 occurred on July 30, with a total estimated mean daily flow of 7.2 cfs resulting from storm water runoff in three canyons (Ancho Canyon, Cañada del Buey, and Los Alamos Canyon; Ortiz and McCullough 2010). By comparison, the average daily flow in the Rio Grande at Otowi Bridge on July 30 was 1,040 cfs, or approximately 145 times higher than the flow from LANL. Excluding effluent, stream flow in 2009 on the Pajarito Plateau was dominated by storm water runoff, mostly occurring in July. No snowmelt runoff was recorded crossing the eastern Laboratory boundary. Total storm water runoff measured at downstream gages in the canyons leaving the Laboratory was estimated at about 24 acre-feet (ac-ft), the least since 1995, the first year for which runoff estimates are available for all the canyons. In addition, approximately 28 ac-ft of effluent released from the Los Alamos County WWTP is estimated to have passed the eastern LANL boundary in Pueblo Canyon. Figure 6-2 shows the estimated storm water runoff at LANL from June through October and the seasonal precipitation since 1995.

There were no unusual storm water runoff events at LANL in 2009. The largest recorded flood was measured in Ancho Canyon below NM 4 (stream gage E275) on July 30, with an estimated peak discharge of 414 cfs (Ortiz and McCullough 2010). This was the fourth largest event in the 15 years of record at this station and occurred in response to a typical short-duration summer thunderstorm. No significant new sediment deposits resulted from this flood. All other recorded runoff events at LANL in 2009 had peak discharges of 60 cfs or less.



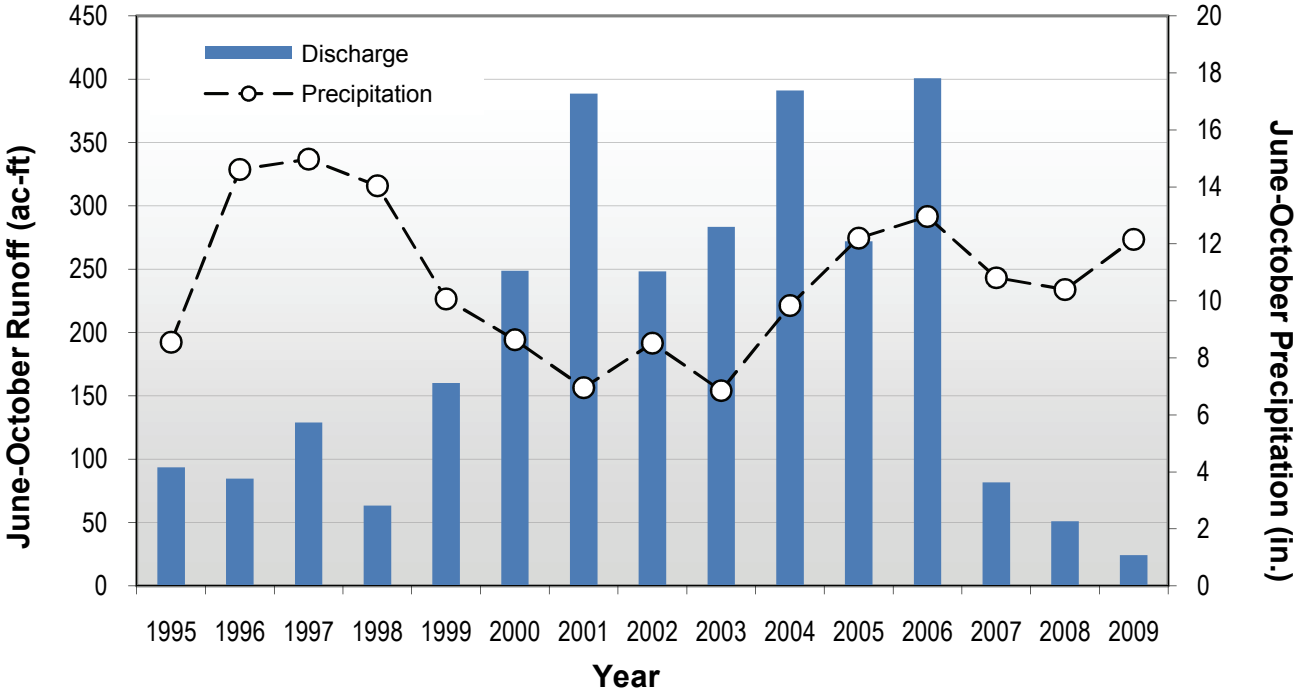


Figure 6-2. Estimated storm water runoff in LANL canyons (Pueblo Canyon to Ancho Canyon) and precipitation at TA-6 during the months of June through October from 1995 through 2009.

C. SURFACE WATER AND SEDIMENT STANDARDS AND SCREENING LEVELS

Table 6-1 summarizes the standards, screening levels, and comparisons used to evaluate the monitoring data. For brevity, they are all commonly referred to as "screening levels" in this chapter. The surface water screening levels include biota concentration guides (BCGs), water quality standards, and risk-based screening levels. The suite of screening levels for surface water varies, depending on the stream flow conditions and established or potential uses, as discussed below in Section C.1. Results for sediment are compared with background concentrations, human health risk-based screening levels, and BCGs. Because some of the criteria are not for current uses, actual impacts can be less than indicated by these comparisons. For example, use of livestock watering standards is required by New Mexico regulations, although there are no livestock at the Laboratory except for some feral, trespassing cows grazing at low elevations near the west bank of the Rio Grande. In addition, risk-based screening levels for drinking water are included for consistency with other evaluations at the Laboratory, although use of surface water at LANL for human drinking water is highly unlikely.

1. New Mexico Surface Water Standards

The New Mexico Water Quality Control Commission (NMWQCC) establishes surface water standards for New Mexico in Standards for Interstate and Intrastate Surface Waters (NMWQCC 2005). Certain watercourses may be 'classified' and have segment-specific designated uses. A designated use may be an attainable or an existing use (e.g., wildlife watering, aquatic life) for the surface water. Nonclassified surface water may be described as ephemeral, intermittent, or perennial, each of which also has corresponding designated uses. The designated uses for surface water are associated with use-specific water quality criteria, including numeric criteria. Some of the standards are for total concentrations, which are compared to data from non-filtered surface water samples. Other standards are for dissolved concentrations, which are compared to data from filtered samples.

The NMWQCC classified all surface water within the Laboratory boundary with segment-specific designated uses (NMWQCC 2005) (Figure 6-3). Four stream segments are classified as perennial, with designated uses of coldwater aquatic life, livestock watering, wildlife habitat, and secondary contact. Three of these segments are spring-fed (Cañon de Valle, Pajarito Canyon, and Water Canyon), and the fourth is supplied by treated sanitary effluent (Sandia Canyon). The remaining stream segments are classified as ephemeral or intermittent, with designated uses of limited aquatic life, livestock watering, wildlife habitat, and secondary contact.

Surface water within the Laboratory is not a source of municipal, industrial, or irrigation water, though wildlife does use the water. While direct use of the surface water is minimal within the Laboratory, stream flow may extend beyond the LANL boundary where the potential is greater for more direct use of the water. Stream flows sometimes extend onto Pueblo de San Ildefonso land, particularly flows in Pueblo Canyon derived from treated sanitary effluent discharged from the Los Alamos County WWTP. Spring water may be used traditionally and ceremonially by Pueblo de San Ildefonso members and may result in exposure through ingestion or direct contact.

2. Radionuclides in Surface Water

DOE Order 5400.5 prescribes total dose limits associated with exposure to radionuclides in environmental media. Because of the limited extent of stream flow, there are no drinking water systems on the Pajarito Plateau that rely on surface water supplies. The emphasis of the radiological assessment of surface water is, therefore, on potential exposures to aquatic organisms, rather than to humans, although human health screening levels are included for completeness. For protection of biota, concentrations of radionuclides in surface water are compared with BCGs obtained following DOE guidance (DOE 2002, 2004), with site-specific modifications by McNaughton et al. (2008). DOE DCGs, calculated based on a target dose limit of 100 mrem/yr, are used as a human health screening level for base flow and snowmelt runoff. For screening purposes, single sample results are first compared with BCGs and DCGs to identify if radionuclides at a location pose a potential risk to biota or humans. Following DOE guidance (DOE 2003), final evaluations of potential risk at these locations use annual time-weighted radionuclide content of the water rather than individual sample results.

Surface water analytical results for gross alpha radiation, radium isotopes, and tritium are also compared with the NMWQCC standard for protection of livestock watering use, which is a designated use for surface water within the Laboratory boundary (NMWQCC 2005). NMWQCC standards are not specific about exposure frequency or duration. Therefore, for screening purposes, single sample results are compared with numeric criteria for these analytes, as discussed in Section C.3. It should be noted that the gross alpha standard does not apply to source, special nuclear, or byproduct material regulated by DOE under the Atomic Energy Act, and the gross alpha radiation data discussed in this chapter were not adjusted to remove these sources of radioactivity.



Table 6-1
Application of Surface Water and Sediment Standards and Screening Levels to Monitoring Data

Media and Analyte Type	Standard	Screening Level	Reference	Notes
Surface Water, Radionuclides and Radioactivity	New Mexico gross alpha water quality standard for surface water	Biota Concentration Guides (BCGs) and Derived Concentration Guidelines (DCGs)	DOE (1990, 2002, 2004)	Surface water is generally present sporadically or is not available for long-term access and does not provide persistent drinking water. The actual exposure pathway is to plants and animals and not to humans. BCGs are obtained from RESRAD-BIOTA 1.5 and are based on 1 rad/day exposure limit for aquatic animals and 0.1 rad/day for riparian animals. DCGs based on 100 mrem/yr are included for completeness, although use of surface water at LANL for drinking water is highly unlikely.
			20.6.4 NMAC NMWQCC (2005)	Based on the protection of livestock watering for radium-226, radium-228, tritium, and gross alpha radiation. NMWQCC standards are not specific about exposure frequency or duration; for screening purposes, single sample results are compared with numeric criteria. The gross alpha standard excludes alpha radiation from source, special nuclear, and byproduct material regulated by the Atomic Energy Act.
Surface Water, Nonradionuclides	New Mexico water quality standards for surface water	New Mexico water quality standards for surface water	20.6.4 NMAC NMWQCC (2005)	Single sample results are compared with screening levels based on water quality standards.
		Tap water screening levels	NMED (2009a) EPA (2009)	Single sample results in base flow and snowmelt runoff are compared with risk-based tap water screening levels for analytes that are not included in the NMWQCC human health standards (converted to 10^{-5} risk level for carcinogens per NMWQCC guidance), although use of surface water at LANL for drinking water is highly unlikely.
Sediment, Radionuclides	None	Human health screening levels	LANL (2005a)	Screening action levels (SALs) are derived to determine if more detailed assessment is needed to evaluate potential impacts to the public; comparisons in this report are made for recreational exposure parameters. SALs are based on a dose rate limit of 15 mrem/year. Recreational SALs are appropriate for Laboratory lands because of public access. There are no residential uses of LANL lands, and residential use is impractical at many locations (e.g., active floodplains in canyon bottoms).
		BCGs	DOE (2002, 2004)	Dose limit to biota is the same as for surface water. Individual results are compared with BCGs obtained from RESRAD-BIOTA 1.5.
		Background	Ryti et al. (1998) or McLin and Lyons (2002)	Results from Pajarito Plateau stations are compared with plateau-specific background levels. Results from regional stations are compared with background levels specific to major rivers and reservoirs within the Rio Grande drainage system.
Sediment, Nonradionuclides	None	Human health screening levels	LANL (2007a)	Recreational or industrial screening levels are derived to determine if more detailed assessment is needed to evaluate potential impacts to the public.
		Background	Ryti et al. (1998)	Results for inorganic chemicals from Pajarito Plateau stations are compared with plateau-specific background levels. There are no established background levels for inorganic chemicals in major rivers and reservoirs within the Rio Grande drainage system and no established background levels for organic chemicals on or off the Pajarito Plateau.

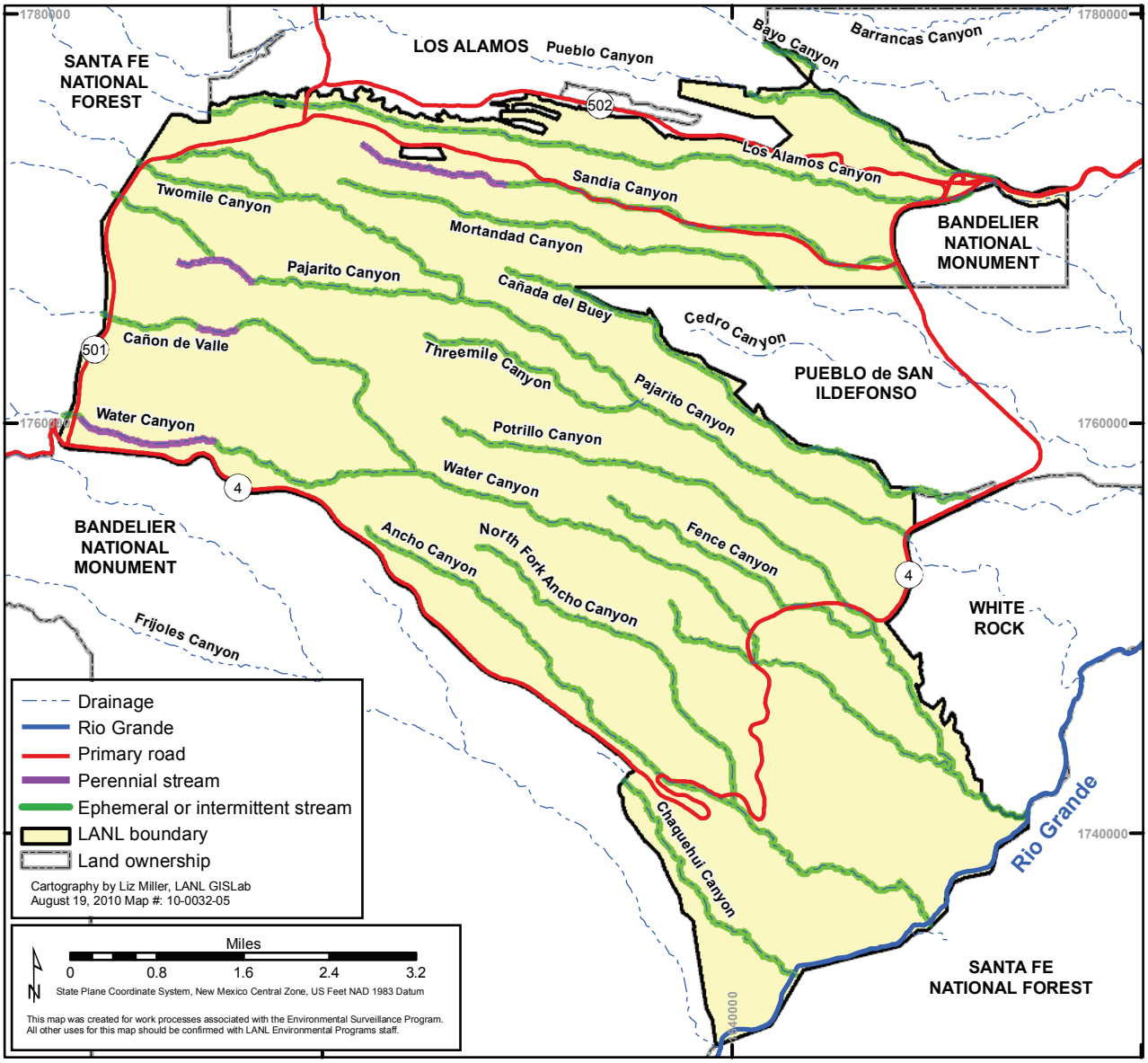


Figure 6-3. Major drainages within Los Alamos National Laboratory land, showing designated stream segments.

3. Nonradioactive Constituents in Surface Water

Surface water concentrations of nonradioactive constituents are compared with screening levels that correspond to the designated uses for the stream (NMWQCC 2005), as discussed in Section C.1. Hardness-dependent aquatic life numeric criteria are calculated using a water hardness value of 100 mg CaCO3/L (EPA 2006). For evaluating the potential impact of chronic exposure to surface water constituents on aquatic life in perennial stream segments, the Laboratory uses the protocol employed by NMED for assessing standards attainment in New Mexico (NMED 2009b). For designated perennial stream segments, single sample results from base flow samples are compared with the chronic aquatic life criterion. For storm water samples and all samples from other stream segments, single sample results are compared with the acute aquatic life criterion. For analytes that do not have human health standards in NMWCCC (2005), tap water screening levels (NMED 2009a; EPA 2009) are used as human health screening levels for base flow and snowmelt runoff, consistent with other evaluations at the Laboratory (e.g., LANL 2009d, 2009e, 2009f). EPA values are converted using a target risk level of 10^{-5} for carcinogens per NMWQCC (2005).

4. Sediment

Sediment analytical results are compared with screening levels to identify concentrations that may require further assessment. The Laboratory uses human health SALs to identify radionuclides of interest (LANL 2005a). Comparisons with SALs are used to determine if more detailed evaluations are required. Recreation is the dominant use in canyon bottoms along streams at the Laboratory, and recreational SALs provide the most appropriate comparison to sediment data. Concentrations of nonradioactive compounds in sediment are compared with recreational soil screening levels (SSLs) developed by LANL (2007a). All of these screening levels are protective because they are calculated based on the assumption that humans are exposed to the chemicals or radionuclides for extended periods of time (chronic exposure), which is not likely on LANL property because of the restricted access. The assumption of chronic exposure also provides a bounding case in other, off-site, locations. Sediment data from the Pajarito Plateau are also compared with established plateau-specific background concentrations of inorganic chemicals or radionuclides that are naturally occurring or result from atmospheric fallout (Ryti et al. 1998; McDonald et al. 2003) and sources other than LANL. Radionuclide data from regional sediment stations are compared with background levels established for major drainages of the area: the Rio Grande, the Rio Chama, and the Jemez River (McLin and Lyons 2002; McLin 2004). There are no established background levels for inorganic chemicals along these regional rivers, and results upriver and downriver from LANL are compared to evaluate possible impacts. Also, there are no established background levels for organic chemicals and all detected results are compared with screening levels.

D. SAMPLING LOCATIONS AND DATA ANALYSIS METHODS

1. Regional Monitoring Locations

Surface water and sediment are sampled in all major canyons that cross current or former Laboratory lands. Stream channel sediment is sampled to evaluate the potential accumulation of contaminants in the aquatic environment (DOE 1991). LANL collects surface water samples across the Pajarito Plateau within and near the Laboratory, with particular emphasis placed on monitoring close to and downstream of potential Laboratory contaminant sources, such as at the downstream Laboratory boundary or NM 4. These samples include base flow grab samples from locations where effluent discharges or natural springs maintain stream flow.

LANL collects storm water runoff samples in streams at stream gages using automated samplers (Figure 6-4). Many gages are located near where drainages cross the Laboratory's eastern boundary or NM 4. Base flow, snowmelt runoff, or persistent surface water are also sampled at some gages and at other locations along stream channels (Figure 6-5). Additional storm water samples were collected in 2009 as part of a baseline PCB, metals, and gross alpha study (Figure 6-6). All storm water samples are filtered and preserved in LANL's storm water operations facility because filtering highly sediment-laden waters in the field is difficult. These samples are then shipped to commercial analytical laboratories without compositing or splitting the samples.

Seven of the surface water sampling locations at the Laboratory in 2009 were situated within or very close to designated perennial stream segments, as discussed in Chapter C.1 and shown on Figure 6-3. These locations are in the south fork of Sandia Canyon ("Sandia right fork at power plant" or gage E121), Sandia Canyon below the wetland (gage E123), middle Sandia Canyon at the terminus of persistent base flow, Pajarito Canyon below North Anchor East basin, Cañon de Valle below Material Disposal Area (MDA) P (now removed) (gage E256), Water Canyon above NM 501, and Water Canyon between NM 501 and Cañon de Valle ("between E252 and Water at Beta").

Sediment stations on the Pajarito Plateau and vicinity (Figure 6-7) are located within approximately 8 km of the Laboratory's boundary, with the majority located within the Laboratory's boundary. Many of the annual sediment sampling stations on the Pajarito Plateau are located within canyons to monitor sediment in the active channel related to past and/or present effluent discharges. In accordance with the Consent Order, LANL has completed extensive evaluations of sediment, including both active channel and floodplain sediment deposits,

in several canyons (LANL 2004a, 2006a, 2009d, 2009e, 2009f, 2009g; Reneau et al. 2004). These evaluations complement the active channel sampling at these annual sediment stations.

LANL also collected sediment in 2009 from short tributary drainages to Cañada del Buey and Pajarito Canyon below and within MDA G at TA-54 (Figure 6-8), which is an active waste storage and disposal area. Sampling stations were established outside its perimeter fence in 1982 to monitor possible transport of radionuclides from MDA G. Inorganic and organic chemicals are also sampled at these locations.

Additionally, surface water and sediment were sampled at several locations on Pueblo de San Ildefonso lands, both in canyons draining the Laboratory and along the Rio Grande. DOE entered into a Memorandum of Understanding with the Pueblo de San Ildefonso and the Bureau of Indian Affairs in 1987 to conduct environmental sampling on Pueblo land. The drainages that pass from LANL onto Pueblo de San Ildefonso land are Bayo, Los Alamos, Mortandad, Pueblo, and Sandia canyons and Cañada del Buey.

We collected sediment samples from dry stream beds to a depth of 2 to 16 cm, depending on the thickness of the uppermost sediment layer. For flowing streams, samples were collected from near the edge of the main channel. Deposits of fine-grained sediment along the Rio Grande were sampled from the sides of shallow hand-dug holes to depths of up to 27 cm, after identifying the base of the 2009 sediment. Additional samples of fine-grained sediment were collected in Los Alamos and Pueblo canyons from hand-dug holes and stream banks to depths of up to 74 cm to evaluate PCB congeners.

2. On-Site and Perimeter Monitoring Locations

Regional base flow and sediment sampling stations for 2009 were located along a 19-km long stretch of the Rio Grande, extending from immediately upriver of Otowi Bridge and Los Alamos Canyon to near Frijoles Canyon, downriver of all canyons draining LANL. Samples from upriver stations reflect baseline concentrations and provide a basis for evaluating potential Laboratory impacts to the Rio Grande. In 2009, we collected sediment samples from four areas along the Rio Grande, one area upgradient from the Laboratory (above Otowi Bridge), and three areas downgradient (above Buckman, below the White Rock Overlook, and between Chaquehui and Frijoles Canyons; Figure 6-7). In addition, LANL collected paired surface water samples from the Rio Grande (above Otowi Bridge and above Buckman; Figure 6-5) in five sampling events.

3. Sampling Procedures

The procedures for sampling depend on the type of stream flow and location. Grab samples of base flow and snowmelt runoff are collected from free-flowing streams near the bank. The grab samples are either filtered or left unfiltered and preserved in the field. The gages, located mostly in canyon bottoms, are equipped with automated ISCO samplers that are activated at the start of significant storm water runoff events. Typically, the automated samplers collect water from the first 30 minutes of the runoff event to sample water near the leading edge of flood bores, also called the "first flush." This is the sixth year that the first flush of storm water has been sampled, and it is a significant change from previous years (2003 and earlier) when samples were collected over a two-hour period.

Higher concentrations occur in the first flush compared with the average concentration during a flow event because suspended sediment concentration is highest near the flood bore (Malmon et al. 2004, 2007). As a result, the post-2003 data are not directly comparable to data from previous years.

E. WATERSHED SAMPLING RESULTS BY CONSTITUENTS

The supplemental data tables on the included compact disc present all the 2009 watershed-related surface water and sediment analytical results. The tables present radiological results in sequence for each of these media and then present the results for major water quality analytes and inorganic and organic chemicals. Surface water and sediment samples are analyzed for gross alpha and gross beta radiation and selected radionuclides (americium-241, cesium-137, plutonium-238, plutonium-239/240, strontium-90, uranium-234, uranium-235, uranium-238,

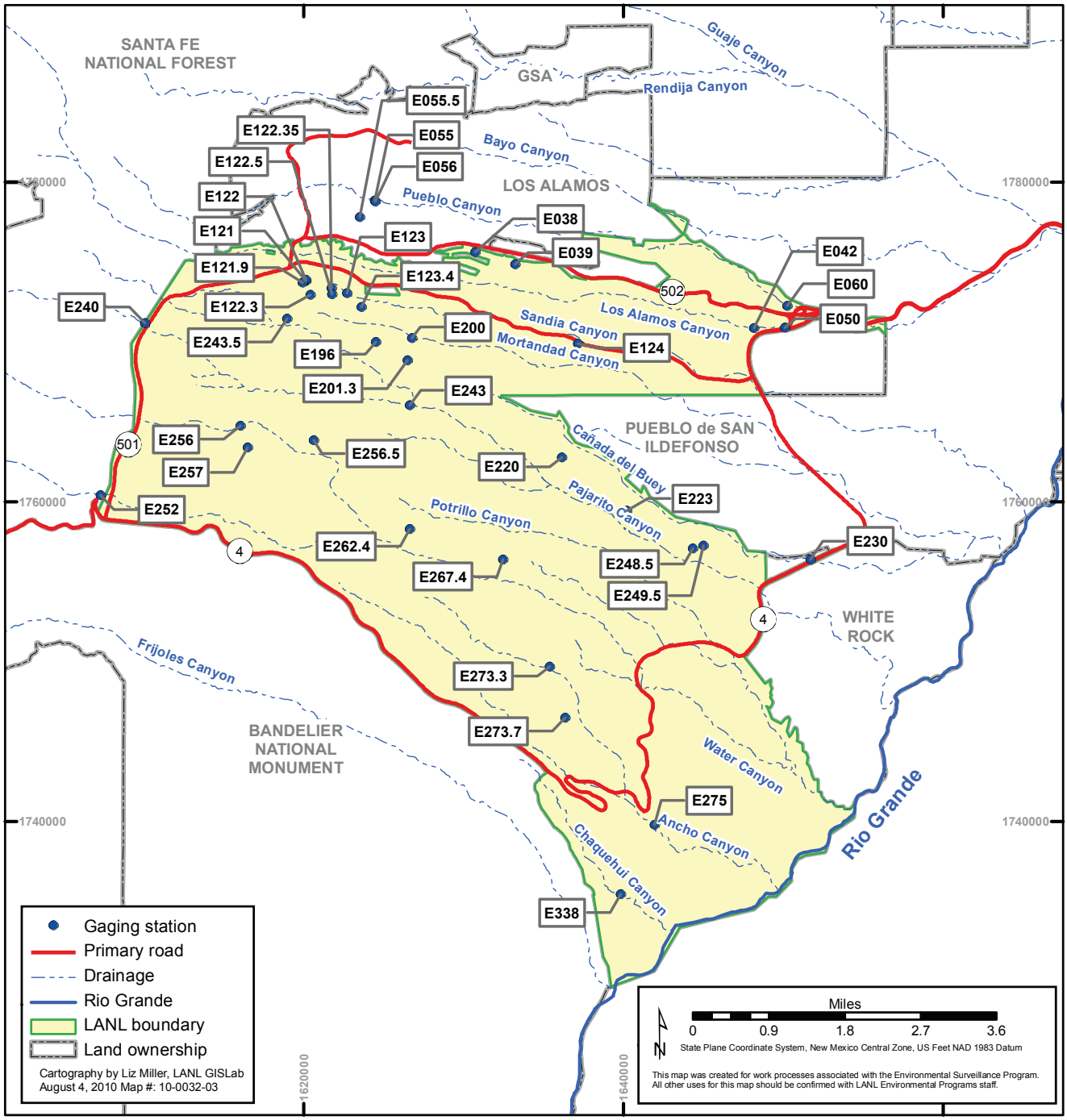


Figure 6-4. Gaging stations sampled in 2009 within and in the vicinity of Los Alamos National Laboratory.

tritium, cobalt-60, potassium-40, neptunium-237, radium-226, radium-228, and sodium-22). The tables also list the total propagated one-sigma analytical uncertainty and the analysis-specific minimum detectable activity, where available. For most radionuclide measurements, a detection is an analytical result that does not include an analytical laboratory (or in some cases, secondary validation) qualifier code of X or U (indicating not detected). The tables and their contents are as follows:

- Table S6-1 lists the results of radiochemical analyses of surface water for 2009.
- Table S6-2 presents the trace-level tritium results for surface water samples.
- Table S6-3 presents the results of radiochemical analyses of sediment.

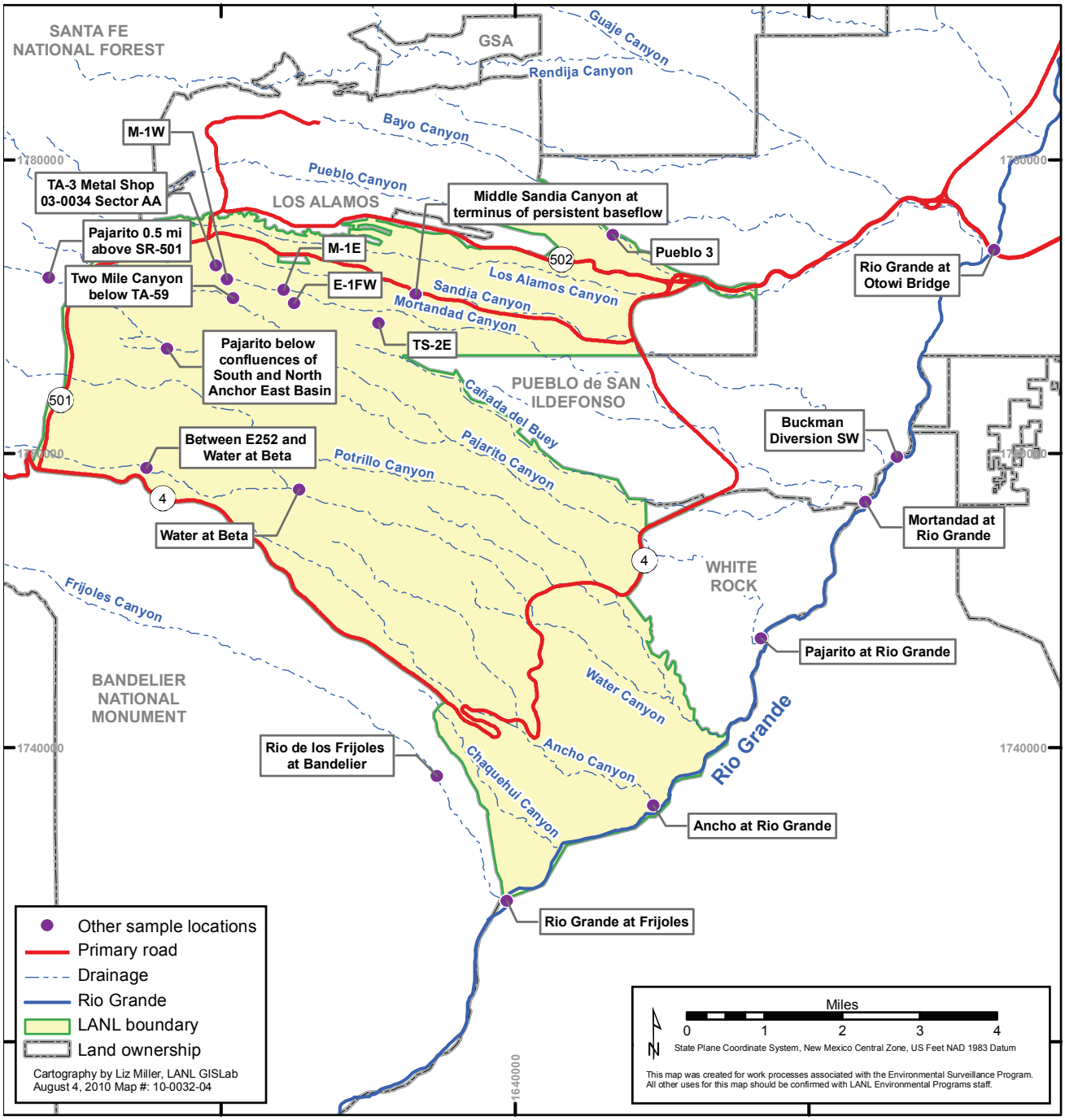


Figure 6-5. Other surface water locations sampled in 2009 within and in the vicinity of Los Alamos National Laboratory.

- Table S6-4 presents the concentrations of major chemical constituents in surface water.
- Tables S6-5 and S6-6 present results of inorganic chemical analyses for surface water and sediment, respectively.
- Table S6-7 presents the number and type of organic chemical analyses performed on surface water samples.
- Table S6-8 presents all detected organic chemical results in surface water.
- Tables S6-9 and S6-10 present summaries of organic chemical analyses of sediment samples.
- Table S6-11 presents results of particle size analyses of the sediment samples.

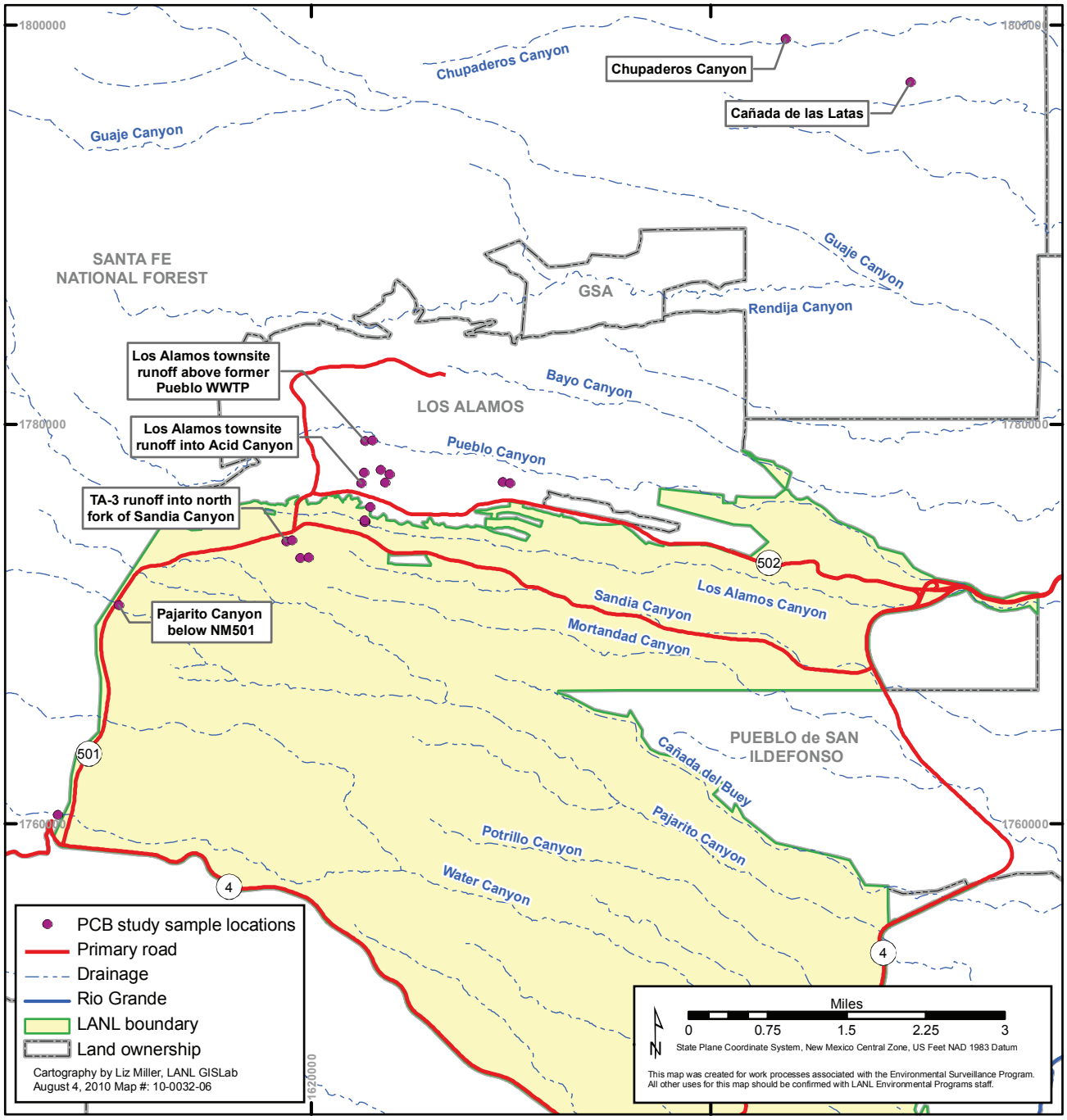


Figure 6-6. Surface water locations sampled in 2009 as part of a baseline PCB, metals, and gross alpha radiation study. Labeled locations are discussed in the text.

Qualifier codes are shown in some tables to provide additional information on analytical results that are not detections; in some cases, for example, the analyte was found in the laboratory blank, or there were other analytical issues. The tables show two categories of qualifier codes: those from the analytical laboratory and those from secondary validation (Tables S5-5, S5-6, and S5-7).

The overall quality of most surface water in the Los Alamos area is good, with low levels of dissolved solutes. Of the more than 100 analytes reported in sediment and surface water within the Laboratory, most are at concentrations far below screening levels. However, nearly every major watershed indicates some impact from

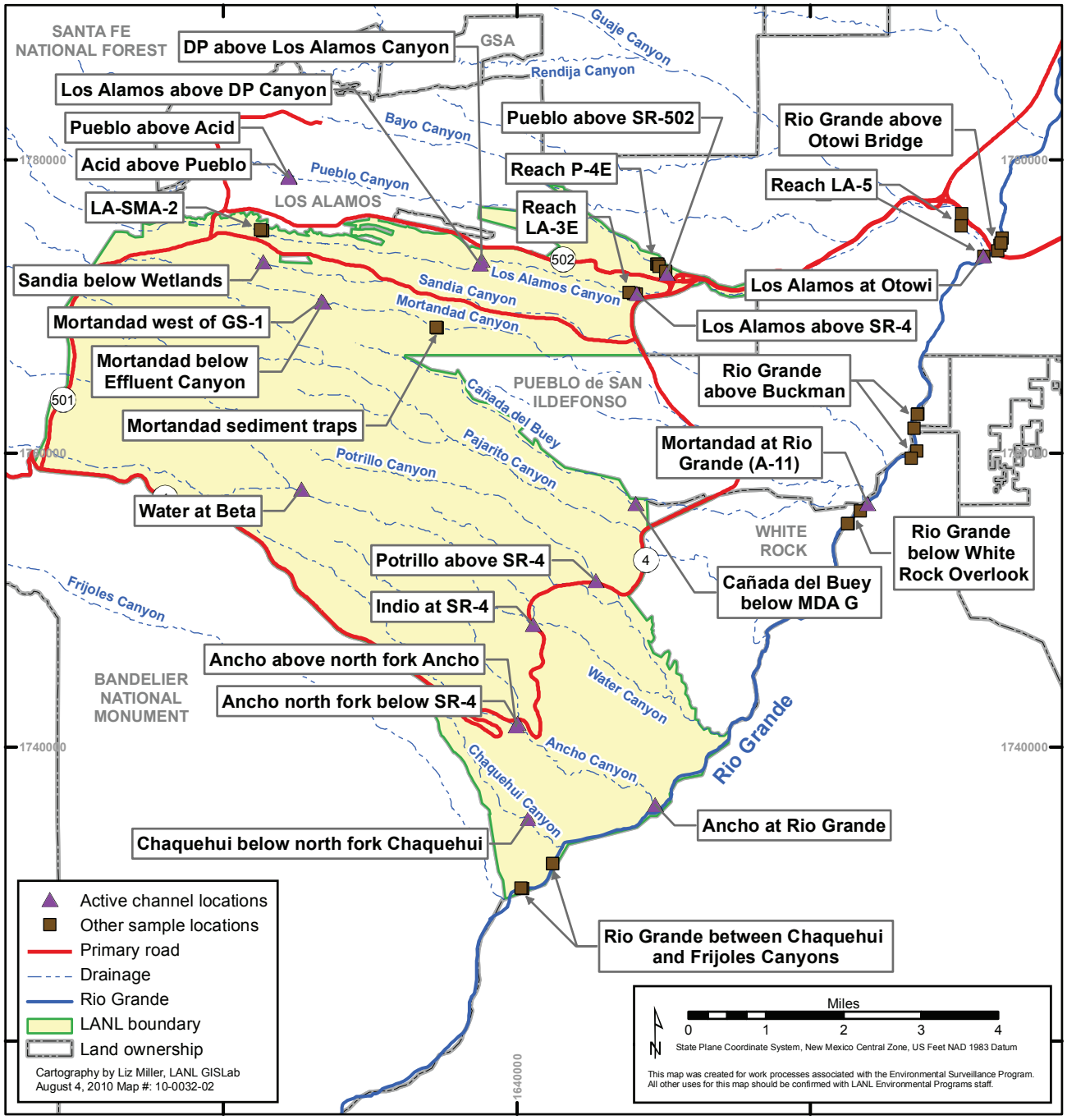


Figure 6-7. Sediment locations sampled in 2009 within and in the vicinity of Los Alamos National Laboratory. MDA G locations are shown in Figure 6-8.

Laboratory operations, often for just a few analytes. The following sections present a Laboratory-wide overview of surface water and sediment quality and then discuss the key findings in more detail on a watershed-by-watershed basis. It should be noted that analytical results that are above screening levels can be derived from a variety of sources including Laboratory releases, runoff from developed areas such as the Los Alamos townsite, naturally occurring radionuclides and chemicals, or "false positives" from analytical laboratories. (Section H of Chapter 5 discusses quality issues that have occurred at analytical laboratories in more detail.) It is not always possible to identify specific sources, and results above screening levels are considered to represent potential Laboratory impacts unless the evidence is compelling for non-LANL sources.

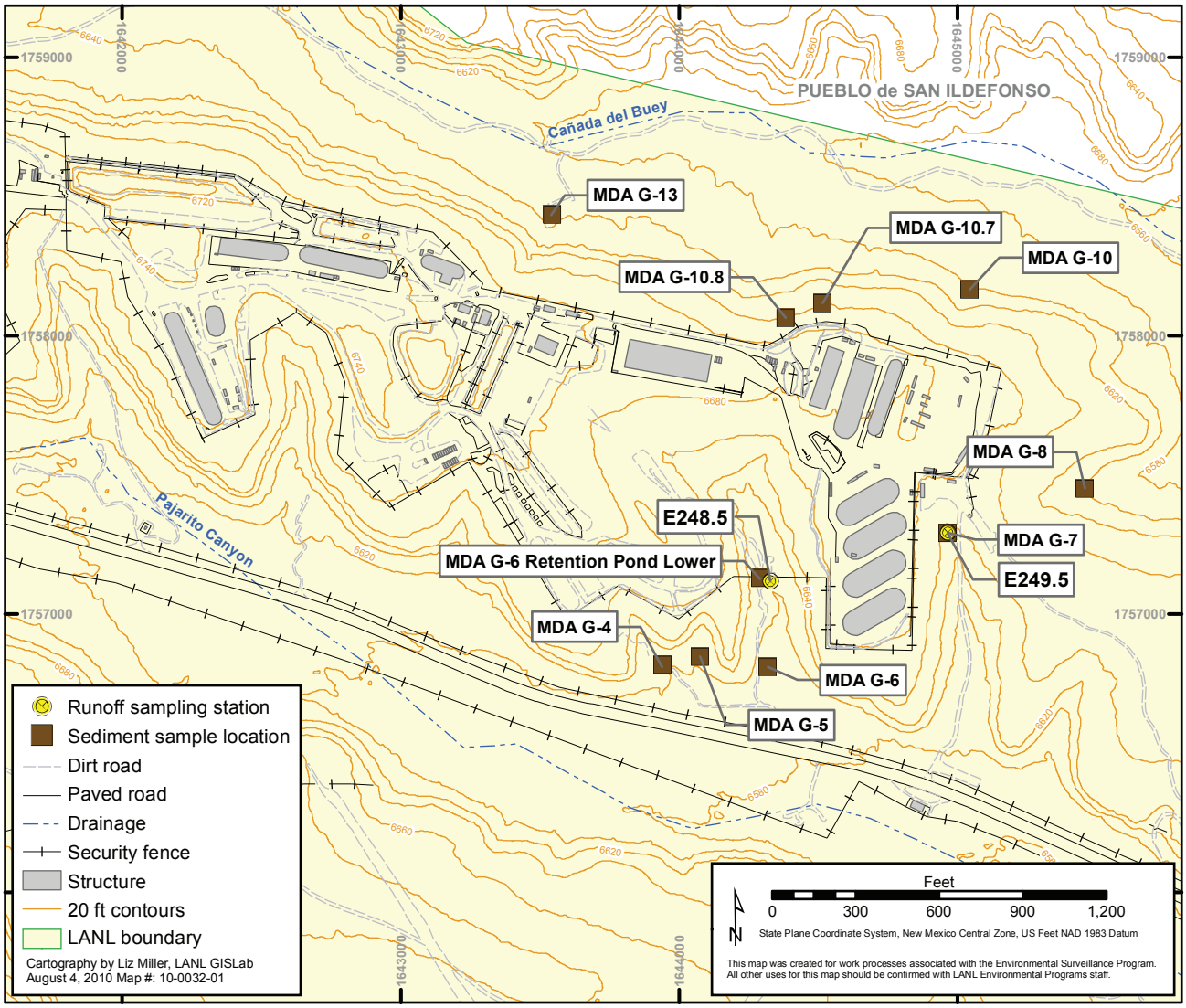


Figure 6-8. Sediment and storm water runoff sampling stations at TA-54 adjacent to MDA G.

1. Radionuclides and Radioactivity in Surface Water and Sediment

a. Surface Water

During 2009, the Laboratory obtained analytical data on radionuclides and/or radioactivity from 101 surface water sampling events at 67 locations on the Pajarito Plateau, each event consisting of the collection of one or more samples from a specific location. There were an additional 11 sampling events along the Rio Grande at three locations. The BCGs were exceeded for two radionuclides in storm water samples: radium-226 (BCG of 4.08 pCi/L) and radium-228 (3.39 pCi/L). Both of these radionuclides are naturally occurring, and have not been identified as having significant releases from the Laboratory. The highest concentrations of both radium isotopes occurred in two storm water samples from Ancho Canyon (gage E275, July 28 and July 30), indicating that they are collocated and supporting a natural origin. Radium-226 was detected at 9.20 and 9.88 pCi/g on July 28 and July 30, respectively, and radium-228 at 15.4 and 22.6 pCi/g. In addition, one of these, radium-228, exceeded the BCG in a sample collected from Pueblo Canyon above Acid Canyon, upstream of all Laboratory releases of radionuclides, at 4.58 pCi/g, also on July 30. These data are discussed in Chapter 3, Section C.2. No DCGs were exceeded in the surface water samples from 2009 based on the criteria of 100 mrem/yr, including sediment-laden storm water samples.

Consistent with previous years, many surface water samples in 2009 had gross alpha radiation levels above the NMWQCC surface water standard of 15 pCi/L for livestock watering. Of the 77 non-filtered storm water samples analyzed from the Pajarito Plateau, 38% exceeded 15 pCi/L, including sample sites with no upstream releases of radionuclides from Laboratory activities. For example, a storm water sample collected on August 8 from Chupaderos Canyon, north of Los Alamos on Santa Fe National Forest land, had 513 pCi/L gross alpha radiation. Similarly, a sample collected on July 30 from Cañada de Las Latas, also north of Los Alamos on National Forest land, had 139 pCi/L gross alpha radiation. The analytical results from 2009 support earlier conclusions that the majority of the alpha radiation in surface water on the plateau is due to the decay of naturally occurring isotopes in sediment and soil from uncontaminated areas carried in storm water runoff and that Laboratory impacts are relatively small (e.g., Gallaher 2007). Naturally occurring radionuclides that are alpha emitters include isotopes of radium, thorium, and uranium. As noted previously, livestock watering does not occur at the Laboratory except for some feral, trespassing cows near the Rio Grande.

Gross alpha radioactivity is a general screening measurement of limited value in assessing radiological hazards because specific alpha emitters in the water cannot be identified or quantified. Therefore, gross alpha radiation results are not discussed in detail in this report. Instead, this report focuses on specific individual radionuclides identified in LANL waste streams (Watkins and Del Signore 2005) or those known to be associated with the nuclear industry (Langmuir 1997).

The maximum concentrations of radionuclides associated with Laboratory operations in surface water samples in 2009 were measured in storm water during the summer monsoon season at different locations in Chaquehui, DP, Los Alamos, and Mortandad canyons. The highest concentrations of americium-241 and plutonium-239/240 were measured in a sample collected in Los Alamos Canyon above NM 4 (gage E042) on July 6, downstream from known releases of radioactive effluents from TA-01 and TA-21. The highest concentrations of cesium-137, plutonium-238, and tritium were measured in a sample collected in Mortandad Canyon below Effluent Canyon (gage E200) on August 18, downstream from the active TA-50 Radioactive Liquid Waste Treatment Facility (RLWTF) outfall. The highest concentration of strontium-90 was in a sample collected from DP Canyon below TA-21 (gage E039) on July 14, below a former outfall that also released treated radioactive effluent. The highest concentrations of uranium-234, uranium-235, and uranium-238 were measured in a sample collected in Chaquehui Canyon at TA-33 (gage 338) on July 30, a site with known releases of uranium. Comparison of the concentrations of the uranium isotopes and potassium-40 in the 2009 storm water samples also indicates that the Chaquehui Canyon sample is elevated in uranium relative to other locations, supporting a LANL contribution. With the exception of the uranium isotopes in Chaquehui Canyon, all the other measurements discussed above are consistent with recent years, although there have been no other storm water samples collected from Chaquehui Canyon since 2005 to use for comparison.

b. Sediment

Analytical data on radionuclides in sediment were obtained from 50 samples in 2009 as part of the annual surveillance program, including 30 samples from canyons draining the Pajarito Plateau and 20 samples from banks, bars, and slackwater areas along the Rio Grande. The Pajarito Plateau samples were mostly from active channel locations that are typically dominated by coarse-grained sediment and also included fine-grained sediment at several locations. The Rio Grande samples were all fine-grained sediment.

Six radionuclides were measured at concentrations greater than the LANL sediment background values in the 2009 environmental surveillance samples. Four of these (americium-241, cesium-137, plutonium-238, and plutonium-239/240) had maximum concentrations in a fine-grained sample collected from the Mortandad Canyon sediment traps, down canyon from the TA-50 RLWTF, and are consistent with results from previous years (e.g., LANL 2006a, Reneau and Koch 2008). One of these, tritium, had its maximum concentration in a sample collected along the Rio Grande above Otowi Bridge, above Los Alamos Canyon and other canyons draining LANL, and probably represents background variability. The sixth radionuclide, uranium-238, had its maximum concentration in a sediment sample collected along the Rio Grande below the White Rock Overlook.

This was the finest-grained sample collected along the river, with 44% clay and 54% silt, and the uranium probably represents background variability as well. The sample location is a scour hole near the river bank where silt and clay settled out during low water conditions (Figures 6-9 and 6-10). Several inorganic chemicals and PCBs were also relatively high in this sample, as discussed later in section G.2.



Figure 6-9. **Photograph of sample location along Rio Grande below the White Rock Overlook with the highest concentration of uranium-238 and other analytes (Location ID WR-609869); November 11, 2009.**



Figure 6-10. **Close-up of sampled layer at Location ID WR-609869, 0–8 cm deep, showing fine-grained sediment with mud cracks.**

2. Inorganic Chemicals in Surface Water and Sediment

a. Surface Water

During 2009, the Laboratory obtained analytical data on metals and other inorganic chemicals from 130 surface water sampling events at 67 locations on the Pajarito Plateau, each event consisting of the collection of one or more samples from a specific location. There were an additional 11 sampling events along the Rio Grande at three locations. These data were compared with various screening levels, as discussed in Section C.3. Some of these screening levels are for dissolved constituents, which are compared with filtered sample results, and some are for totals, which are compared with non-filtered sample results. A total of six inorganic chemicals had maximum concentrations above screening levels. Under the Clean Water Act §303(d) list, the NMWQCC listed parts of one or more canyons within or near LANL as impaired for nine metals: aluminum, arsenic, cadmium, copper, lead, mercury, selenium, vanadium, and zinc (NMWQCC 2006). These metals are discussed below, along with other inorganic chemicals that have results above screening levels. A summary of results and their significance for these inorganic chemicals is presented in Table 6-2.

The screening level for aluminum is based on aluminum dissolved in the water column, and 11% of filtered surface water samples collected on the Pajarito Plateau in 2009 contained aluminum concentrations above the acute aquatic life standard of 750 µg/L. In addition, 35% of the filtered base flow samples collected from within or adjacent to designated perennial stream segments had detected aluminum concentrations above the chronic aquatic life standard of 87 µg/L. However, most or all of this aluminum may be naturally occurring (e.g., Reneau and Kuyumjian 2009). For example, Water Canyon above NM 501, upstream from Laboratory operations and immediately upstream of a designated perennial segment, had 669 and 916 µg/L aluminum in two samples collected in 2009 (on March 25 and October 16). Similarly, a sample from the perennial stream in Frijoles Canyon in Bandelier National Monument had 114 µg/L aluminum in a sample collected October 21, 2009. Aluminum is a natural component of soil and is not known to be derived from Laboratory operations in any significant quantity. The NMED Surface Water Quality Bureau has also noted that "the large number of exceedances" for aluminum on the Pajarito Plateau "may reflect natural sources associated with the geology of the region" and that aluminum also exceeds 750 µg/L in other parts of the Jemez area (NMED 2009c).

The screening level for arsenic is based on arsenic dissolved in the water column, and only one filtered surface water sample collected on the Pajarito Plateau in 2009 had arsenic above the human health standard of 9 µg/L. This site was a "run-on" (water that runs onto a site from another source) sample collected in the Sandia Canyon watershed in TA-3 above contaminated sites, receiving storm water runoff from a developed area, and no stream channel samples were above the screening level. Although Water Canyon had previously been listed as impaired for arsenic by the NMWQCC, surface water data in recent years do not indicate any concerns with arsenic in this canyon.

The screening level for cadmium is based on cadmium dissolved in the water column, and no filtered surface water samples collected on the Pajarito Plateau in 2009 contained cadmium concentrations above the acute aquatic standard of 2.0 µg/L. In addition, there were no detected cadmium results from a designated perennial stream segment above the chronic aquatic standard of 0.28 µg/L. These results are consistent with results from 2007 and 2008. Although Water Canyon had previously been listed as impaired for cadmium by the NMWQCC, surface water data in recent years do not indicate any concerns with cadmium in this canyon or other canyons.

The screening level for copper is based on copper dissolved in the water column and 7% of the filtered surface water samples from the Pajarito Plateau in 2009 had copper results above the acute aquatic life standard of 14 µg/L, which is similar to the results from 2008 (8% of samples). These results are from the watersheds of DP and Sandia canyons from sites that receive runoff from developed areas, including the Los Alamos townsite. The highest value of 32.8 µg/L was obtained from the north fork of Sandia Canyon (gage E122), downstream from the main administrative area at TA-3. However, five other results from this stream segment had copper results below 13.4 µg/L and no downstream results exceeded the screening level. No results from a designated perennial

stream segment on the Pajarito Plateau in 2009 contained copper concentrations above the chronic aquatic life standard of 9.0 µg/L. The sources of copper in LANL watersheds have not been thoroughly evaluated, but its spatial distribution indicates copper is at least partly derived from runoff from developed areas.

Table 6-2
Summary of Results for Select Metals in Surface Water Samples from 2009

Metal	Sample Preparation	Screening Level (µg/L) *	Percentage of Samples with Detected Results Above Screening Level *	Master Watersheds with Detected Results Above Screening Levels	Significance
Aluminum	Filtered	750 (aa) 87 (ca)	10% (aa) 35% (ca)	Ancho, Los Alamos, Mortandad, Pajarito, Sandia, and Water canyons	NMWQCC impaired listing; above screening levels in non-LANL affected stream segments, indicating elevated local background
Arsenic	Filtered	9 (hh)	1% (hh)	Sandia Canyon	NMWQCC impaired listing; no results above human health screening levels along a stream channel, only in a single runoff sample from a developed area
Cadmium	Filtered	2.0 (aa) 0.25 (ca)	0%	None	NMWQCC impaired listing; no results above screening levels, consistent with 2007 and 2008
Copper	Filtered	13.4 (aa) 9.0 (ca)	7% (aa)	Los Alamos and Sandia canyons	NMWQCC impaired listing; results above screening level all receive runoff from developed areas and are mostly outside main stream channels
Cyanide, Total	Non-filtered	5.2 (wh)	1% (wh)	Pajarito Canyon	Only one result above wildlife habitat screening level
Lead	Filtered Non-filtered	64.6 (aa) 2.5 (ca) 15 (tw)	0% (aa) 0% (ca) 6% (tw)	Mortandad and Water canyons	NMWQCC impaired listing; no results above NMWQCC screening levels;
Manganese	Non-filtered	876 (tw)	2% (tw)	Los Alamos Canyon	Only one result above tap water screening level; naturally occurring manganese associated with reducing conditions in alluvium
Mercury	Non-filtered	0.77 (wh)	0%	None	NMWQCC impaired listing; no results above the screening level, consistent with 2008
Selenium	Non-filtered	5.0 (wh & ca)	0%	None	NMWQCC impaired listing; no results above screening level
Vanadium	Filtered	100 (lw)	0%	None	NMWQCC impaired listing; no results above screening level, consistent with 2007 and 2008
Zinc	Filtered	117 (aa) 118 (ca)	6% (aa)	Los Alamos, Mortandad, and Sandia canyons	NMWQCC impaired listing; results above screening level are only from locations with small drainage areas receiving runoff from paved roads and other developed areas

* aa = acute aquatic life standard; ca = chronic aquatic life standard; hh = human health standard; lw = livestock watering standard; tw = tap water screening level; wh = wildlife habitat standard.

The screening level for cyanide is based on total concentrations in non-filtered samples and one surface water sample in 2009 had a total cyanide result above the wildlife habitat standard of 5.2 µg/L. This result, 9.51 µg/L,

was from a storm water sample collected from the MDA G-7 drainage (gage E249.5) in the Pajarito Canyon watershed on August 30.

The screening level for lead is based on lead dissolved in the water column. No filtered surface water samples collected from a designated perennial stream segment on the Pajarito Plateau in 2009 contained lead concentrations above the chronic aquatic life standard of 2.5 µg/L. Similarly, no result was above the acute aquatic life standard of 64.6 µg/L. Although Cañon de Valle had previously been listed as impaired for lead by the NMWQCC, surface water data in recent years do not indicate any concerns with lead in this canyon or other canyons for aquatic life. However, three samples of snowmelt runoff or persistent surface water had concentrations of lead above the tap water screening level if 15 µg/L. The highest value of 40.1 µg/L was obtained from a small tributary drainage to Cañada del Buey (gage E220) on April 11.

The screening level for mercury is based on total mercury, and no non-filtered surface water samples collected from the Pajarito Plateau in 2009 contained detected mercury concentrations above the wildlife habitat standard of 0.77 µg/L. This is consistent with results from 2008. Although Los Alamos, Pueblo, and Sandia canyons had previously been listed as impaired for mercury by the NMWQCC, surface water data in recent years do not indicate any concerns with mercury in these canyons or other canyons.

The screening level for selenium is based on total recoverable selenium, and no non-filtered surface water samples collected from the Pajarito Plateau in 2009 contained detected selenium above the wildlife habitat standard and the chronic aquatic standard of 5.0 µg/L. Although Cañon de Valle and Guaje, Los Alamos, Pueblo, Mortandad, and Pajarito canyons had previously been listed as impaired for selenium by the NMWQCC, surface water data from 2009 does not indicate any concerns with selenium in these canyons or other canyons. The NMED Surface Water Quality Bureau has also noted that "Assessment of available data resulted in delisting all of the AUs [assessment units] previously listed for selenium, presumably because the previous listings were based on elevated concentrations of selenium following the 2000 Cerro Grande fire" (NMED 2009c).

The screening level for vanadium is based on vanadium dissolved in the water column, and no filtered surface water samples collected from the Pajarito Plateau in 2009 contained vanadium concentrations above the livestock watering standard of 100 µg/L. These results are consistent with results from 2007 and 2008. Although Water Canyon had previously been listed as impaired for vanadium by the NMWQCC, the 2009 surface water data did not indicate any concerns with vanadium in this canyon or other canyons.

The screening level for zinc is based on zinc dissolved in the water column, and 6% of the filtered surface water samples collected from the Pajarito Plateau in 2009 had detected results above the acute aquatic life standard of 117 µg/L. These were all from sites with small drainage areas that receive runoff from roads and other developed areas in the watersheds of Acid, Mortandad, and Sandia canyons. The highest zinc concentration (235 µg/L) was a "run-on" location in the Acid Canyon watershed receiving runoff from the Los Alamos town site. Although the main channel of Water Canyon had previously been listed as impaired for zinc by the NMWQCC, the 2009 surface water data did not indicate any concerns with zinc along the main stream in this canyon, which is consistent with the results from 2007 and 2008.

In addition to the metals discussed above, one other metal, manganese, exceeded a screening level in one sample. The manganese concentration was above the tap water screening level of 876 µg/L in a non-filtered base flow sample from Pueblo Canyon downstream from the Los Alamos County WWTP (Pueblo 3 station, 2,130 µg/L). Elevated manganese has been found in this area previously and represents naturally occurring manganese that is reduced in areas of persistent saturated conditions in the alluvium (LANL 2004a, pp. 7–37).

b. Sediment

For metals and other inorganic chemicals in sediment, analytical data were obtained from 51 samples in 2009 as part of the annual surveillance program, including 31 samples from canyons draining the Pajarito Plateau and 20 samples from banks, bars, and slackwater areas along the Rio Grande. The Pajarito Plateau samples were mostly from active channel locations that are typically dominated by coarse-grained sediment and also included fine-grained sediment at several locations. The Rio Grande samples were all fine-grained sediment.

In 2009, 19 metals and other inorganic chemicals were detected in sediment at concentrations above the LANL sediment background values, although all results are below recreational SSLs. Thirteen of the maximum results for these chemicals were obtained from off-site samples collected along the Rio Grande. Differing background conditions along the Rio than on the Pajarito Plateau contribute to these elevated values, as found in previous years (e.g., Reneau and Kuyumjian 2009). These data are discussed further in Section G.2.

In 2009, maximum concentrations for six metals (antimony, chromium, lead, mercury, silver, and zinc) were measured in sediment samples collected from the Pajarito Plateau at LANL. The maximum results for antimony, silver, and zinc came from samples collected in small drainages below MDA G at TA-54 within the Pajarito Canyon watershed, which is consistent with results from prior surveillance sediment samples (e.g., Reneau and Kuyumjian 2009). The maximum result for chromium was obtained from the main stream channel in Sandia Canyon, in an area with known chromium contamination (LANL 2009f). The maximum result for lead was obtained from a fine-grained sediment sample from the Mortandad Canyon sediment traps, consistent with prior results from this area (LANL 2006a). The maximum result for mercury was obtained from the main stream channel in Los Alamos Canyon above DP Canyon in an area where low levels of mercury contamination had been previously found (LANL 2004a).

3. Organic Chemicals in Surface Water and Sediment

a. Surface Water

During 2009, analytical data for organic chemicals were obtained from 55 surface water sampling events at 34 locations on the Pajarito Plateau, each event consisting of the collection of one or more samples from a specific location. Analytical data were also obtained from 11 sampling events at three locations along the Rio Grande. The analyses included the following suites: dioxins and furans, explosive compounds, pesticides, PCBs, semi-volatile organic compounds (SVOCs), and volatile organic compounds (VOCs). These data were compared with various screening levels, as discussed in Section C.3. Under the federal Clean Water Act §303(d) list, the NMWQCC has listed parts of three canyons within LANL as impaired for PCBs in the water column: Los Alamos, Pueblo, and Sandia canyons (NMWQCC 2006). These organic chemicals along with other organic chemicals that have results above screening levels are discussed below.

Analyses for dioxins and furans were obtained from 11 non-filtered surface water samples collected at nine locations on the Pajarito Plateau in 2009. One or more dioxin or furan congeners were detected in 10 of these samples from locations in Ancho, Chaquehui, Effluent, Mortandad, Pueblo, and Ten Site canyons. None of these results were above screening levels.

For explosive compounds, analyses were obtained from 18 non-filtered storm water samples collected at nine locations on the Pajarito Plateau in 2009. A total of seven different explosive compounds were detected at four locations in Cañon de Valle, Pajarito Canyon, and Water Canyon. The highest concentrations of each were measured in Cañon de Valle below MDA P, downstream from a high-explosive machining facility at TA-16. The two RDX results from this station, 15.3 and 15.6 µg/L on March 24 and October 15, respectively, were both above the tap water screening level of 6.11 µg/L.

For pesticides, analyses were obtained from 13 non-filtered surface water samples collected at three locations on the Pajarito Plateau and along the Rio Grande in 2009. Single pesticides were detected in three of these samples from two locations along the Rio Grande, both above and below canyons draining the Laboratory. One of the results, 0.00758 µg/L for DDE[4,4'-] at Buckman on May 14, was above the wildlife habitat standard of 0.001 µg/L.

For PCBs, analyses were obtained in 2009 using both the Aroclor method (EPA method 8082) and the congener method (EPA method 1668A). Aroclor analyses were obtained from 30 non-filtered surface water samples collected at 17 locations on the Pajarito Plateau, and four of these samples from four locations in Los Alamos and Sandia Canyons had detected Aroclors (Aroclor-1254 and Aroclor-1260). The highest concentrations of both were from the upper Sandia Canyon watershed (gage E122.3, 2.2 µg/L for Aroclor-1254 and 2.6 µg/L for Aroclor-1260). Aroclor analyses were also obtained from 10 samples at two locations along the Rio Grande, but no Aroclors were detected in these samples.

PCB congener analyses were obtained from 56 non-filtered surface water samples collected at 29 locations on the Pajarito Plateau, and all of these samples, including samples from background areas, had detected PCBs. PCB congener analyses were also obtained from 10 samples at two locations along the Rio Grande, and PCBs were detected in two of these samples, both upriver from canyons draining the Laboratory. Most of the Pajarito Plateau samples, 89%, had total detected PCB concentrations above the human health standard of 0.00064 µg/L, including background locations and "run-on" locations above LANL solid waste management units (SWMUs) that receive runoff from developed areas, including the Los Alamos townsite. Most of these samples, 55%, were also above the wildlife habitat standard of 0.014 µg/L. For example, a sample collected from Chupaderos Canyon in the Santa Fe National Forest north of Los Alamos had 0.024 µg/L PCBs. The source of these PCBs is atmospheric fallout, and the relatively high concentration is associated with high suspended sediment concentrations. Higher concentrations are associated with runoff from developed areas, including the Los Alamos townsite. Town-site runoff samples had up to 0.188 µg/L PCBs, with the maximum measured in the drainage above the former Pueblo WWTP. The highest concentrations of PCB congeners were measured in Los Alamos Canyon, and these results are discussed later in section F.1.

For SVOCs, analyses were obtained from 21 non-filtered surface water samples collected at 21 locations on the Pajarito Plateau in 2009. Ten samples were also collected from two locations along the Rio Grande. Thirteen SVOCs were detected in one or more samples from five locations, including three Pajarito Plateau locations in Mortandad, Pajarito, and Twomile canyons and the two Rio Grande locations. Two base flow samples had detected SVOCs above the human health standards. A sample collected from Mortandad Canyon near the Rio Grande on September 28, which consisted of treated sanitary wastewater from the White Rock WWTP, had benzo(a)pyrene above the screening level of 0.18 µg/L, at 0.237 µg/L. A sample collected from the Rio Grande at Buckman on September 22, upriver from Mortandad Canyon, had results for benzo(a)pyrene and dibenz(a,h)anthracene above screening levels.

For VOCs, analyses were obtained from 31 non-filtered surface water samples collected at 24 locations on the Pajarito Plateau in 2009 and from an additional 11 samples from three locations along the Rio Grande. Nine VOCs were detected in one or more samples from nine locations, including Cañon de Valle and Pajarito, Pueblo, Sandia, and Water Canyons and two Rio Grande locations. Two results for one VOC, bromodichloromethane, from the south fork of Sandia Canyon (gage E121), were above the tap water screening level of 1.17 µg/L, at 1.4 and 4.67 µg/L. Bromodichloromethane was also above the tap water screening level in upper Sandia Canyon in 2008.

b. Sediment

We obtained analytical data on explosive compounds in sediment from 26 samples in 2009 as part of the annual surveillance program, including six samples from canyons draining the Pajarito Plateau and 20 samples from banks, bars, and slackwater areas along the Rio Grande. The Pajarito Plateau samples were from coarse-grained sediment in active channels and the Rio Grande samples were from fine-grained sediment. There were no explosive compounds detected in these samples.

Analytical data on PCBs in sediment were obtained by the Aroclor method (EPA method 8082) from 19 samples in 2009 as part of the annual surveillance program. These samples were all collected from canyons draining the Pajarito Plateau and were mostly active channel locations that are typically dominated by coarse-grained sediment. Aroclor-1254 was detected in five samples and Aroclor-1260 was detected in seven samples. Maximum concentrations for both Aroclors were from the main stream channel in Sandia Canyon, in an area with known PCB contamination (LANL 2009f). None of the Aroclor results was above recreational SSLs.

We obtained analytical data for PCB congeners in sediment using EPA method 1668A on 38 fine-grained samples in 2009 as part of the annual surveillance program, including 18 samples from Los Alamos and Pueblo Canyons and 20 samples from along the Rio Grande. We obtained these data to evaluate congener "fingerprints" and PCB sources, and they are discussed further in Sections F.1 and G.3.

F. CANYON-SPECIFIC RESULTS

1. Los Alamos Canyon (includes Acid, Barrancas, Bayo, DP, Guaje, Pueblo, and Rendija Canyons)

Los Alamos Canyon has a large drainage area that heads in the Sierra de los Valles, with a stream channel length of about 17 mi (27 km). The total drainage area is about 61 mi^2 (157 km^2), of which 54% is located within Guaje Canyon and its tributaries (including Barrancas and Rendija Canyons). The Laboratory has used land in the Los Alamos Canyon watershed continuously since the early 1940s, with operations conducted in the watersheds of several tributary canyons (Acid, Bayo, DP, and Pueblo canyons). Several of the canyons within the watershed also receive urban runoff from the Los Alamos townsite, and lower Pueblo Canyon receives treated sanitary municipal wastewater from the Los Alamos County WWTP.

Historical releases of radioactive liquid effluents into Acid, DP, and Los Alamos Canyons have introduced americium-241, cesium-137, plutonium-238, plutonium-239/240, strontium-90, and tritium, among other radionuclides, into the canyon bottoms. Most of these radionuclides bind to stream sediment and persist at concentrations well above atmospheric fallout levels. Cesium-137 and plutonium-239/240 are the most important radionuclides in the Los Alamos Canyon watershed from the perspective of potential human health risk, although concentrations are low enough that they do not pose an unacceptable risk to recreational users of the canyons (LANL 2004a; LANL 2005b). The main source for cesium-137 was discharges into DP Canyon from a treatment facility at TA-21 between 1952 and 1986. The main source for plutonium-239/240 was discharges into Acid Canyon from former TA-1 and former TA-45, located within the current Los Alamos townsite, between 1945 and 1964. These radionuclides and other contaminants have been transported by floods down these canyons, off-site across Pueblo de San Ildefonso land, and to the Rio Grande near Otowi Bridge (Graf 1994, 1996; Reneau et al. 1998; LANL 2004a). Plutonium-239/240 from historic Acid Canyon discharges has been traced in sediment more than 55 km to lower Cochiti Reservoir (Gallaher and Efurd 2002). PCBs have also been released into the Los Alamos Canyon watershed from multiple sources, with their spatial distribution indicating both Laboratory and Los Alamos town site sources. The transport of PCBs in storm water is of particular concern in this watershed because the screening level for PCBs in water is very low (0.00064 µg/L, based on the NMED human health standard), and most samples are higher than the screening level. In the last 10 years, the Laboratory has taken a series of measures to reduce potential human health and ecological risk and storm water transport of contaminants in the Los Alamos Canyon watershed. In the last year, this work has included construction of grade-control structures along the main stream channels in lower Pueblo Canyon and in DP Canyon (LANL 2010a; LANL 2010b) and excavation of PCB-contaminated sediment and soils in upper Los Alamos Canyon below SWMU 01-001(f) (also referred to as Hillside 140 or LA-SMA-2) (LANL 2010c).

PCBs were analyzed in surface water samples in the Los Alamos Canyon watershed in 2009 using both the Aroclor method (seven samples) and the congener method (36 samples). The Aroclor analyses included six base flow samples, with no detected PCBs, and one storm water sample, with detected PCBs above the screening level (from Los Alamos Canyon above the weir, gage E042). The absence of detected Aroclors in the base flow samples is due to the association of PCBs with sediment particles. The congener analyses included 32 storm water samples and four base flow samples, and all had detected PCBs, including 16 "run-on" samples from the Los Alamos town site, above Laboratory SWMUs. Run-on samples had up to 0.188 µg/L of total detected PCB congeners, above the former Pueblo WTTP. The highest concentrations in the watershed, up to 1.85 µg/L, were measured in Los Alamos Canyon above the weir (gage E042) on October 13. On July 6, storm water samples were collected both above and below the weir, and the total detected PCB concentration below the weir (gage E050) was only 25% of the concentration above the weir (0.466 µg/L vs. 1.84 µg/L). This reduction is consistent with the deposition of suspended sediment in the retention basin above the weir.

Using the Aroclor method, PCBs were also detected in sediment at four active channel locations in the Los Alamos Canyon watershed in 2009. The highest detected result for Aroclor-1254 (0.0073 mg/kg) and the

highest sum of detected Aroclors (0.0118 mg/kg) was from Los Alamos Canyon above the weir. The only other detect for Aroclor-1254 (0.0049 mg/kg) and the second highest sum of detected Aroclors (0.0105 mg/kg) was upstream in Los Alamos Canyon above DP Canyon. In contrast, only Aroclor-1260 was detected in lower DP Canyon, at a lower concentration (0.0015 mg/kg). There was only one detected result in the Pueblo Canyon watershed, 0.0068 mg/kg for Aroclor-1260 from the Pueblo Canyon channel above Acid Canyon, which indicates a non-LANL source for at least some of the PCBs in this watershed. These results are consistent with earlier data which indicated that Los Alamos Canyon above DP Canyon was the most important source area for PCBs in this watershed, and that non-LANL sources were also important (e.g., LANL 2008a; Reneau and Kuyumjian 2009).

Additional data on PCBs in sediment were obtained from the Los Alamos Canyon watershed in 2009 using the congener method to identify congener "fingerprints" and compare these with PCB congener data obtained along the Rio Grande. Five samples each were collected from fine-grained sediment in Los Alamos Canyon above the weir (reach LA-3E), lower Pueblo Canyon (reach P-4E), and lower Los Alamos Canyon (LA-5). The samples in each area included three samples of older floodplain sediment where the highest concentrations of LANL-derived radionuclides had been previously measured (LANL 2004a) and two samples of relatively young sediment near the active channels. Three samples were also collected from below SWMU 01-001(f) (LA-SMA-2), where the highest PCB concentrations in the watershed have been measured. Consistent with the Aroclor data, higher concentrations of PCBs were measured in Los Alamos Canyon above the weir than in lower Pueblo Canyon (average of 0.081 mg/kg vs. 0.035 mg/kg). In both areas, the highest concentrations were also measured in relatively old, subsurface samples where radionuclide concentrations were relatively high. Much lower concentrations were measured in lower Los Alamos Canyon (average of 0.0026 mg/kg), and much higher concentrations were measured below SWMU 01-001(f) (average of 11.7 mg/kg). These data are discussed further at the end of this section in the context of congener fingerprints.

Plutonium-239/240 is the most important radionuclide in the Pueblo Canyon watershed from the perspective of potential human health risk (LANL 2004a) and plutonium-239/240 concentrations in sediment transported by floods today are much less than concentrations during the period of active releases of radioactive effluent into Acid Canyon from 1945 to 1964. Figure 6-11 shows variations in plutonium-239/240 concentration in active channel sediment in lower Pueblo Canyon between ca. 1950 and 2009, extending the record presented previously (LANL 2004a; Reneau et al. 2004; Reneau and Koch 2008) with data from more recent surveillance sediment samples. As shown in the previous studies, plutonium-239/240 concentrations were much higher prior to 1965, and since that time have shown no distinct trends. The year-to-year variations seen in these samples may be due at least in part to variability in silt and clay percentages, as there are strong relations between sediment particle size and contaminant concentration (LANL 2004a; Reneau et al. 2004).

In lower Acid Canyon, analyses of active channel sediment samples show an overall decrease in plutonium-239/240 concentrations between 1970 and 2009 (Figure 6-12, modified from Reneau and Kuyumjian 2009), with inter-year and intra-year variability also seen. The plutonium-239/240 concentration measured here in 2009, 2.67 pCi/g, is similar to that measured in previous years. Downstream in lower Los Alamos Canyon near the Rio Grande, plutonium-239/240 was below the LANL sediment background value of 0.068 pCi/g in the 2009 sample, similar to that seen in 2008.

Cesium-137 is the most important radionuclide in Los Alamos Canyon from the perspective of potential human health risk (LANL 2004a). Cesium-137 concentrations in sediment transported by recent floods are much less than concentrations during the period of active releases of radioactive effluent into DP Canyon from 1952 to 1986. Figure 6-13 plots cesium-137 concentrations in samples from the active channel of lower DP Canyon since 1971 and shows that concentrations have been relatively low and constant since about 1989. Downstream, samples from the active stream channel in Los Alamos Canyon above NM 4 and near the Rio Grande in 2009 had cesium-137 concentrations below the background value of 0.9 pCi/g, similar to that seen in 2008.

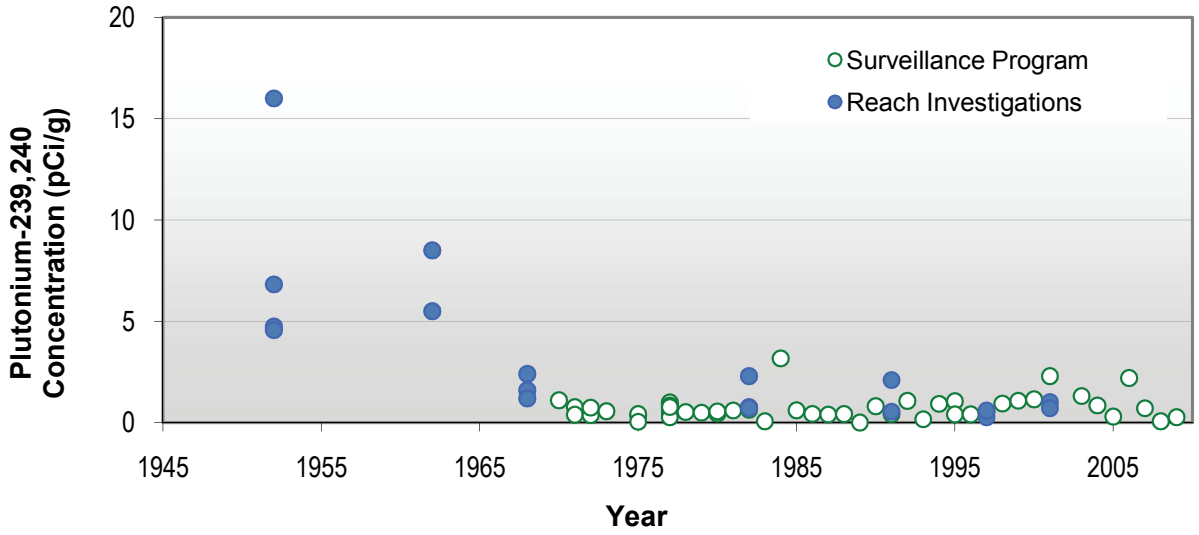


Figure 6-11. **Variations in plutonium-239/240 concentration over time in active channel sediment in lower Pueblo Canyon; all results are detects, and most are above the background value of 0.068 pCi/g**

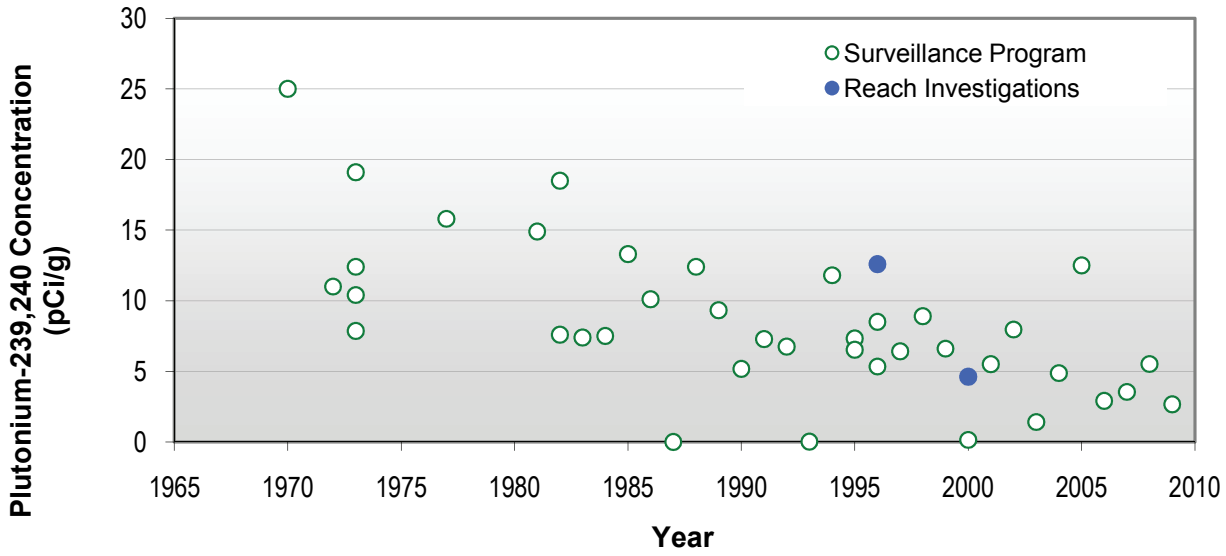


Figure 6-12. **Variations in plutonium-239/240 concentration over time in active channel sediment in lower Acid Canyon; most values are detects and are above the background value of 0.068 pCi/g.**

No radionuclides in surface water samples in 2009 in the Los Alamos Canyon watershed were measured above BCGs or DCGs, although three radionuclides had their highest results in 2009 in this watershed. Americium-241 and plutonium-239/240 had maximum results in a storm water sample collected in Los Alamos Canyon above the weir (gage E042) on July 6. Both of these radionuclides had their highest measured results at this station in 2008 following a potable water line break at TA-21. The potable water line break eroded contaminated soils on the canyon wall, depositing them in the canyon bottom where they could be remobilized in subsequent runoff events (Reneau and Kuyumjian 2009). Time series plots for americium-241 and plutonium-239/240 at E042 from 1997 to 2009 are shown in Figures 6-14 and 6-15, indicating that results from 2009 are less than in 2008, and that results from 2009 are generally within the ranges measured in recent years. On July 6, 2009, samples were collected from both above and below the weir (gages E042 and E050), and results for americium-241 and plutonium-239/240 below the weir were 24% and 39%, respectively,

of the concentrations measured above the weir. This reduction in radionuclide concentration below the weir is consistent with the deposition of most of the suspended sediment upstream and an association of most radionuclides with sediment. The higher concentration of these radionuclides in turbid storm water compared with radionuclides in relatively clear snowmelt runoff also is shown in Figures 6-14 and 6-15.

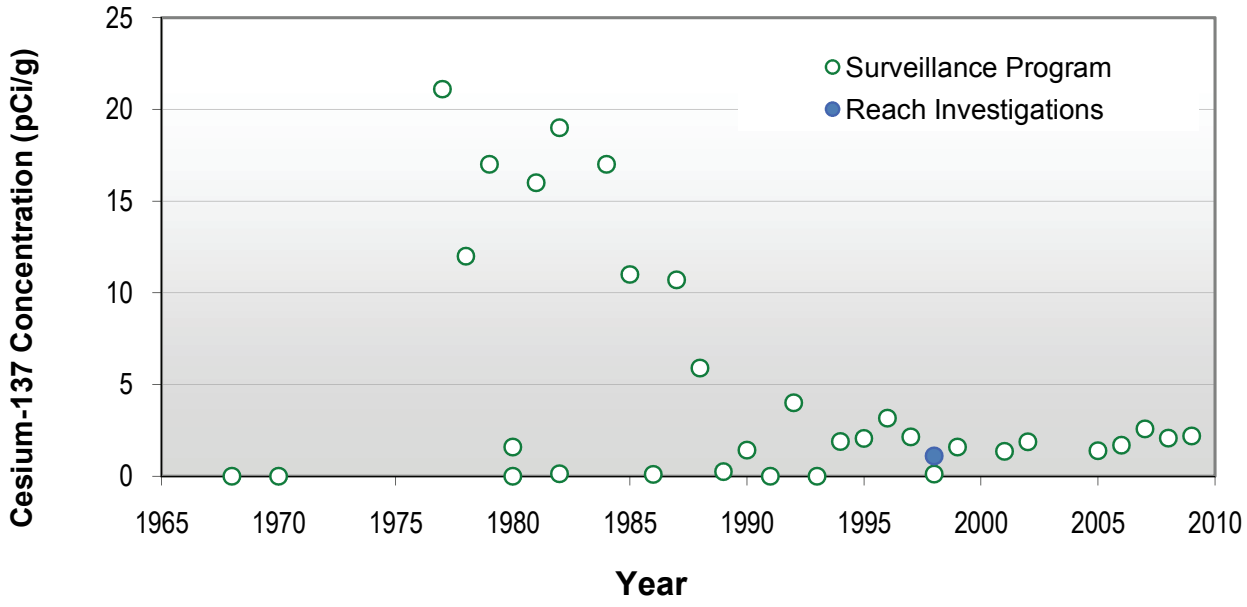


Figure 6-13. **Variations in cesium-137 concentration over time in active channel sediment in lower DP Canyon; most values are detects and are above the background value of 0.9 pCi/g.**

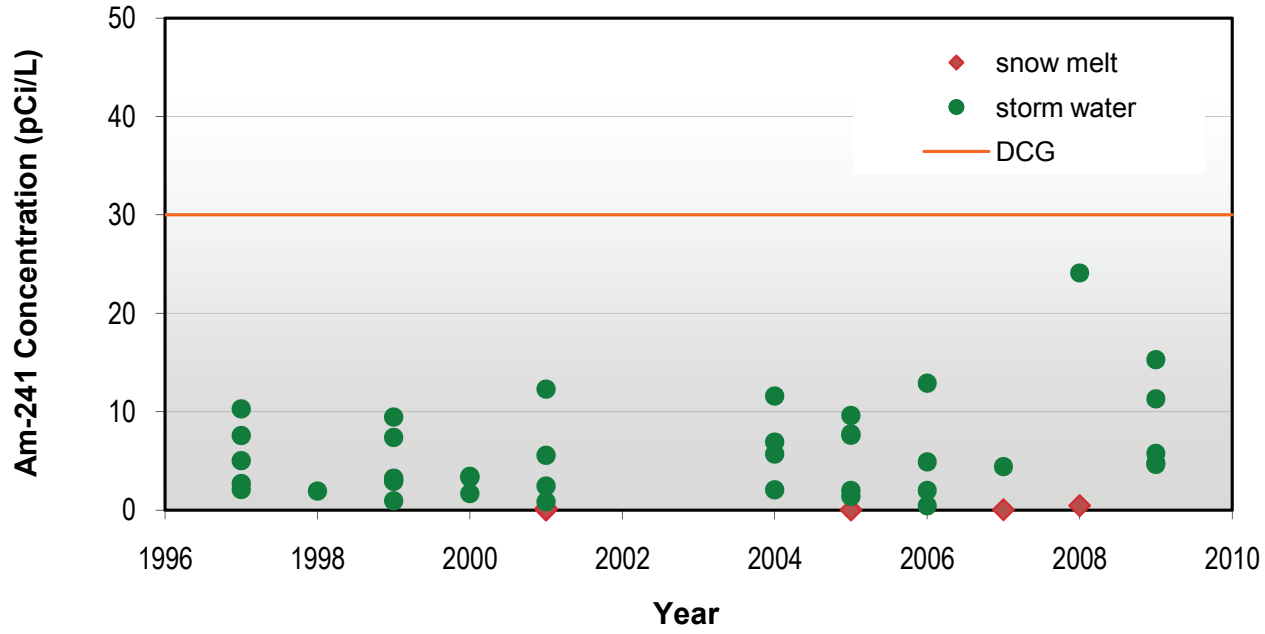


Figure 6-14. **Variations in americium-241 concentration over time in non-filtered surface water samples above Los Alamos Canyon weir (gage E042); all values above 0.05 pCi/L are detects.**

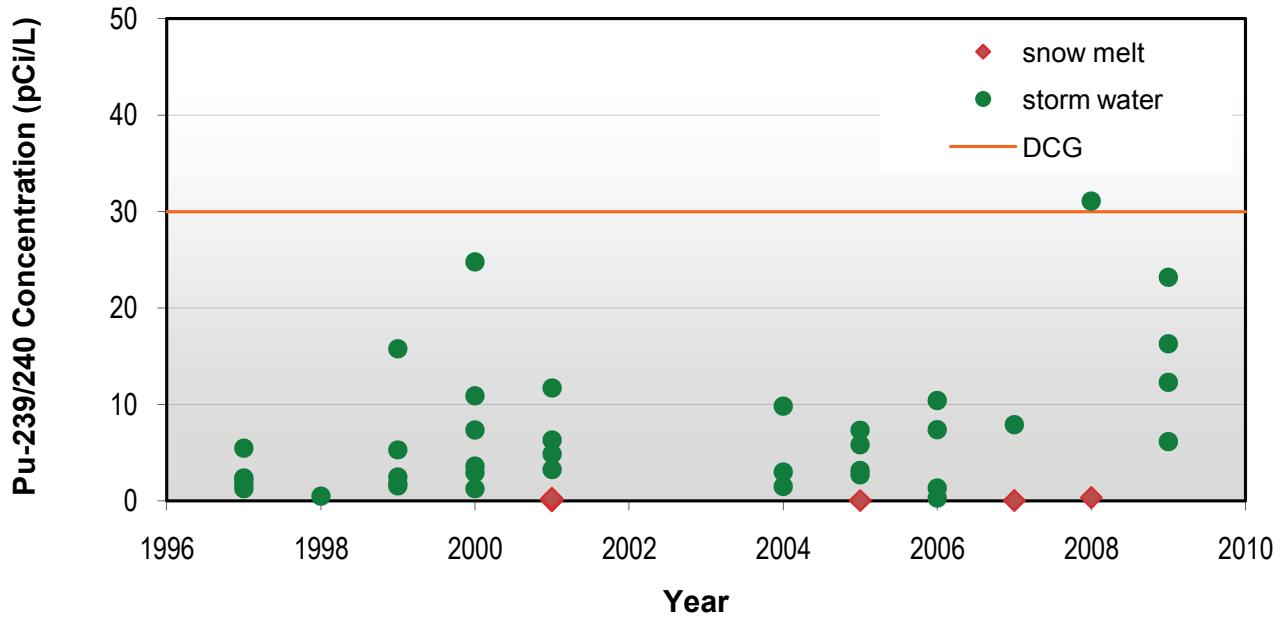


Figure 6-15. Variations in plutonium-239/240 concentration over time in non-filtered surface water samples above Los Alamos Canyon weir (gage E042); all values above 0.04 pCi/L are detects.

Strontium-90 had its maximum measured concentration in surface water, 111 pCi/L, at the Laboratory in 2009 in DP Canyon below TA-21 (gage E039) in a base flow sample collected on July 14. Base flow at this location is derived from discharges of shallow alluvial groundwater where the alluvium pinches out on bedrock. The result from 2009 is within the range measured in recent years (Figure 6-16). It is also within the range measured since 1995 in shallow alluvial groundwater a short distance upstream (LANL 2004a). Strontium-90 is more soluble than most other radionuclides, and results in filtered and non-filtered water from this location are very similar. Unlike americium-241, plutonium-239/240, and other radionuclides, concentrations in storm water are much lower than in base flow because of this contrasting geochemical behavior and the different sources for water (Figure 6-16).

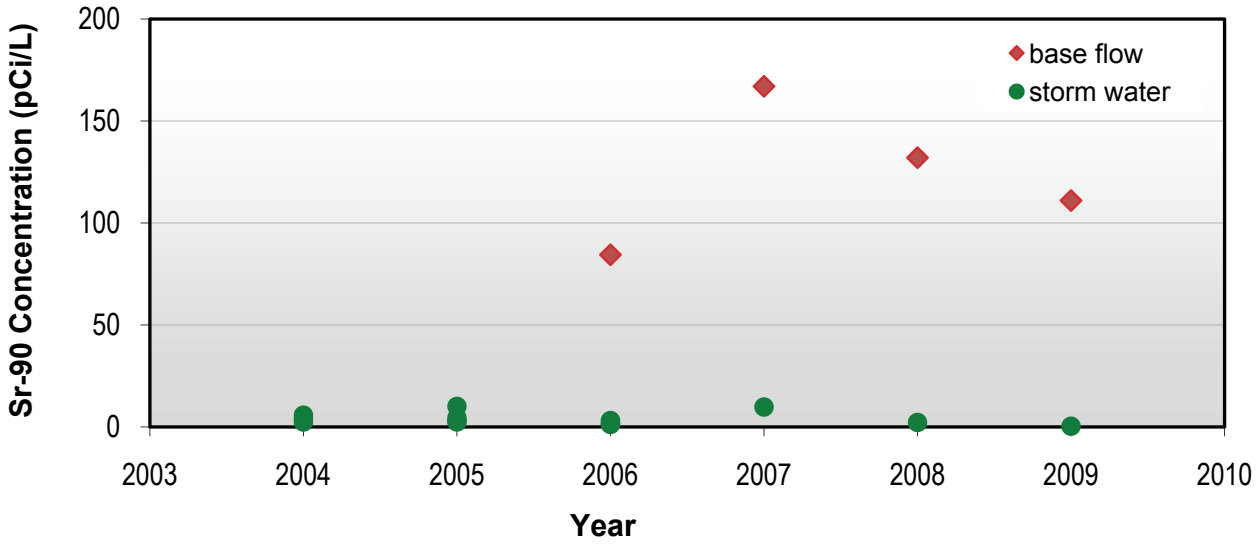


Figure 6-16. Variations in strontium-90 concentration over time in non-filtered surface water samples in DP Canyon below TA-21 (gage E039); all values above 0.4 pCi/L are detects.

In sediment, there was one elevated result for a metal in the Los Alamos Canyon watershed in 2009. Mercury was measured at 0.176 mg/kg in an active channel sample from Los Alamos Canyon above DP Canyon, which is above the sediment background value of 0.1 mg/kg. This is the first time mercury has been measured above the background value at this location, although it has been measured at higher concentrations in fine-grained sediment collected in this area (reach LA-2W, LANL 2004a). In 2008, mercury was elevated downstream at the Los Alamos Canyon weir, and the inferred source was erosion at SWMU 21-027(a) associated with a potable water line break on July 4–5, 2008 (Reneau and Kuyumjian 2009). SWMU 21-027(a) is a possible source for the mercury measured in 2009 as well.

PCB congeners from sediment or water samples can be grouped together into 10 homologs, based on the number of chlorine atoms on the biphenyl rings, which allows visual comparison of similarities or differences between samples or groups of samples. The designations for the 10 homologs range from monochlorobiphenyl (or monoCB, with a single chlorine atom) to decachlorobiphenyl (or decaCB, with 10 chlorine atoms). Figure 6-17 shows average homolog percentages in each of the four areas in Los Alamos and Pueblo Canyons that were sampled in 2009. Figure 6-17 also shows the average from Sandia Canyon (reach S-2) for comparison (the latter from LANL 2009f, also presented in Reneau and Kuyumjian 2009).

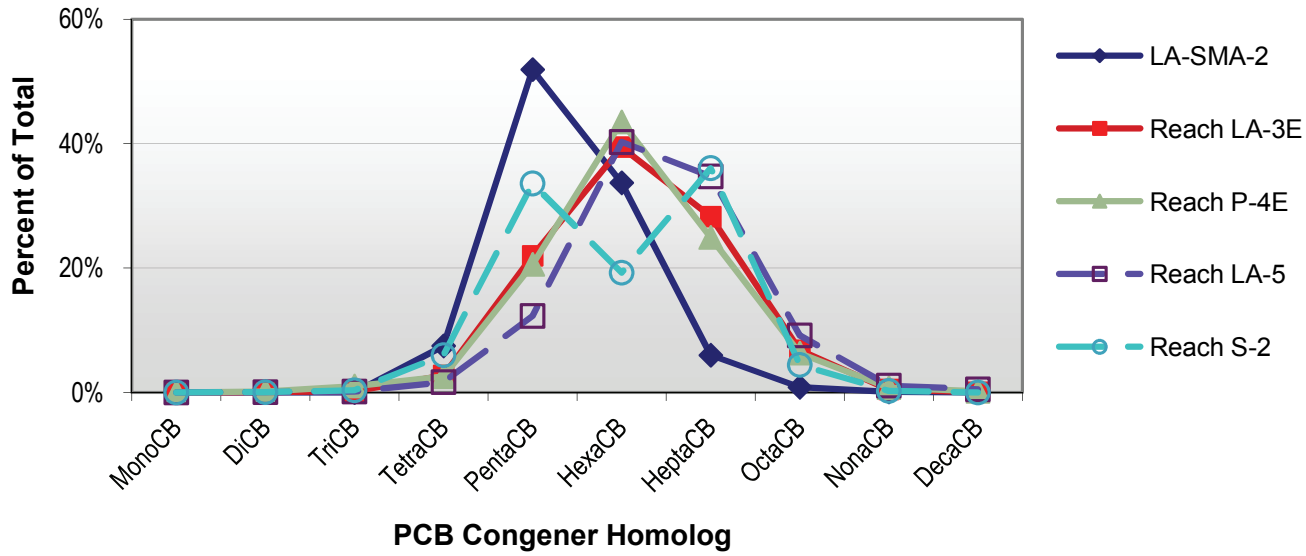


Figure 6-17. Average values for PCB congener homolog data from sediment samples collected in Los Alamos, Pueblo, and Sandia canyons.

Several relations are notable in Figure 6-17. First, the homolog signatures are remarkably similar between reaches LA-3E and P-4E, indicating that, for samples collected farther downstream, we cannot use these data to differentiate upper Los Alamos Canyon vs. Pueblo Canyon sources for PCBs in sediment. Second, samples from reach LA-5 have a somewhat different signature, with lower pentaCB and higher heptaCB than seen in the upstream sample areas. This difference suggests one or more additional sources of PCBs for lower Los Alamos Canyon downstream of the Los Alamos-Pueblo confluence, although such sources have not been identified. Third, although LA-SMA-2 has been the main site of concern for PCBs in the Los Alamos Canyon watershed, its homolog signature is much different than found downstream in reach LA-3E, and the homolog data indicate that less than half of the PCBs in LA-3E are derived from LA-SMA-2. Using Aroclor data, we had also previously concluded that PCBs at LA-SMA-2 (dominated by Aroclor-1254) were not the main source for PCBs found farther down canyon (dominated by Aroclor-1260; LANL 2008a). Instead, the LA-SMA-2 PCBs and associated sediment have been largely restricted to the canyon bottom near the source, where over 1 m of sediment has been deposited since Laboratory operations began in 1943. Fourth, the Sandia Canyon homolog pattern is much different from the other areas, supporting the existence of unique signatures in many areas that can help differentiate sources.

2. Sandia Canyon

Sandia Canyon heads on the Pajarito Plateau within TA-3 and has a total drainage area of about 5.5 mi^2 (14 km^2) and a channel length of about 11 mi (18 km). This relatively small watershed extends eastward across the central part of the Laboratory and crosses Bandelier National Monument and Pueblo de San Ildefonso land before ending at the Rio Grande. Effluent discharges from a sanitary WWTP, supplemented by releases from a steam plant, create perennial flow conditions along a 2-mile reach below TA-3. Surface flow rarely extends past the Laboratory boundary, and no runoff event was recorded at the E125 gage above NM 4 in 2009. Two contaminants that have been of concern in Sandia Canyon are chromium and PCBs. Chromium, discharged in water from the TA-3 power plant from 1956 to 1972, has been the focus of extensive ongoing investigations related to groundwater contamination (LANL 2009f). PCBs were released from a former transformer storage area at TA-3 and were the target of remediation activities involving excavation of soil near the source (LANL 2001). Contaminant concentrations in sediment deposits decrease downstream from TA-3, and relatively low levels of contaminants are present above NM 4, adjacent to the eastern Laboratory boundary (LANL 2009f).

Four metals in surface water samples from the Sandia Canyon watershed had results above screening levels in 2009: aluminum, arsenic, copper, and zinc. These included the highest results for arsenic and copper, both in samples collected from the north fork of Sandia Canyon, which receives runoff from large developed areas in the Laboratory's main administrative area at TA-3. The maximum arsenic result, 10.4 µg/L, the only result in 2009 above the human health standard of 9 µg/L, was obtained from a storm water sample collected on October 1 at a run-on location above SWMUs. The maximum copper result, 32.8 µg/L, above the acute aquatic life standard of 13.4 µg/L, was from a base flow sample collected at gage E122 on November 2. However, five other results from this stream segment had copper results below 13.4 µg/L. Aluminum and zinc both had higher results in background areas and/or runoff samples from developed areas in other watersheds.

PCBs were detected in three out of 21 surface water samples analyzed from the Sandia Canyon watershed in 2009 by the Aroclor method; all detected concentrations were above the screening level of 0.00064 µg/L. The concentrations of detected Aroclors in storm water at the Laboratory in 2009 were highest in a sample collected July 5 at gage E122.3, in a small tributary drainage below the Sigma Building at TA-3. Total detected PCBs in this sample were 4.8 µg/L, a combination of Aroclor-1254 and Aroclor-1260. Using the congener method, PCBs were also analyzed in nine storm water samples collected above and below two SWMUs in the Sandia Canyon watershed. PCBs were detected in all nine samples, at concentrations of 0.00537 to 0.0565 µg/L. Similar concentrations were measured above and below each SWMU, indicating that the SWMUs did not contribute significantly to the PCBs in storm water here.

Active channel sediment collected from Sandia Canyon below the wetland in 2009 had two metals detected above sediment background values: chromium and silver. Both of these metals have been previously identified as contaminants in this part of Sandia Canyon (e.g., LANL 2009f), although the measured concentrations at this location have varied widely. Figure 6-18 shows variations in the concentrations of chromium in active channel samples at and near this location since 1998. The variations may, in part, reflect variations in particle size between samples (e.g., the anomalously high concentration measured in 2003), but also, in part, different source areas. For example, a short distance up canyon from the sample site is a side drainage from the Los Alamos County landfill that has an active alluvial fan, and years with relatively low chromium and silver concentration may include a larger percentage of sediment from this source. Low concentrations of PCBs were also detected in the active channel below the wetland in 2009, at similar concentrations to recent years (0.0411 mg/kg Aroclor-1254 and 0.0443 Aroclor-1260). Figure 6-19 shows variations in the concentrations of detected PCBs in active channel samples at and near this location since 1998, indicating generally higher values from 1998 to 2005 than from the last four years (2006 to 2009). No radionuclides were detected above background values at this location in 2009.

3. Mortandad Canyon (includes Cañada del Buey and Effluent, Pratt, and Ten Site Canyons)

Mortandad Canyon heads on the Pajarito Plateau in the main Laboratory complex at TA-3 and crosses Pueblo de San Ildefonso land before reaching the confluence with the Rio Grande. It has a total drainage area of about 10 mi^2 (27 km^2) and a main channel length of about 10 mi (16 km). Mortandad Canyon receives

treated water discharged into Effluent Canyon from the TA-50 RLWTF. No runoff events have crossed the Laboratory boundary in Mortandad Canyon proper since a stream gage was installed in 1993, and the only reported event that crossed the boundary occurred in 1952 (LANL 2006a). The Mortandad Canyon sediment traps are located approximately two miles upstream of the Laboratory's eastern boundary, and in most years including 2009, runoff events have not extended past the sediment traps.

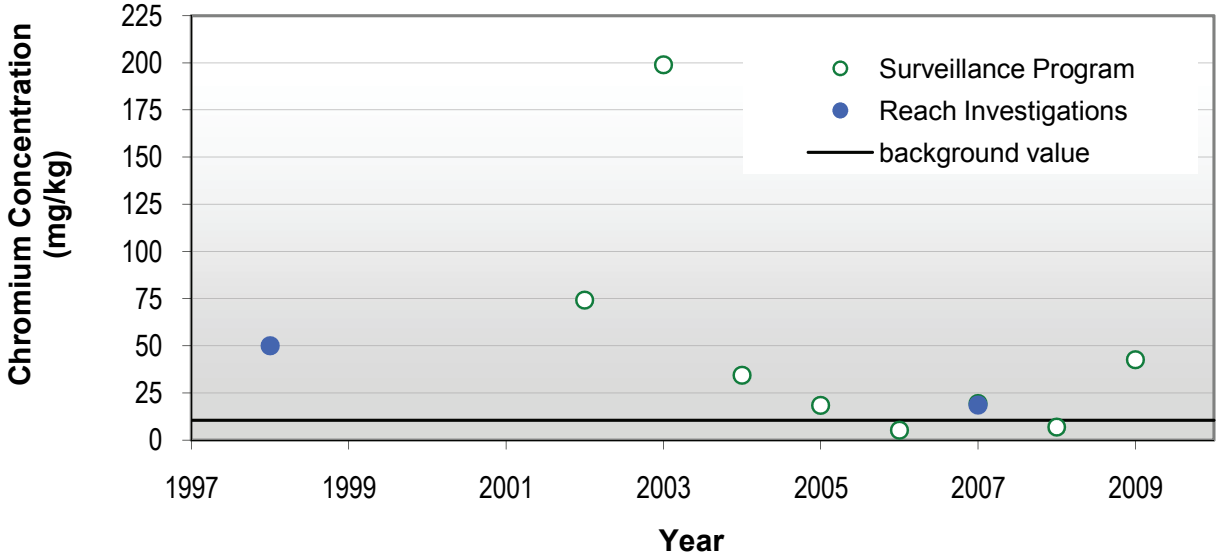


Figure 6-18. Variations in chromium concentration over time in the active stream channel of Sandia Canyon below the wetland.

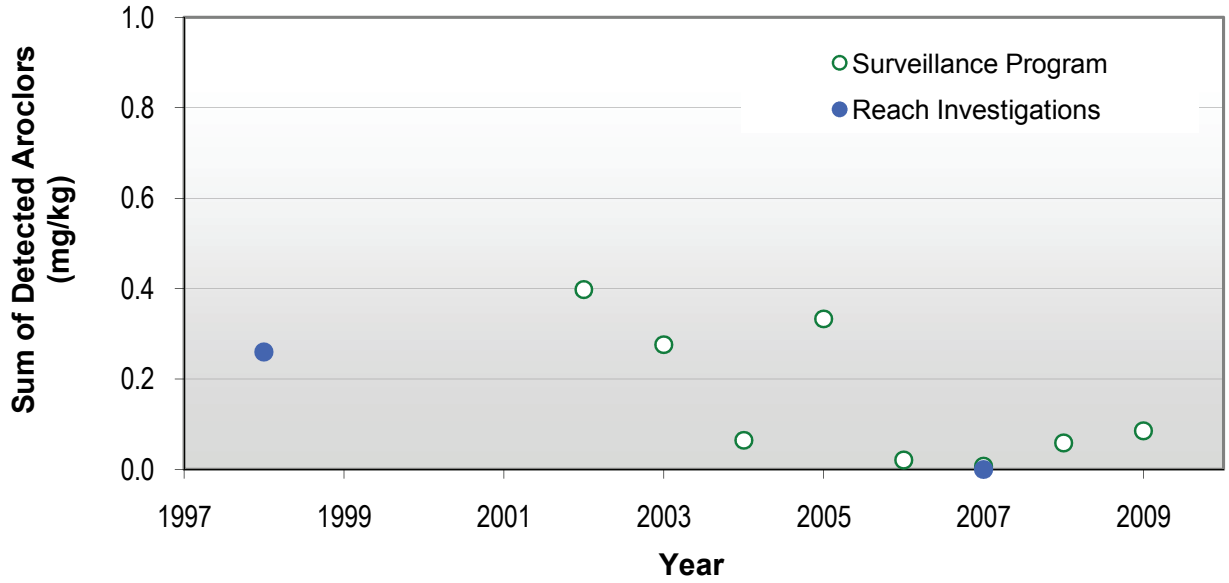


Figure 6-19. Variations in PCB concentration over time in the active stream channel of Sandia Canyon below the wetland; values are the sum of detected Aroclors.

Cañada del Buey is a major tributary that heads in TA-63 and passes through the town of White Rock and Pueblo de San Ildefonso land before joining Mortandad Canyon near the Rio Grande. It has a drainage area of about 4 mi^2 (11 km^2) and a main channel length of about 8 mi (13 km). Runoff events have crossed the Laboratory boundary in Cañada del Buey every year since a gage (E230) was established above NM 4 in 1994, although in most years flow has not been recorded at the next upstream station (E225), indicating that the runoff originates in the lower part of the watershed. The lower part of Cañada del Buey receives treated sanitary

wastewater from a Los Alamos County WWTP near the White Rock Overlook, which flows into Mortandad Canyon and the Rio Grande.

The highest concentrations of several radionuclides in surface water samples collected in 2009 were measured in base flow collected on August 18 from the stream channel in Mortandad Canyon downstream from the TA-50 RLWTF outfall (gage E200), including cesium-137, plutonium-238, and tritium. Time series plots for cesium-137, plutonium-238, and tritium at E200 from 2002 to 2009 are shown in Figures 6-20, 6-21, and 6-22, respectively, indicating that results from 2009 are generally within the ranges measured in recent years. Plutonium-238 concentrations are higher in storm water than in base flow, indicating an association with sediment particles. Tritium concentrations are higher in base flow, associated with its much different geochemical behavior. Cesium-137, however, shows no consistent difference between storm water and base flow. This suggests that at this location, close to the source, cesium-137 is present both dissolved in the water column and associated with sediment particles.

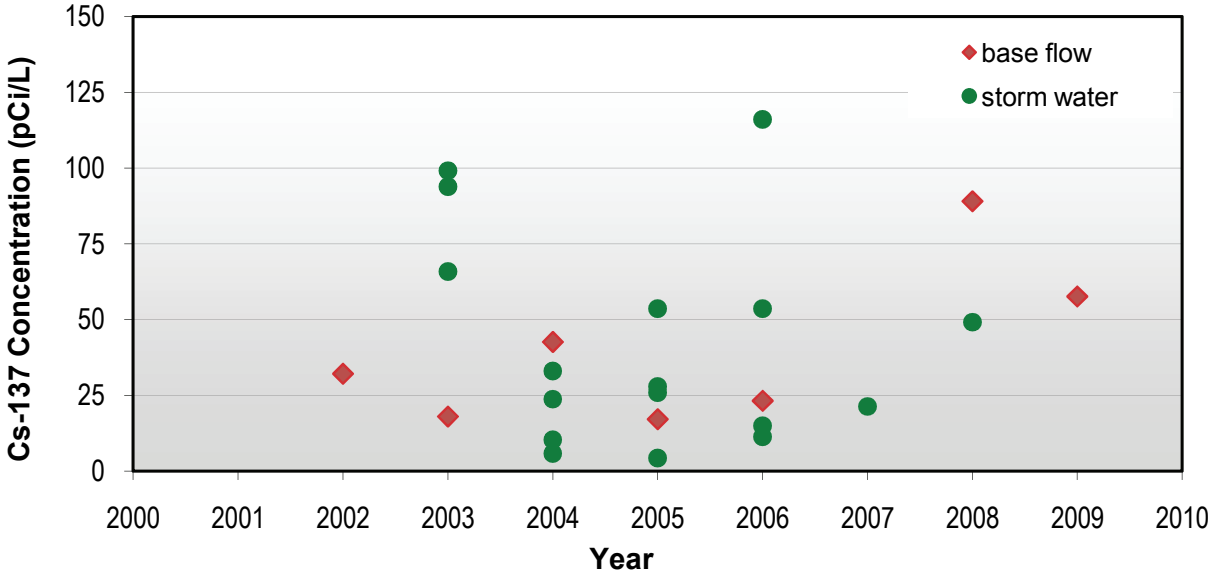


Figure 6-20. Variations in cesium-137 concentration over time in non-filtered surface water samples in Mortandad Canyon below Effluent Canyon (gage E200); all values are detects.

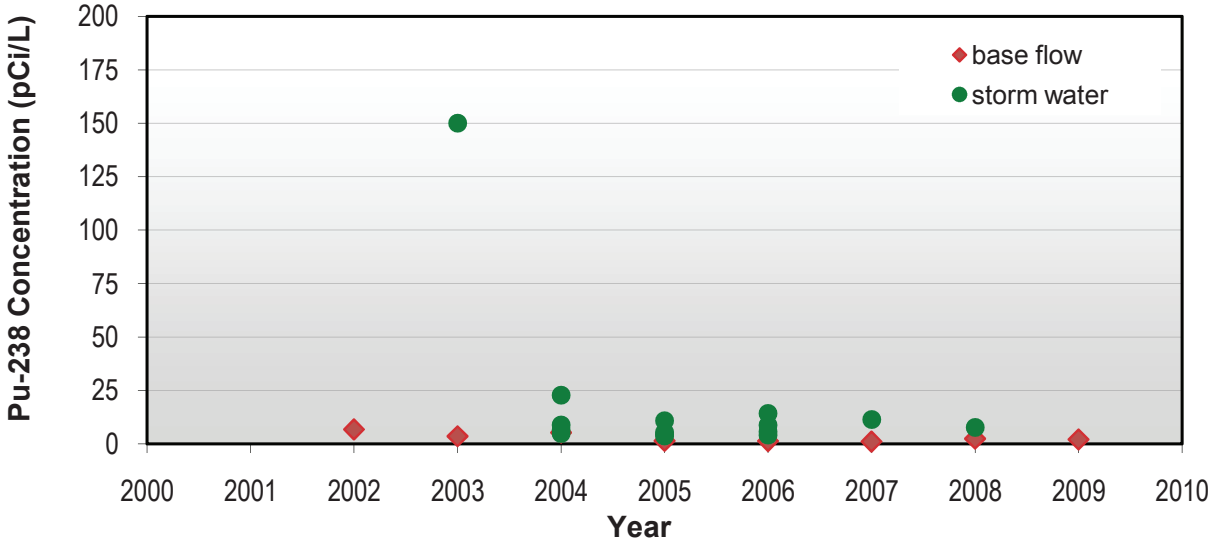


Figure 6-21. Variations in plutonium-238 concentration over time in non-filtered surface water samples in Mortandad Canyon below Effluent Canyon (gage E200); all values are detects.

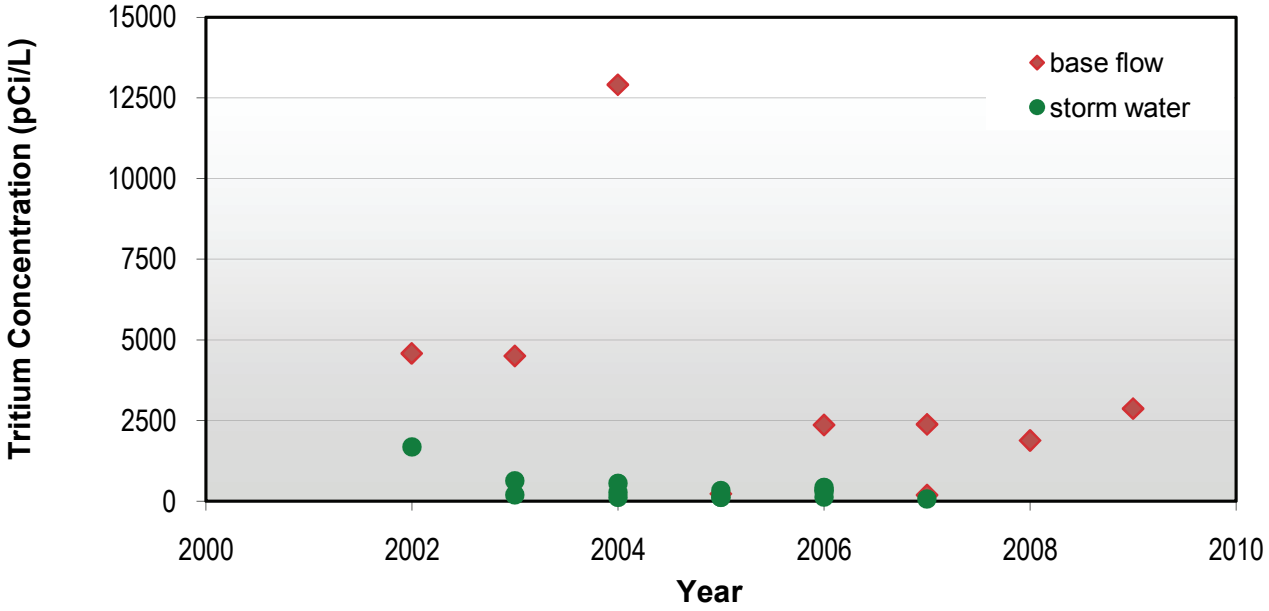


Figure 6-22. Variations in tritium concentration over time in non-filtered surface water samples in Mortandad Canyon below Effluent Canyon (gage E200); all values above 130 pCi/L are detects.

Stream sediment in Mortandad Canyon downstream of Effluent Canyon to near regional well R-28 (1 km above the eastern LANL boundary) contains above-background concentrations of radionuclides, with concentrations decreasing to at or near background levels at the Laboratory boundary (LANL 2006a). Cesium-137 is the most important radionuclide in Mortandad Canyon from the perspective of potential human health risk (LANL 2006a). Cesium-137 concentrations in sediment transported by recent floods are much less than concentrations measured during the period of peak releases of radioactive effluent from the RLWTF into Effluent Canyon prior to 1980. Figure 6-23 plots cesium-137 concentrations in samples from the active channel of Mortandad Canyon below Effluent Canyon since 1972 (updated from LANL 2006a and Reneau and Koch 2008), and shows that concentrations have been relatively low and constant since about 1983, below the recreational SAL of 210 pCi/g. Similar trends are present for other radionuclides in Mortandad Canyon (LANL 2006a).

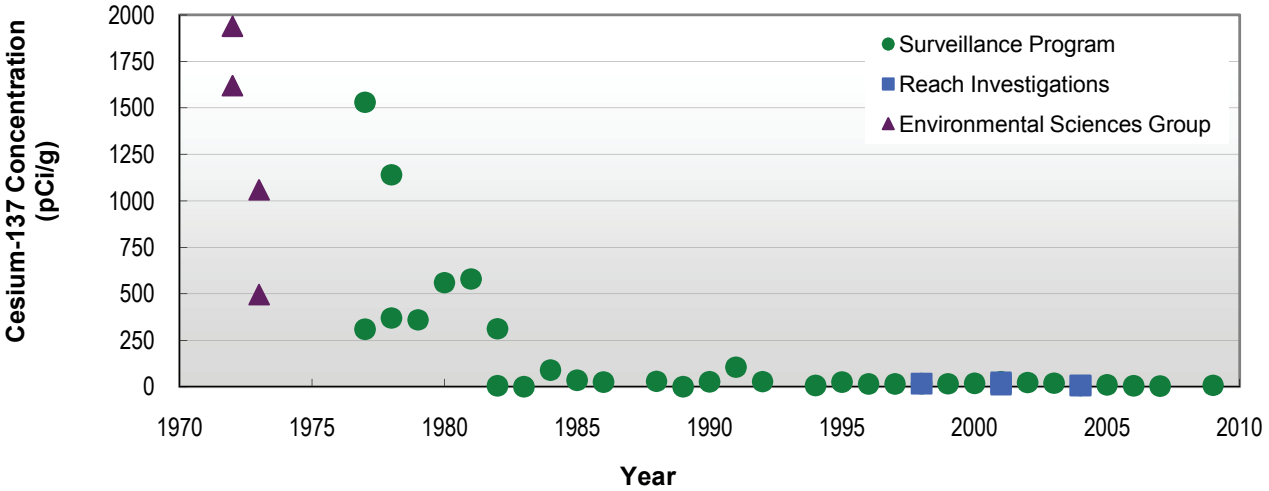


Figure 6-23. Variations in cesium-137 concentration over time in active channel sediment in Mortandad Canyon below Effluent Canyon; most values are detects and are above the background value of 0.9 pCi/g.

Sediment samples have been collected from small drainages below MDA G in the Cañada del Buey watershed since 2003 and have been consistently above background levels for radionuclides, although well below the recreational SALs. Maximum concentrations for different radionuclides in 2009 were measured in different drainages: the MDA G-10 drainage for americium-241 (0.206 pCi/g); the MDA G-10.8 drainage for plutonum-238 (1.06 pCi/g); and the MDA G-10.7 drainage for plutonium-239/240 (0.482 pCi/g) and tritium (0.225 pCi/g). No consistent trends over time are apparent in these data, and the time series for plutonium-238 at MDA G-10.8 is shown as an example in Figure 6-24. None of these radionuclides were detected above background levels downstream in the active channel of Cañada del Buey.

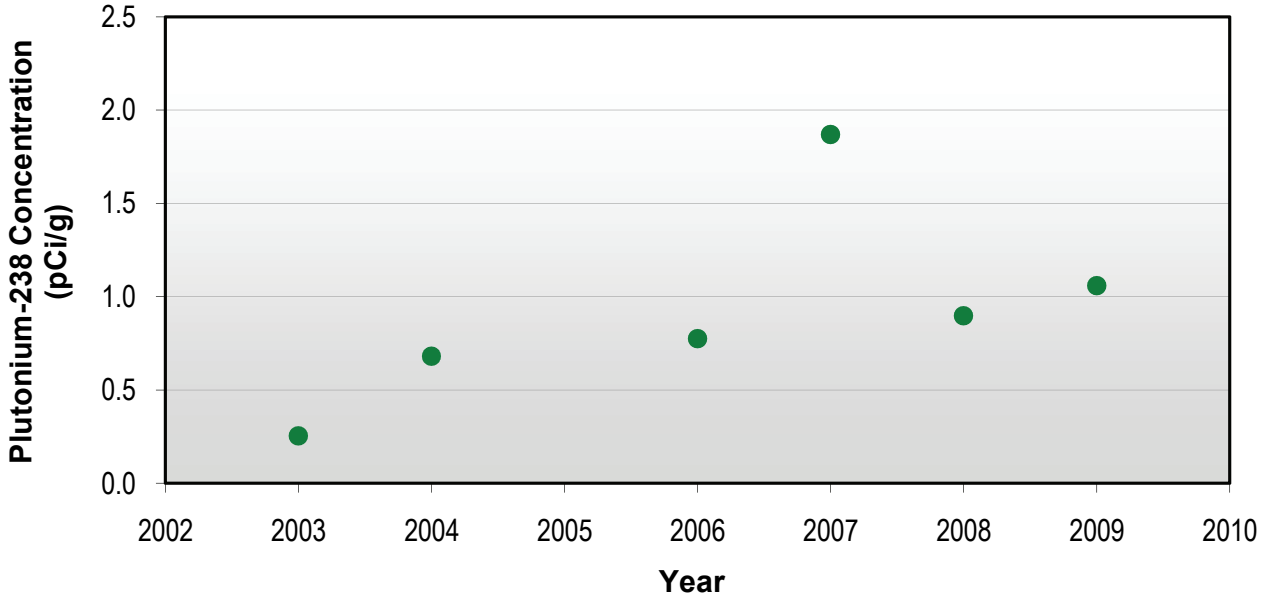


Figure 6-24. Variations in plutonium-238 concentration over time in sediment in the MDA G-10.8 drainage in the Cañada del Buey watershed; all values are detects and are above the background value of 0.006 pCi/g.

Three metals in surface water samples from the Mortandad Canyon watershed had results that were above screening levels in 2009: aluminum, lead, and zinc. Aluminum and arsenic had higher results in background areas and/or runoff samples from developed areas, and these results do not indicate significant LANL impacts. The lead results were also from sites with small drainage areas that receive runoff from developed areas, and lead is a common contaminant in urban areas.

A surface water sample collected from Mortandad Canyon near the Rio Grande on September 28, which consisted of treated sanitary wastewater from the White Rock WWTP, had results above the screening level for the SVOC benzo(a)pyrene. The source of the benzo(a)pyrene is probably releases from the WWTP or runoff from urban areas in White Rock.

4. Pajarito Canyon (includes Twomile and Threemile Canyons)

Pajarito Canyon heads in the Sierra de los Valles in the Santa Fe National Forest and crosses the central part of the Laboratory before passing through the community of White Rock east of NM 4. It has a total drainage area of about 13 mi^2 (33 km^2) and a main channel length of about 15 mi (24 km). Major tributary canyons include Twomile Canyon, which also heads in the Sierra de los Valles, and Threemile Canyon, which heads on the Pajarito Plateau. The Pajarito Canyon watershed includes a variety of active and inactive Laboratory sites (summarized in LANL 2009e). In 2009, there was no recorded runoff at the E250 stream gage in Pajarito Canyon above NM 4, which is the first time this has happened since this gage was established in 1995. Because of this, there were no surface water or sediment samples collected at E250 or downstream in 2009.

In 2009, no radionuclides in surface water samples from the Pajarito Canyon watershed exceeded screening levels. For organic chemicals, only PCBs exceeded a screening level in a storm water sample collected on September 18 from Pajarito Canyon immediately downstream of NM 501 and upstream of all LANL activities (gage E240). This result, 0.000713 µg/L, was slightly above the human health standard of 0.00064 µg/L and represents PCBs contained within atmospheric fallout.

Two inorganic chemicals, aluminum and cyanide, had results above screening levels in surface water samples from the Pajarito Canyon watershed in 2009. A base flow sample collected from Twomile Canyon below TA-59 on September 17 had the highest concentration of aluminum in any sample from 2009 at 5,290 µg/L, well above the acute aquatic life standard of 750 µg/L. Surface water that emerges from the alluvium in this area is often cloudy, probably from the presence of dissolved or colloidal aluminum, which has also been observed in background areas such as Frijoles Canyon in Bandelier National Monument. A base flow sample collected adjacent to a designated perennial stream segment in Pajarito Canyon on March 6, immediately below the confluence with the north Anchor East basin, contained 1,020 µg/L of aluminum, well above the chronic aquatic life standard of 87 µg/L. Another base flow sample collected in Pajarito Canyon above the confluence with Twomile Canyon on March 11 had 989 µg/L of aluminum. These results all probably represent naturally occurring aluminum. A storm water sample collected on August 30 from the MDA G-7 drainage (gage E249.5) had the only concentration of cyanide above the wildlife habitat standard of 5.2 µg/L, at 9.51 µg/L. The source of this cyanide is uncertain.

Sediment samples have been collected from small drainages below MDA G in the Pajarito Canyon watershed for analyses of metals since 2002. In 2009, five inorganic chemicals (antimony, chromium, copper, silver, and zinc) were detected above background levels in one or more of these drainages. These include the highest results for antimony, silver, and zinc in the 2009 surveillance sediment samples. Antimony was highest in the MDA G-7 drainage, and the others were highest in the lower retention pond in the MDA G-6 drainage. All of these maximum results for 2009 were within the range measured in previous years except for zinc. As shown in Figure 6-25, zinc concentrations were highest in 2008 and 2009 at the MDA G-6 lower retention pond. The source of this zinc is uncertain, although zinc is a common contaminant in areas that receive runoff from paved roads; one source of this zinc is tire wear particulates (Walker et al. 1999; Breault and Granato 2000; Callender and Rice 2000).

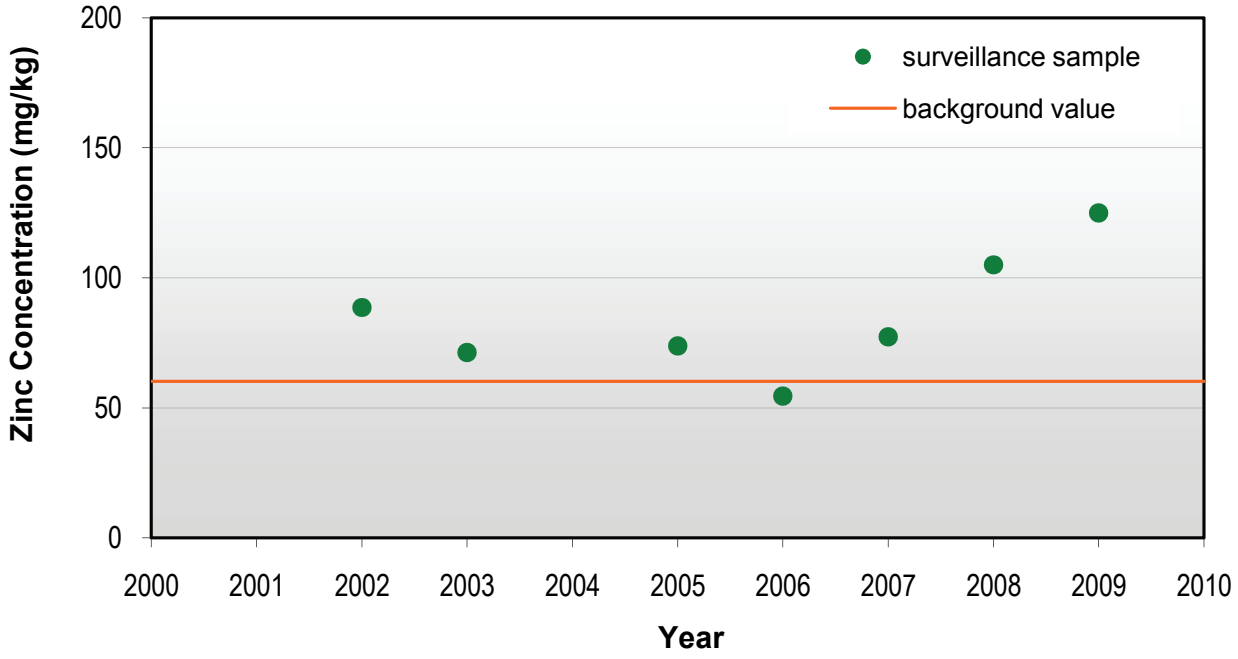


Figure 6-25. Variations in zinc concentration over time in sediment at the MDA G-6 lower retention pond in the Pajarito Canyon watershed; all values are detects.

In addition to the metals discussed above, two organic chemicals (Aroclor-1254 and Aroclor-1260) were detected in the sample from the lower retention pond in the MDA G-6 drainage, and four radionuclides (americium-241, plutonium-238, plutonium-239/240, and tritium) were detected above background levels in several drainages below MDA G. These results are all within the ranges measured in previous years and are below recreational SALs.

5. Water Canyon (includes Cañon de Valle and Fence, Indio, and Potrillo Canyons)

Water Canyon heads in the Sierra de los Valles in the Santa Fe National Forest and extends across the southern portion of the Laboratory to the Rio Grande. It has a total drainage area of about 19 mi^2 (49 km^2) and a main channel length of about 14 mi (23 km). Cañon de Valle is a major tributary that also heads in the Sierra de los Valles. The Water Canyon watershed also includes the shorter canyons of Fence, Indio, and Potrillo Canyons that head on the Pajarito Plateau within LANL. Explosives development and testing and other activities take place in this part of the Laboratory, and elevated concentrations of uranium isotopes, barium, silver, the HE compounds HMX and RDX, along with other analytes have previously been measured in sediment and surface water in the watershed (LANL 2006b). Cañon de Valle has been the subject of focused Laboratory investigations to address barium and HE contamination in surface water and groundwater (LANL 2004b; LANL 2006c), and the Laboratory implemented corrective measures for the canyon in 2009 and 2010 that included construction of a permeable reactive barrier within the alluvium (LANL 2010d).

The highest concentrations of RDX and other HE compounds in surface water at the Laboratory in 2009 were measured in non-filtered base flow samples from Cañon de Valle below MDA P (gage E256) in TA-16, in an area where development of explosive compounds has occurred. Two RDX results from this station, 15.3 and 15.6 µg/L on March 24 and October 15, were both above the tap water screening level of 6.11 µg/L. RDX was not detected downstream in Water Canyon, although HMX was. The HMX concentration in Water Canyon below the confluence with Cañon de Valle (Water at Beta station; 0.763 µg/L on April 7) was about one tenth the concentrations measured below MDA P (6.29 and 12.4 µg/L). A time series of RDX concentrations in Cañon de Valle below MDA P is presented in Figure 6-26. The figure shows that the results from 2009 are within the range measured in recent years. The data presented in Figure 6-26 also indicate that concentrations in base flow are typically higher than in storm water, indicating that the RDX is not primarily associated with sediment particles.

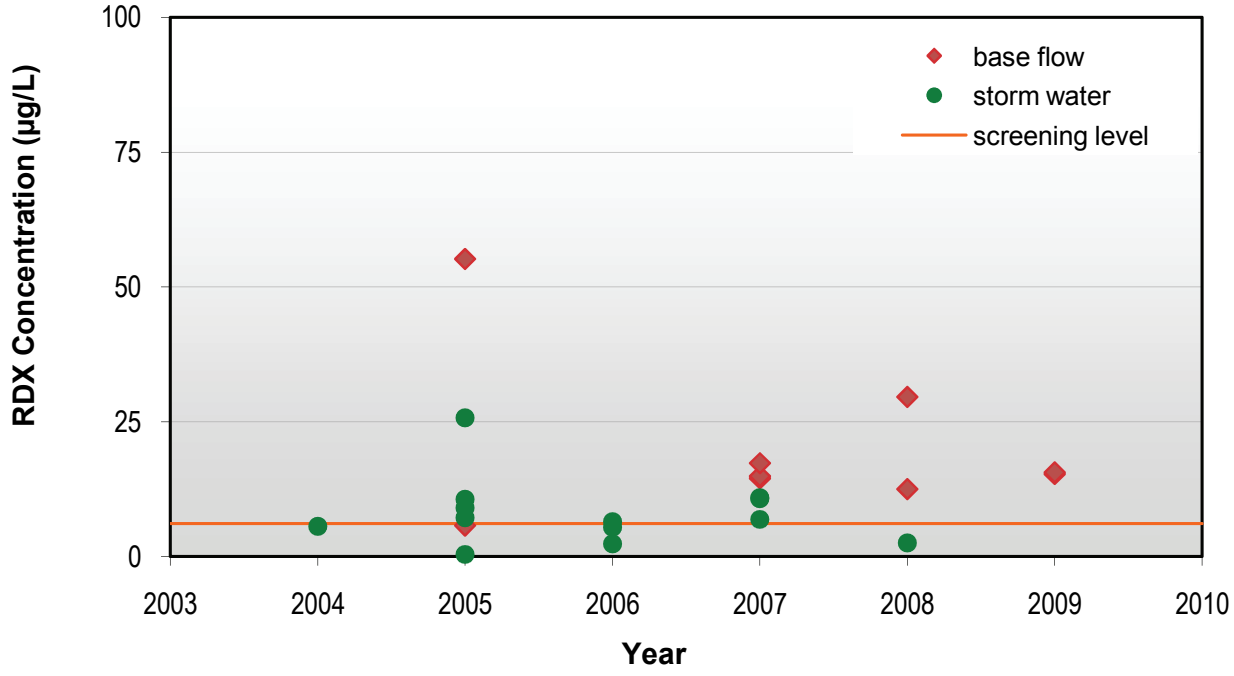


Figure 6-26. Time series of RDX concentrations in surface water samples from Cañon de Valle below MDA P (gage E256); all values are detects.

Two metals, aluminum and lead, had results above screening levels in surface water samples from the Water Canyon watershed in 2009. Aluminum was detected above the chronic aquatic life standard of 87 µg/L in four samples collected from spring-fed base flow locations in the watershed. The highest result for aluminum, 916 µg/L on March 24, was from Water Canyon above NM 501, upstream from all LANL activities, demonstrating that this represents naturally occurring aluminum. Two other results from Water Canyon were also well above this standard: 772 µg/L on April 10 below NM 501 and 669 µg/L above NM 501 on October 16. Aluminum was also detected above this standard at 116 µg/L in Cañon de Valle below MDA P on October 15. Lead had one detected result above slightly above the tap water screening level of 15 µg/L in 2009, at 17.9µg/L, in a tributary drainage to Cañon de Valle on April 17.

Three samples of active channel sediment were collected from the Water Canyon watershed in 2009. Within these samples, two metals, iron and vanadium, were detected slightly above background levels at one location, in Potrillo Canyon above NM 4. These results were less than 10% higher than the sediment background values. Both metals had been previously detected at higher concentrations at this location. No explosive compounds were detected in these samples, and no radionuclides were detected at concentrations above background levels.

6. Ancho Canyon

Ancho Canyon heads on the Pajarito Plateau in TA-49 and extends across the Laboratory to the Rio Grande. It has a total drainage area of about 7 mi^2 (17 km^2) and a main channel length of about 7 mi (12 km). Potential Laboratory sources of contamination in the Ancho Canyon watershed include MDA AB in TA-49, the site of underground testing from 1959 to 1961, and firing sites in the north fork of Ancho Canyon in TA-39 (LANL 2006b).

The only radionuclides exceeding a screening level in surface water samples from the Ancho Canyon watershed in 2009 were radium-226 and radium-228 in two storm water samples from the main channel below NM 4 (gage E275, July 28 and July 30). These isotopes are naturally occurring and are also elevated in areas not affected by releases of radionuclides from Laboratory activities. Similarly, gross alpha radiation exceeded the screening level in these samples, but gross alpha radiation is also elevated in background areas.

One inorganic chemical, aluminum, exceeded a screening level in a storm water sample from the Ancho Canyon watershed in 2009, although aluminum is also naturally elevated above the screening level in background areas on the Pajarito Plateau.

PCB congener analyses were obtained from two storm water samples from the main channel below NM 4 (gage E275) in 2009, and both samples had total detected PCB concentrations above the human health standard of 0.00064 µg/L and the wildlife habitat standard of 0.014 µg/L. The concentrations in these samples, 0.0223 and 0.0743 µg/L, are within the range measured in runoff from developed areas such as the Los Alamos town site. PCB congener homolog data from these samples are compared with data obtained downriver along the Rio Grande in Section G.3.

Three samples of active channel sediment were collected from the Ancho Canyon watershed in 2009. No inorganic chemicals or radionuclides were detected at concentrations above sediment background values in these samples, and no organic chemicals were detected.

7. Chaquehui Canyon

Chaquehui Canyon heads on the Pajarito Plateau near the Bandelier National Monument entrance station and extends across the Laboratory to the Rio Grande. It has the smallest of the primary watersheds at LANL, with a total drainage area of about 1.6 mi^2 (4 km^2) and a main channel length of about 3 mi (5 km). Potential Laboratory sources of contamination in the Chaquehui Canyon watershed are located at TA-33 and include firing sites and outfalls (LANL 2006b).

One storm water sample was collected from the Chaquehui Canyon watershed in 2009, at the E338 gaging station along the main stream channel on July 30. No results for inorganic or organic chemicals exceeded screening levels. The only radionuclide that exceeded a screening level was radium-226, which is also elevated in areas not affected by releases of radionuclides from Laboratory activities. Similarly, gross alpha radiation

exceeded the screening level in this sample, but gross alpha radiation is also elevated in background areas. Although below screening levels, this sample had the highest concentrations of uranium-234, uranium-235, and uranium-238 at LANL in 2009, which is consistent with known releases of uranium at TA-33. Comparison of the concentrations of the uranium isotopes and naturally occurring potassium-40 in the 2009 storm water samples also indicates that the Chaquehui Canyon sample is elevated in uranium relative to other locations, supporting a LANL contribution.

One sample of active channel sediment was collected from the Chaquehui Canyon watershed in 2009, below the confluence of the north fork and the main channel. Two metals, iron and vanadium, were detected above background levels at this location. This was the first year this location had been sampled, but iron and vanadium had been previously detected above the sediment background values down canyon near the Rio Grande. No explosive compounds were detected in this sample, and no radionuclides were detected at concentrations above background values.

G. POTENTIAL IMPACTS TO THE RIO GRANDE

In 2009, we assessed potential Laboratory impacts to the Rio Grande by comparing data from sediment and water samples collected upriver and downriver of LANL drainages and also comparing these data with analytical results obtained from canyons draining the Pajarito Plateau.

1. Surface Water Sampling Results

Natural stream flow and sediment loading in the Rio Grande are quite large compared with Los Alamos area streams. These factors reduce the possibility of identifying significant impacts from the Laboratory in the Rio Grande. Daily average flow in the Rio Grande at the Otowi gage in 2009 ranged from about 500 to 5,900 cfs. In contrast, the estimated combined flows from all the Los Alamos area canyons exceeded 5 cfs only on July 30 (7 cfs). Similarly, the average annual amounts of suspended sediment and bed sediment passing the Otowi gaging station has been calculated to be 1,000 and 100 times, respectively, that contributed by Los Alamos Canyon (Graf 1994).

Surface water samples were collected from three locations along the Rio Grande in 2009 for analysis of inorganic and organic chemicals and radionuclides. These locations are upriver of Los Alamos Canyon and LANL at Otowi Bridge, at the planned surface water diversion-site for Santa Fe at Buckman (at the mouth of Cañada Ancha, downriver from Los Alamos, Sandia, and Mortandad Canyons), and at the mouth of Frijoles Canyon in Bandelier National Monument (downriver from all canyons draining LANL). Five samples each were collected at Otowi Bridge and Buckman on the same days, and one sample was collected at Frijoles Canyon one week after one of the upriver samples.

For organic chemicals, a sample collected from the Rio Grande at Buckman on September 22 had detected results for two SVOCs, benzo(a)pyrene and dibenz(a,h)anthracene, above screening level. The results for benzo(a)pyrene, 0.237 µg/L, and dibenz(a,h)anthracene, 2.16 µg/L, were above the NMWQCC human health standard of 0.18 µg/L (the same for both SVOCs). No other organic chemicals and no inorganic chemicals were detected at concentrations above screening levels.

Nine radionuclides were detected in the Rio Grande water samples: radium-226, radium-228, thorium-228, thorium-230, thorium-232, tritium, uranium-234, uranium-235/236, and uranium-238. No screening levels were exceeded in these samples. All of these radionuclides are naturally occurring except for tritium, which is associated with atmospheric fallout. The highest concentrations for radium-226, the thorium isotopes, and tritium were measured at Otowi Bridge, upriver from LANL, demonstrating non-LANL sources. For the uranium isotopes, the maximum concentrations downriver from Otowi Bridge were 1% to 13% of the maximum concentrations measured upriver, also indicating little or no LANL impacts.

2. Sediment Sampling Results

For a large analytical suite including inorganic and organic chemicals and radionuclides, we collected sets of five samples each from four areas along the Rio Grande in 2009. The four areas were: (1) upriver from Otowi Bridge, which is upriver from Los Alamos Canyon and other LANL sources; (2) upriver from Buckman and the planned Direct Diversion Project surface water intake for the City and County of Santa Fe, which is downriver from Los Alamos Canyon; (3) below the White Rock Overlook, downriver from Sandia and Mortandad Canyons; and (4) between Chaquehui and Frijoles Canyons, downriver from all canyons draining LANL. These samples included a similar range in geomorphic setting and particle size in each area, including low-water and high-water settings and fine silt to fine sand. Figures 6-9, 6-10, and 6-27 show examples of the sample sites.



Figure 6-27. Photograph of sediment sampling area along the Rio Grande above Otowi Bridge; November 12, 2009.

In these samples, one radionuclide was detected above the sediment background concentrations of McLin and Lyons (2002) and McLin (2004). Plutonium-239/240 was detected at 0.0234 pCi/g in one sample collected between Chaquehui and Frijoles Canyons, above the Rio Grande background concentration of 0.013 pCi/g but below the Pajarito Plateau sediment background value of 0.068 pCi/g. Tritium was detected in one sample, at 1.01 pCi/g above Otowi Bridge and above all LANL canyons, well above the LANL sediment background value of 0.093 pCi/g. This result suggests natural background variability. Uranium-238 was also detected above the LANL sediment background value of 2.29 pCi/g in one sample, below the White Rock Overlook. This was the finest-grained sample collected along the Rio Grande in 2009, with 44% clay and 54% silt (Figures 6-9 and 6-10), and the relatively high uranium-238 concentration may also represent natural background variability associated with this unusually fine-grained sample.

For organic chemicals, no explosive compounds were detected in sediment samples from the Rio Grande in 2009, which is consistent with previous years. PCB congener data were also obtained from the sediment samples, and are discussed further in Section G.3.

Concentrations of many inorganic chemicals are elevated in Rio Grande sediment compared with background levels in Pajarito Plateau sediment, but these differences may largely or entirely reflect different background conditions along the Rio Grande or upriver sources. In the 2009 samples, 14 inorganic chemicals had maximum detected results along the river above the LANL sediment background values: aluminum, arsenic, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, and vanadium. For one of these, beryllium, the maximum concentration was measured above Otowi Bridge and potential LANL inputs, confirming a non-LANL source. For nine of the others (aluminum, calcium, chromium, cobalt, copper, iron, magnesium, nickel, and potassium), the maximum concentrations along the river were measured in the same fine-grained sample with the elevated uranium-238 discussed previously, suggesting that the elevated

concentrations are associated with the unusually high silt and clay content. Two other inorganic chemicals, arsenic and manganese, had only single results slightly above the LANL sediment background value (~5% higher) in the 15 samples collected below Otowi Bridge.

Figures 6-28 to 6-30 present box plots with sample results for three metals that have potential LANL sources (barium, chromium, and copper), comparing data from the 2009 samples along the river with previous results from Abiquiu and Cochiti Reservoirs and the LANL sediment background data set. In these figures, the upper and lower ends of the boxes are at the 25th and 75th percentile of the data, and lines within the boxes are the median values. These box plots illustrate that the Rio Grande sediment samples have higher concentrations than found in the Pajarito Plateau sediment background samples, and that Abiquiu and Cochiti Reservoirs have even higher concentrations. The higher concentrations in the reservoirs are probably associated with higher percentages of fine-grained particles that settled out there. Statistical comparisons of the results for barium, chromium, and copper in the 2009 samples collected above Otowi Bridge and the samples collected downriver also showed no differences in the downriver samples that would indicate significant LANL contributions.

Figures 6-31 to 6-33 present relationships between the concentrations of barium, chromium, and copper, and silt and clay content for sediment samples collected along the Rio Grande and in Abiquiu and Cochiti Reservoirs in 2007 to 2009. The linear relations shown in these figures are for samples collected from along the Rio Grande and from Cochiti Reservoir, grouped together because of their geographic proximity and similar source area geology. These figures also include background sediment samples from the Pajarito Plateau for comparison. Concentrations of each of these three metals have strong positive correlations with silt and clay content, showing that variations in particle size between samples are a major cause of differences between samples collected along the river or in the reservoirs and the samples from the plateau. Pajarito Plateau background samples are generally coarser-grained than samples collected along the Rio Grande, leading to lower average and maximum concentrations in the former.

These figures also indicate some differences related to differing geologic units in source areas. For example, for a given silt and clay content, barium is typically lower in Pajarito Plateau background samples than in river or reservoir samples (Figure 6-31) and copper is typically higher (Figure 6-33). In contrast, chromium shows no obvious differences related to source area (Figure 6-32).

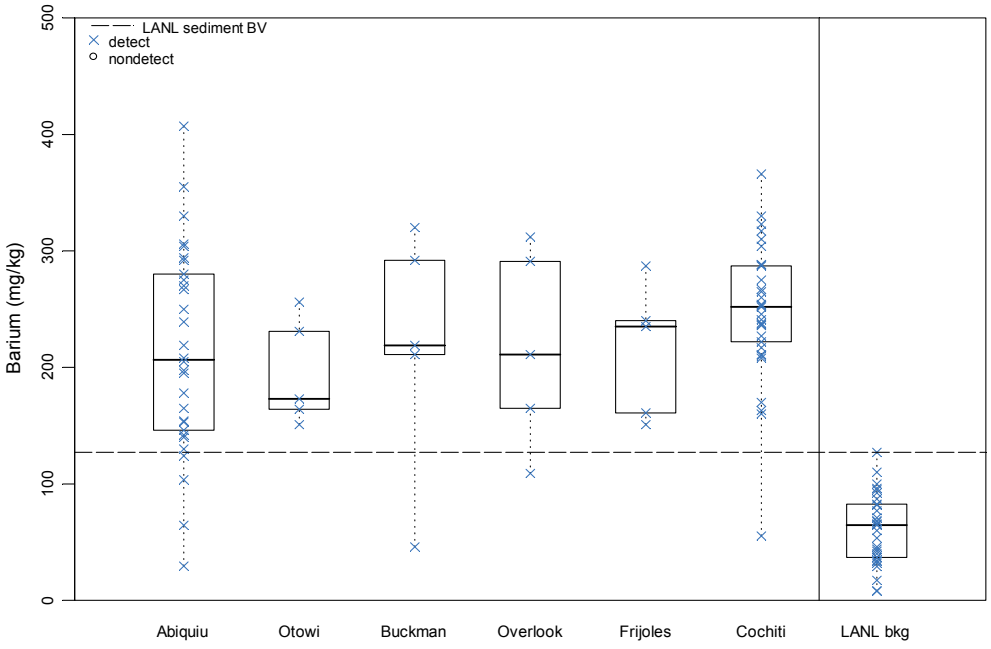


Figure 6-28. Box plots comparing 2009 sediment sample results for barium along the Rio Grande with data from Abiquiu and Cochiti Reservoirs and the LANL sediment background data set.

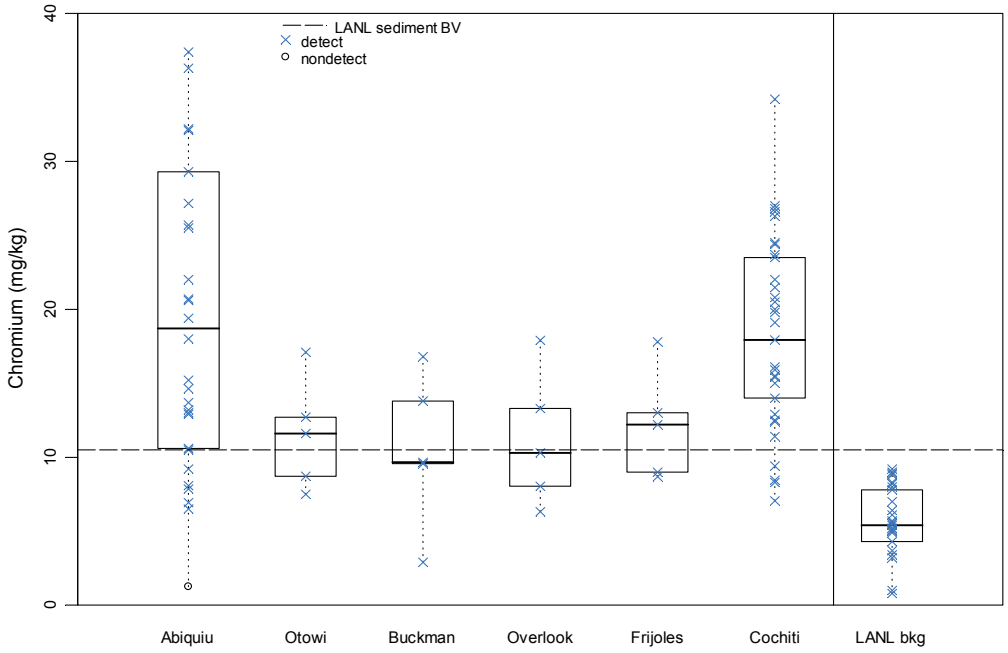


Figure 6-29. **Box plots comparing 2009 sediment sample results for chromium along the Rio Grande with data from Abiquiu and Cochiti Reservoirs and the LANL sediment background data set.**

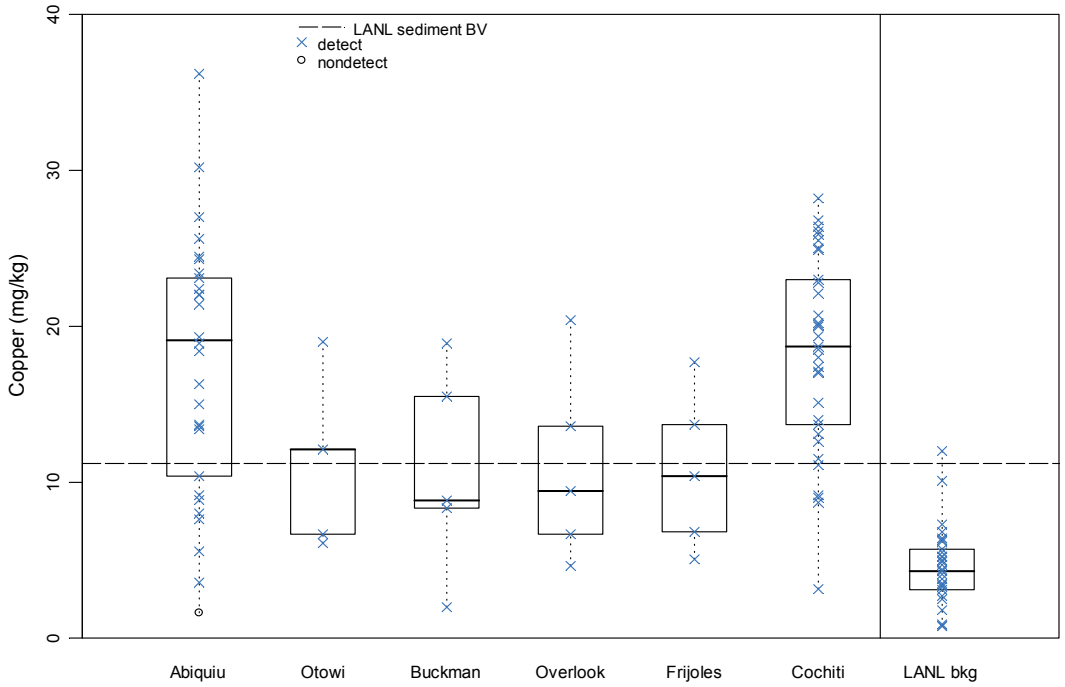


Figure 6-30. **Box plots comparing 2009 sediment sample results for copper along the Rio Grande with data from Abiquiu and Cochiti Reservoirs and the LANL sediment background data set.**

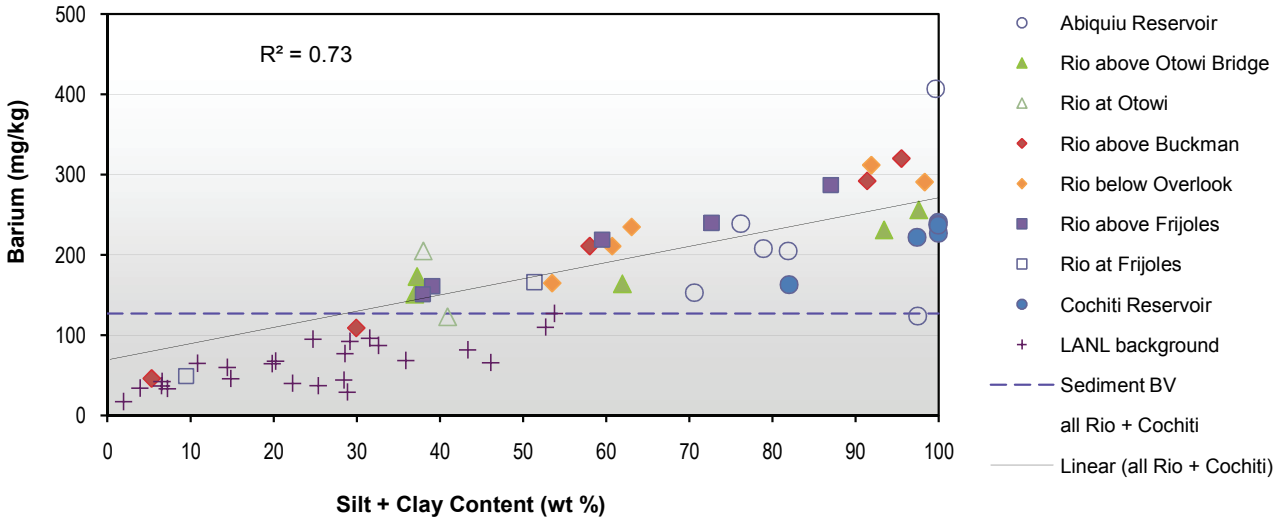


Figure 6-31. Relationships between barium concentration and silt and clay content in sediment samples collected along the Rio Grande and from Abiquiu and Cochiti Reservoirs and in the LANL sediment background data set.

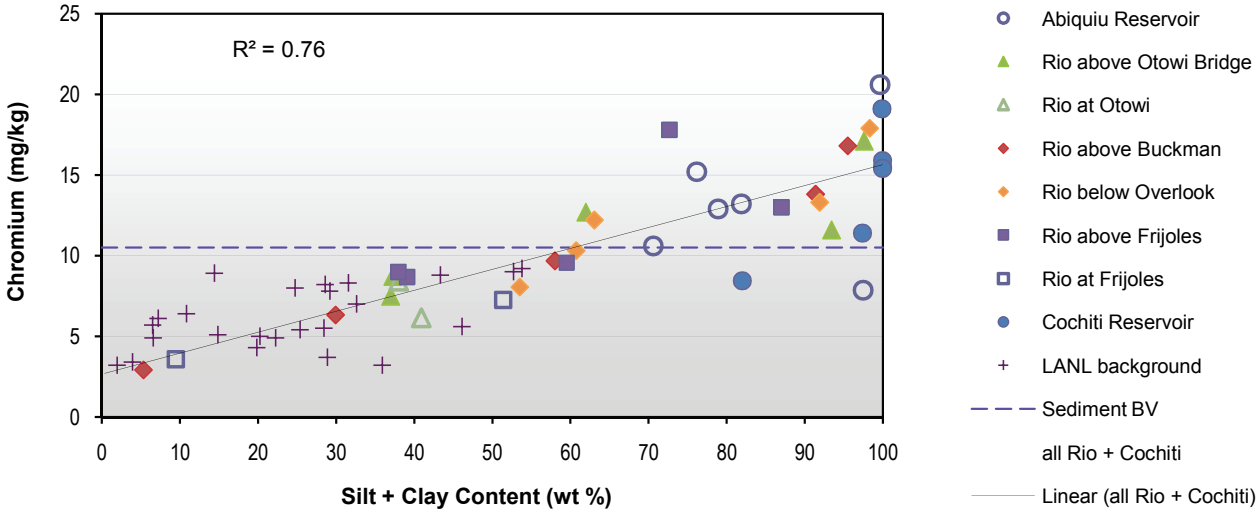


Figure 6-32. Relationships between chromium concentration and silt and clay content in sediment samples collected along the Rio Grande and from Abiquiu and Cochiti Reservoirs and in the LANL sediment background data set.

Potential LANL impacts on the Rio Grande can be evaluated by comparing results in samples with similar particle size collected upriver and downriver from specific LANL drainages. The main LANL source for barium is Cañon de Valle, a tributary to Water Canyon. Samples collected downriver from Water Canyon (Rio above Frijoles, Rio at Frijoles, and Cochiti Reservoir in Figure 6-31) are not noticeably different from those collected upriver from Water Canyon. The main LANL source for chromium is Sandia Canyon, located between the Buckman and White Rock Overlook sample areas, and samples collected downriver are not noticeably different from those collected upriver (Figure 6-32). LANL sources for copper are not well defined, but the data presented in Figure 6-33 do not show clear increases in copper concentration below any specific LANL drainage. An examination of the available analytical data in the context of particle size variations therefore also indicates no clear LANL impact on metals concentrations along the Rio Grande.

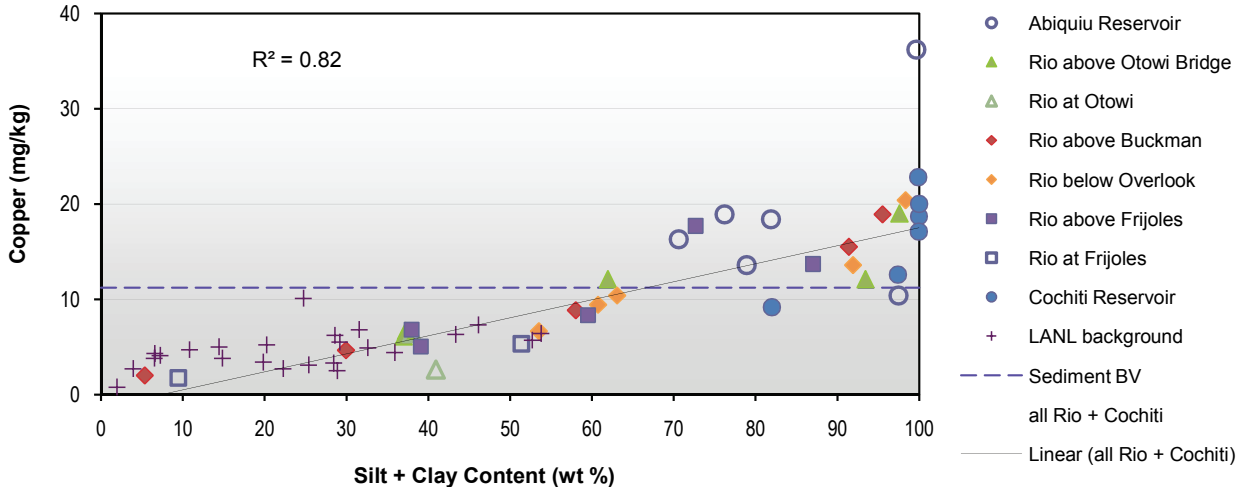


Figure 6-33. Relationships between copper concentration and silt and clay content in sediment samples collected along the Rio Grande and from Abiquiu and Cochiti Reservoirs and in the LANL sediment background data set.

3. PCBs in Sediment

a. PCB Concentrations and Sources

PCB congener data were obtained from 20 sediment samples along the Rio Grande in 2009, building on a pilot study conducted in 2008 and reported previously (Reneau and Kuyumjian 2009). Data from 2008 and 2009 are discussed together in this section, which are the only years for which PCB congener data were obtained from the Rio Grande. In addition to comparing PCB concentrations in samples collected from different locations, comparison of PCB congener "fingerprints" upriver and downriver from Los Alamos Canyon with congener data within the Los Alamos Canyon watershed allow further evaluation of potential Los Alamos contributions to PCBs along the Rio Grande.

Total detected PCB congener concentrations in Rio Grande sediment samples in 2009 are very similar to concentrations measured in 2008. In the two 2008 sample areas, the average concentrations were 0.000085 mg/kg (85 ng/kg) near Otowi Bridge, above Los Alamos Canyon, and 0.000060 mg/kg (60 ng/kg) downriver below the White Rock Overlook. In the four 2009 sample areas, average concentrations ranged from 66 ng/kg above Otowi Bridge to 90 ng/kg between Chaquehui and Frijoles Canyons. The average of 10 Rio Grande samples collected in 2008, 73 ng/kg, is similar to the average of 20 samples collected in 2009, 76 ng/kg. The maximum concentration measured in 2008, 199 ng/kg from below the White Rock Overlook, is also similar to the maximum concentration from 2009, 208 ng/kg from above Buckman. Single samples in 2008 and 2009 had no detected congeners, collected below the White Rock Overlook and above Buckman, respectively.

The PCB congeners from each sample can be grouped together into 10 homologs, as discussed previously in Section F.1, which allows visual comparison of similarities or differences between samples or groups of samples. Homolog data from the 2008 samples were presented previously (Reneau and Kuyumjian 2009), and indicated that there was considerable variation in homolog signatures between sediment samples collected from each area, but that averages were very similar above and below Los Alamos Canyon. The variability is caused by different sediment layers being associated with different runoff events that transport sediment from different sources with the upper Rio Grande watershed, whereas the average values integrate multiple runoff events and provide a better representation of overall PCB characteristics along the river.

The homolog data from the 2009 samples generally indicate the same combination of variability within sample areas but similarities between them as seen in the 2008 samples. Average homolog percentages in the 2009 samples from each of the four areas are shown in Figure 6-34, showing the same general patterns between areas.

For comparison, Figure 6-34 also shows averages from the 2008 samples and from lower Los Alamos Canyon (reach LA-5, discussed in Section F.1). It is notable that the two 2008 sample areas have similar homolog patterns to each other but differ from the four 2009 sample areas. This indicates, on average, differences in sources for the 2008 sediment from the 2009 sediment.

As seen in Figure 6-34, the samples from lower Los Alamos Canyon have higher average percentages of hexaCB and heptaCB than samples collected along the Rio Grande. If Los Alamos Canyon was a significant source of PCBs for the Rio Grande, then the homolog patterns downriver should be shifted to higher values for these homologs relative to the Otowi Bridge samples. This is not the case, and instead average percentages of hexaCB and heptaCB are essentially identical above and below Los Alamos Canyon. This indicates that, for these samples, the predominant source of PCBs is upriver from LANL.

One anomaly that is seen in these data is the higher percentages of monoCB in two of the five samples collected between Chaquehui and Frijoles Canyons, downriver of all LANL canyons, than found in any of the other samples from 2008 or 2009. This suggests a source of PCBs in one of the canyons downriver from the White Rock Overlook, specifically Pajarito, Water, Ancho, or Chaquehui Canyons. However, two of these canyons had no recorded runoff past NM 4 in 2009 (Pajarito and Water Canyons), and PCB congener data obtained from Ancho Canyon storm water in 2009 had a different homolog pattern (Figure 6-34). This anomaly will be investigated further with samples planned for 2010 from Ancho and Chaquehui canyons (LANL 2010e).

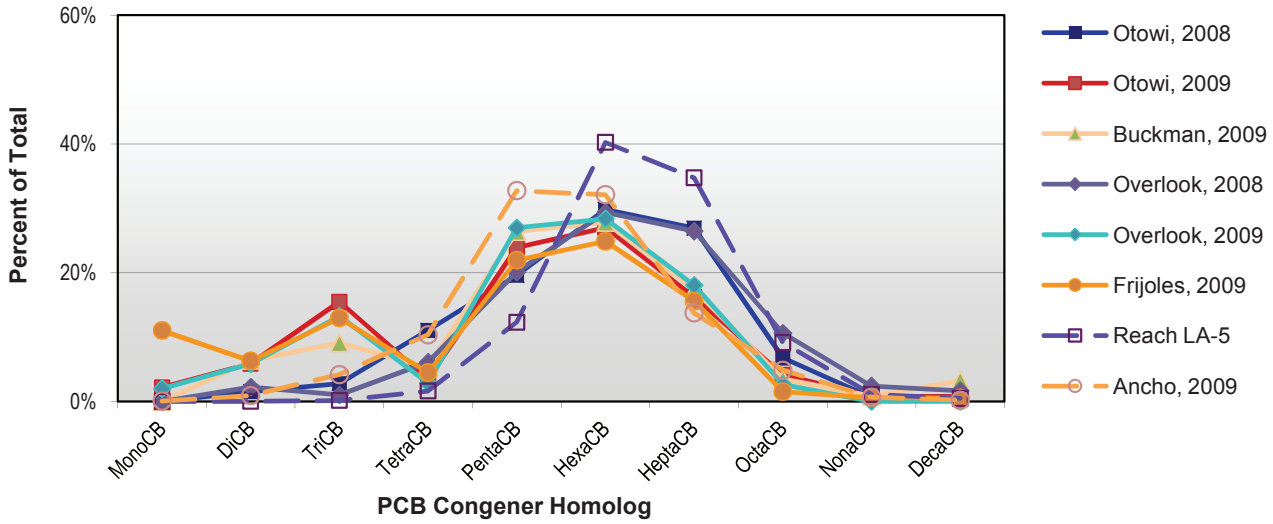


Figure 6-34. Average values for PCB congener homolog data from sediment samples collected along the Rio Grande, in lower Los Alamos Canyon, and from Ancho Canyon storm water.

b. PCB Flux.

PCB congener data obtained from sediment samples along the Rio Grande, in combination with measurements of discharge and sediment flux at the Otowi Bridge gaging station made by the US Geological Survey (USGS), allow estimates to be made of the total mass of PCBs transported by the Rio Grande. These estimates can be compared with estimates of PCB flux at LANL, particularly in Los Alamos Canyon, which contains the main potential LANL sources of PCBs that could be transported to the Rio Grande.

Using data presented by the USGS (e.g., Stile 2010), the average annual flux of suspended sediment in the Rio Grande at Otowi Bridge was about 2,100,000 Mg/yr from 1948 to 2009 and was also about 2,100,000 mg/yr over the last 10 years (2000–2009). This is very similar to the value of 2,000,000 Mg/yr used in a previous study of plutonium along the Rio Grande, based on data from 1948 to 1985 (Graf 1994). Graf (1994) estimated that bedload sediment flux was much less, averaging about 300,000 Mg/yr or 14% of the suspended sediment flux and was a smaller component of the plutonium budget because of the inverse relation between contaminant concentrations and particle size. He estimated that only about 5% of the plutonium in the Rio Grande was associated with bedload sediment, and bedload can also be assumed to be a minor part of the PCB flux in the Rio Grande.

Suspended sediment flux in the Rio Grande in water year 2008 (WY2008, October 1, 2007, to September 30, 2008) was above average, estimated as about 6,000,000 Mg. Using this value and the average PCB concentration measured in Rio Grande sediment near Otowi Bridge in 2008 (85 ng/kg) provides an estimated flux of 0.51 kg of PCBs past Otowi Bridge in WY2008. However, this may be an underestimate because of the sampling of coarser sediment that settled out of the river instead of the sediment that remained in suspension. For example, the sediment samples from this area in 2008 had an average of 46% silt and clay and 54% sand, whereas six samples of Cochiti Reservoir sediment collected in 2007 and 2008 averaged 97% silt and clay. If we use our PCB concentration in the finest-grained Rio Grande sediment sample from 2008 (199 ng/kg in a sample with 93% silt and clay, similar to the silt and clay content of Cochiti Reservoir sediment samples), the estimated PCB flux in WY2008 is increased to 1.2 kg.

Suspended sediment flux in the Rio Grande in WY2009 was much less than in WY2008, estimated as about 800,000 Mg (Stile 2010). Using this value and the average PCB concentration measured in Rio Grande sediment near Otowi Bridge in 2009 (66 ng/kg) provides an estimated flux of 0.05 kg of PCBs past Otowi Bridge in WY2009, about 10% of the WY2008 estimate. As discussed above, adjusting for particle size variations would increase this estimate by two to three times.

Estimates of longer-term average PCB flux in the Rio Grande can also be made by combining our sediment data with the long-term average suspended sediment flux of 2,100,000 Mg/yr. Use of our average PCB concentration near Otowi Bridge of 76 ng/kg from 2008 and 2009 yields a PCB flux of 0.16 kg/yr, and use of our maximum PCB concentration of 168 ng/kg from this area yields a PCB flux of 0.35 kg/yr.

The estimates of PCB flux in the Rio Grande can be compared with estimates of PCB flux in the Los Alamos Canyon watershed to evaluate the relative importance of Los Alamos Canyon as a PCB source for the Rio Grande. The only published estimate of suspended sediment yield from Los Alamos Canyon into the Rio Grande was made by Graf (1994), an average of 2,000 Mg/yr. Combined with the average PCB concentrations measured in fine-grained sediment in lower Los Alamos Canyon in 2009, 2,623 ng/kg (0.0026 mg/kg), this yields an estimated PCB flux of 0.005 kg/yr, 1–3% of the total estimated long-term flux in the Rio Grande. This small percentage is consistent with the absence of notable differences in PCB homolog signatures along the Rio Grande above and below Los Alamos Canyon. Enhanced sampling of storm water in lower Los Alamos Canyon at gaging station E110 is planned to begin in 2010 (LANL 2009h), which, in combination with improvements to the gaging station, should result in improved estimates of PCB flux from Los Alamos Canyon into the Rio Grande.

An additional estimate of PCB flux in Los Alamos Canyon can be made up canyon at the Los Alamos Canyon weir, which is down canyon from the main PCB sources in the watershed. By using analyses of PCBs by the Aroclor method in depth-integrated samples though the entire thickness of accumulated sediment (LANL 2008b) and surveys that document sediment volume, we estimate that 0.16 kg of PCBs was deposited behind the weir between June 2000 and October 2008. This provides an average of about 0.02 kg/yr. The average trapping efficiency of the weir during this period is not certain, but using comparisons of suspended sediment concentrations in storm water samples at upstream and downstream gaging stations (E042 and E050, respectively) indicates that a 50% trapping efficiency for suspended sediment is a reasonable estimate. The average PCB flux reaching the weir may, therefore, have been about 0.04 kg/yr, and the flux continuing down canyon about 0.02 kg/yr. Because sediment is deposited downstream as floods attenuate, only part of this is expected to reach the Rio Grande, which is consistent with the lower estimate of 0.005 kg/yr farther down canyon than was presented in the previous paragraph.

The values presented above should be considered as preliminary estimates because of the small data set and the uncertainties and assumptions that went into these estimates. However, they provide a starting point for understanding the sources and fluxes of PCBs in the Rio Grande, and these estimates should be improved with additional data collection that is planned for 2010 from the Rio Grande, Cochiti Reservoir, and the Los Alamos Canyon watershed.

H. QUALITY ASSURANCE

To process watershed samples, the same quality assurance (QA) protocols and analytical laboratories described in Chapter 5 were used. Chapter 5 also describes the QA performance for the year.

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7. Soil Monitoring



contributing author:
Philip Fresquez

To Read About **Turn to Page**

Introduction 255
Soil Comparison Levels 256
Institutional Monitoring 256
Facility Monitoring 261
Special Monitoring Studies 268
Quality Assurance for the Soil, Foodstuffs, and Biota Monitoring Program 272
References 274

A. INTRODUCTION

A soil monitoring program offers the most direct means of determining the concentrations (activities), distribution, and long-term trends of radionuclides and chemicals present around nuclear facilities (DOE 1991). Soil is an integrating medium that can account for contaminants released to the atmosphere, either directly in gaseous emissions, indirectly from re-suspension of contamination, or through liquid effluents released to a stream that may be used for irrigation on farmlands. Consequently, soil contaminant data may provide information about potential pathways (e.g., soil ingestion, food ingestion, re-suspension into the air, and groundwater contamination) that could deliver radioactive materials or chemicals to humans and biota.

The overall soil surveillance program implemented by Los Alamos National Security, LLC, at the Los Alamos National Laboratory (LANL or the Laboratory) consists of:

1) An institutional component that monitors soil within and around the perimeter of LANL in accordance with US Department of Energy (DOE) Orders 450.1A (DOE 2003) and 5400.5 (DOE 1993);

2) A facility component that monitors soil (and sediment) within and around the perimeter of two Laboratory sites:

   - Principal radioactive waste disposal area (Area G) in accordance with DOE Orders 435.1 (DOE 1999a) and M 435.1-1 (DOE 1999b), and
   - Principal explosive test facility (Dual Axis Radiographic Hydrodynamic Test [DARHT]) in accordance with the Mitigation Action Plan (DOE 1996); and

3) A special studies component that investigates cases where there may be an absence of data concerning a localized (or potential) contaminant source that has the potential to impact human health and/or the environment as mandated from mitigation action plans, environmental surveillance program, or from public concern.

The objectives of LANL's soil surveillance program are to determine

1) Radionuclide and chemical (inorganic and organic chemicals) concentrations in soil collected from potentially impacted areas (institution-wide, facility-specific, or potential source) and compare them to the appropriate soil standards (e.g., regional background levels, screening levels, and standards);

2) Concentration trends over time (i.e., whether radionuclide and/or chemical concentrations are increasing or decreasing); and

3) The committed effective dose equivalent from radionuclides potentially received by surrounding area residents and biota (see Chapter 3 for the potential radiation doses that individuals and biota may receive from exposure to soil), and risk to residents and biota from heavy metal and organic chemical exposures.

B. SOIL COMPARISON LEVELS

To evaluate potential Laboratory impacts from radionuclides and chemicals in soil, we first compare the analytical results of samples collected from the Laboratory's on-site and perimeter areas with regional statistical reference levels (RSRLs). Where the results exceed these regional background levels, we then compare the concentrations with human health screening levels (SLs) and, finally, if needed, with the appropriate regulatory standard, if available. A more detailed description of the levels and/or the standard used to evaluate the results of radionuclides and chemicals in soil are given below. An overall summary can be found in Table 7-1.

- Regional Statistical Reference Levels (RSRLs): RSRLs are the mean plus three standard deviations (= 99% confidence level) of the average background for radionuclides and chemicals in soil collected from regional locations away from the influence of the Laboratory over at least the last five sampling periods. RSRLs, which represent natural and fallout levels, are calculated as additional data become available and can be found in the supplemental data tables of this report.
- Screening Levels (SLs): SLs for radionuclides are set below the DOE single-pathway dose limit of 25 mrem/yr (DOE 1993, DOE 1999c) so that potential human health concerns may be identified in advance, i.e., a "yellow flag." If a radionuclide exceeds the SL, we investigate the basis for the exceedance. LANL developed SLs to identify radionuclides of potential human health concern on the basis of a 15-mrem/yr protective dose limit for several scenarios (LANL 2005) using the residual radioactive (RESRAD) computer model (Yu et al. 1995). For other chemicals (inorganic and organic), we compare concentrations to the New Mexico Environment Department SLs that are set at a 10-5 risk level for carcinogens and a hazard quotient (HQ) of one for non-carcinogens (NMED 2006). To evaluate radionuclide and other chemicals in soil in the most conservative manner, the results from on-site and perimeter areas are compared to SLs based on a residential scenario, which assumes that a family lives at these locations on a year-round basis.
- Standard: If an SL for a radionuclide is exceeded, then a dose to a person is calculated using RESRAD and all of the measured radionuclide concentrations available for a given year. (These data are presented in Table S7-1.) The calculated dose is based on a residential scenario with soil ingestion, inhalation of suspended dust, external irradiation, and ingestion of homegrown fruits and vegetables as the exposure pathways. Unit conversions, input parameters, model and parameter assumptions, and the uncertainty analysis we used are presented in a report by Fresquez et al. (1996). This calculated dose is compared to the 25-mrem/yr DOE dose standard.

Table 7-1
Application of Soil Standards and Other Reference Levels to LANL Monitoring Data

Constituent	Sample Location	Standard	Screening Level	Background Level
Radionuclides	Perimeter, On-site, and Area G	25 mrem/yr	15 mrem/yr (residential)	RSRL
	DARHT	25 mrem/yr	15 mrem/yr (residential)	RSRL/BSRL[a]
Chemicals	Perimeter, On-site, Area G	na[b]	10^{-5} risk (residential) or HQ = 1	RSRL
	DARHT	na	10^{-5} risk (residential) or HQ = 1	RSRL/BSRL[a]

[a]Baseline Statistical Reference Level. A discussion of these levels is provided in Section D.3.

[b]na = Not available.

C. INSTITUTIONAL MONITORING

1. Monitoring Network

Institutional surface soil samples are collected from 17 on-site (LANL), 11 perimeter, and six regional (background) locations on a triennial basis (every third year) (Figure 7-1). Areas sampled at LANL are not from contaminated areas referred to as solid waste management units (SWMUs) or areas of concern (AOCs).

Instead, the majority of on-site soil sampling stations are located on undisturbed mesa tops close to and, if possible, downwind from major facilities or operations at LANL in an effort to assess soil that may have been contaminated from stack emissions and fugitive dust (the re-suspension of dust from SWMUs/AOCs and active firing sites). Monitoring of LANL, perimeter, and regional background soil sites has been conducted since the early 1970s (Fresquez et al. 1996).

On-site samples were collected from Technical Area (TA) 16 (S Site), TA-21 (DP Site), near TA-33, north of TA-50/35 at TA-60, TA-51, west of TA-53, east of TA-53, east of TA-54, Potrillo Drive at TA-36, near Test Well DT-9 at TA-49, R Site Road east at TA-15, and Two-Mile Mesa at TA-06. We also collected five additional samples from along the south side of State Road (SR) 502 within the TA-73 boundary—these points are downwind of TA-21 (the former plutonium processing facility) and associated SWMUs/AOCs including Material Disposal Areas (MDAs) A, B, and T.

The 11 perimeter stations, located within 2.5 mi of the Laboratory, were sampled to determine the soil conditions of the inhabited areas to the north (North Mesa, Sportsman's Club, Quemazon Trail, west airport, and east airport) and east of the Laboratory (White Rock, San Ildefonso, Otowi, and Tsankawi/PM-1). Additional samples were collected west of US Forest Service property (across from TA-8) and south on Bandelier National Monument property (near TA-49) to provide comprehensive coverage.

Soil sample (analysis) data from on-site and perimeter stations are compared with RSRLs. These RSRLs are derived from samples collected from regional locations from northern New Mexico that surround the Laboratory in all major directions and where radionuclides and chemicals in soil are primarily from natural sources or worldwide fallout events. These regional areas are located near Ojo Sarco, Dixon, and Borrego Mesa (near Santa Cruz dam) to the northeast; Rowe Mesa (near Pecos) to the southeast; Youngsville to the northwest; and Jemez to the southwest. All locations are at similar elevations as LANL, are more than 20 miles away from the Laboratory, and are beyond the range of potential influence from normal Laboratory operations as required by the DOE (DOE 1991).

2. Methods and Analysis

At each site, soil composite samples for radionuclides and target analyte list (TAL) elements (mostly metals) were collected with a stainless steel soil ring 4 inches in diameter pushed 2 inches deep at the center and corners of a 33-ft by 33-ft square area. The five samples per site were combined and mixed thoroughly in a large Ziploc bag to form a composite sample. Composite samples were then placed in pre-labeled 500-mL polyethylene bottles, sealed with chain-of-custody tape, and placed into individual Ziploc bags. All samples were handled and shipped under full chain-of-custody procedures to Paragon Analytics, Inc., for analysis. These samples were analyzed for tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, uranium-238, and for 23 TAL elements (aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, antimony, arsenic, cadmium, lead, selenium, silver, thallium, and mercury).

In addition, soil grab samples from each site were collected from the 0- to 6-in. depth with disposable polystyrene scoops for the analysis of seven polychlorinated biphenyl (PCB) Aroclors, 65 semi-volatile organic compounds (SVOCs), and 23 high explosive (HE) compounds. Individual samples were placed into a pre-labeled 500-mL amber-colored glass jar, sealed with chain-of-custody tape, placed into a Ziploc bag, and immediately cooled to 4° C. All samples were handled and shipped under full chain-of-custody procedures to GEL (General Engineering Laboratory) Analytics, Inc., for analysis.

The results from these sample analyses are presented in supplemental Tables S7-1 to S7-5. (Note: We report on the analyses of radionuclides and TAL elements in vegetation collected from these same sites in Chapter 8, Section B.3.)

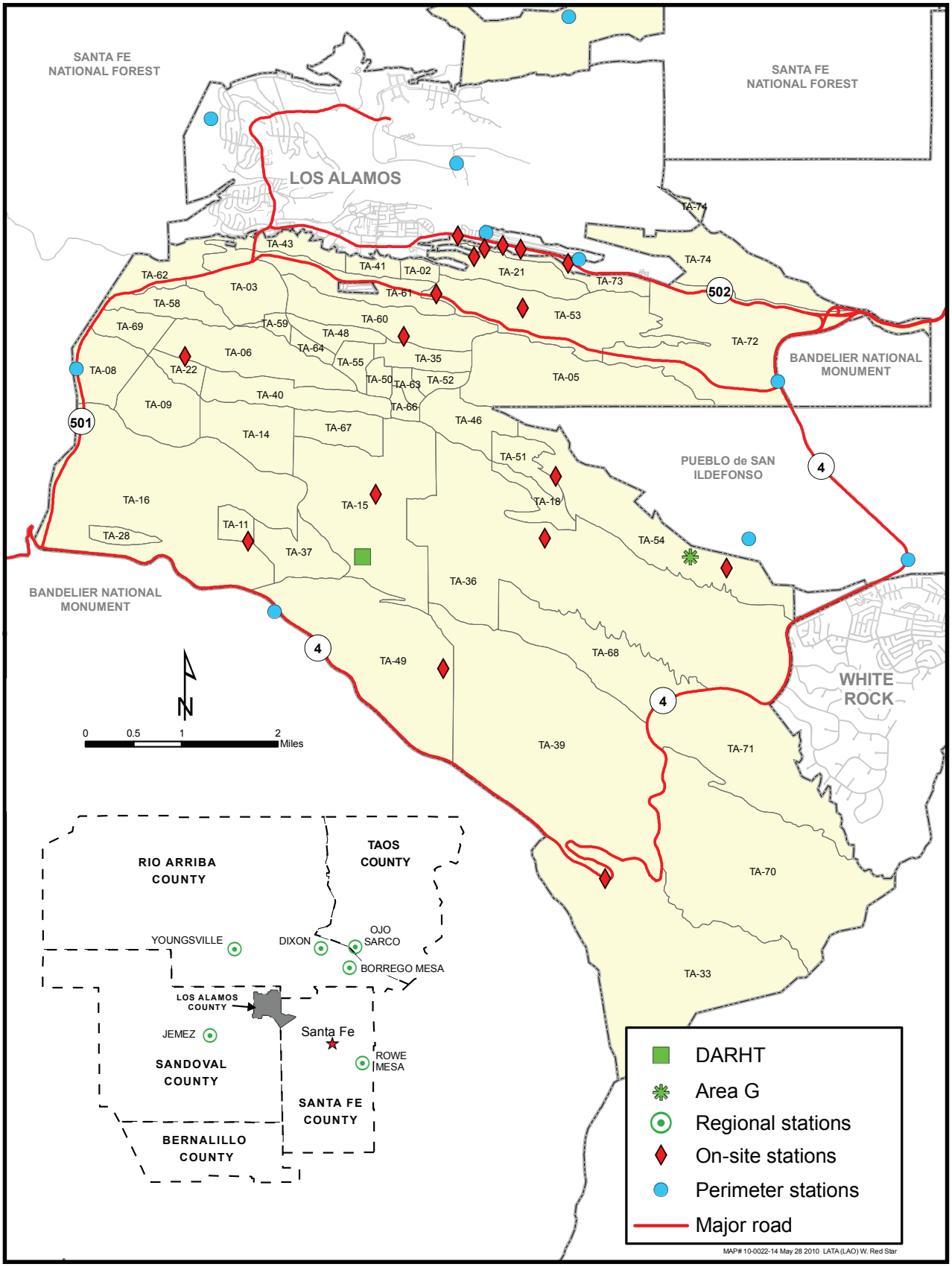


Figure 7-1. **On-site, perimeter, and regional soil sampling locations. The Otowi perimeter station is not shown but is about five miles east of LANL on SR 502.**

3. Radionuclides

All radionuclide (activity) concentrations in soil collected from perimeter and on-site areas in 2009 were very low (pCi/g range), and most were either not detected or detected below the RSRLs (Table S7-1). A non-detected value is one in which the result is lower than three times the counting uncertainty and is not significantly different (α = 0.01, or 99% confidence level) from zero (Keith 1991, Corely et al. 1981) or less than the minimum detectable activity. These data are very similar to past results (Fresquez 2007).

In perimeter soils, the only radionuclide that was detected in higher concentrations than the RSRL was plutonium-239/240 and only at a few sites; these sites were located on the western (across from TA-8 [GT Site]) and northern (east airport and west airport) sides of LANL. The amounts of plutonium-239/240 in these soils, however, were far below residential SLs and are generally not increasing over time (Figure 7-2).

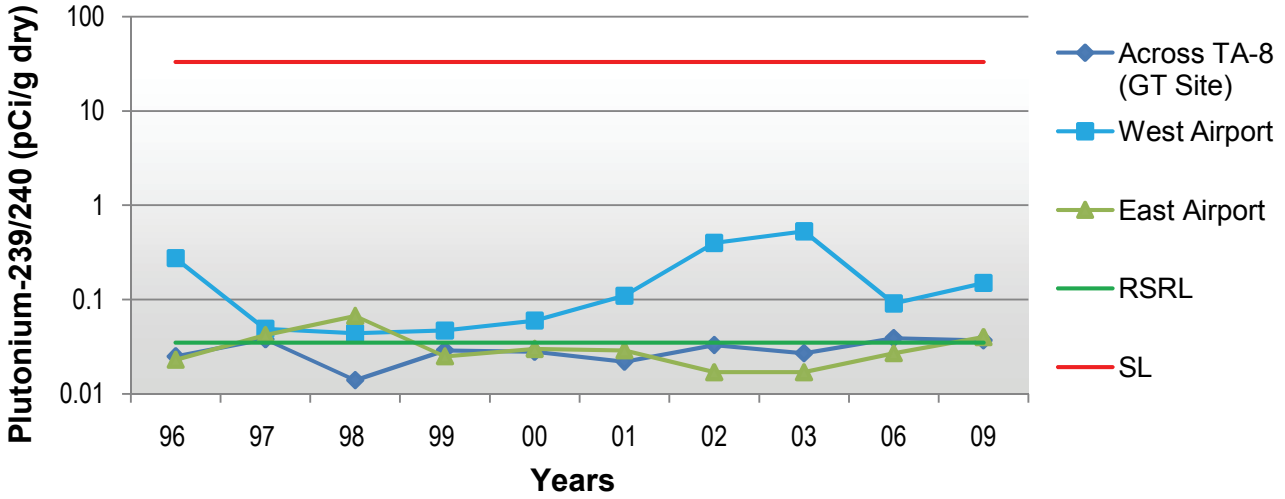


Figure 7-2. Plutonium-239/240 concentrations in soil samples collected from three perimeter locations—across TA-8 (GT Site), west airport, and east airport stations—from 1996 through 2009 as compared with the regional statistical reference level (RSRL) and the screening level (SL). Note the logarithmic scale on the vertical axis.

Similarly, the only radionuclides in soil collected from on-site areas with any significance included plutonium-239/240 and americium-241 at two general locations within the Laboratory. These two locations were at (1) the northern part of the Laboratory along SR 502 at TA-73 (downwind of the former plutonium processing facility and/or its associated SWMUs/AOCs at TA-21) and (2) the eastern portion of the Laboratory downwind of Area G at TA-54.

With respect to the location at the northern part of the Laboratory downwind of the former plutonium processing facility, plutonium-239/240 (and some americium-241) was detected above the RSRLs in all five samples that were collected along SR 502 at TA-73—the highest is approximately 13 times background. These sites are across the street from the two perimeter sites, identified as "east airport and west airport," that also contained higher amounts of plutonium-239/240 than the RSRL. Although the concentrations of plutonium-239/240 and americium-241 in soil from these areas along SR 502 at TA-73 were above RSRLs, they were still far below residential SLs and are generally not increasing over time (Figures 7-3 and 7-4).



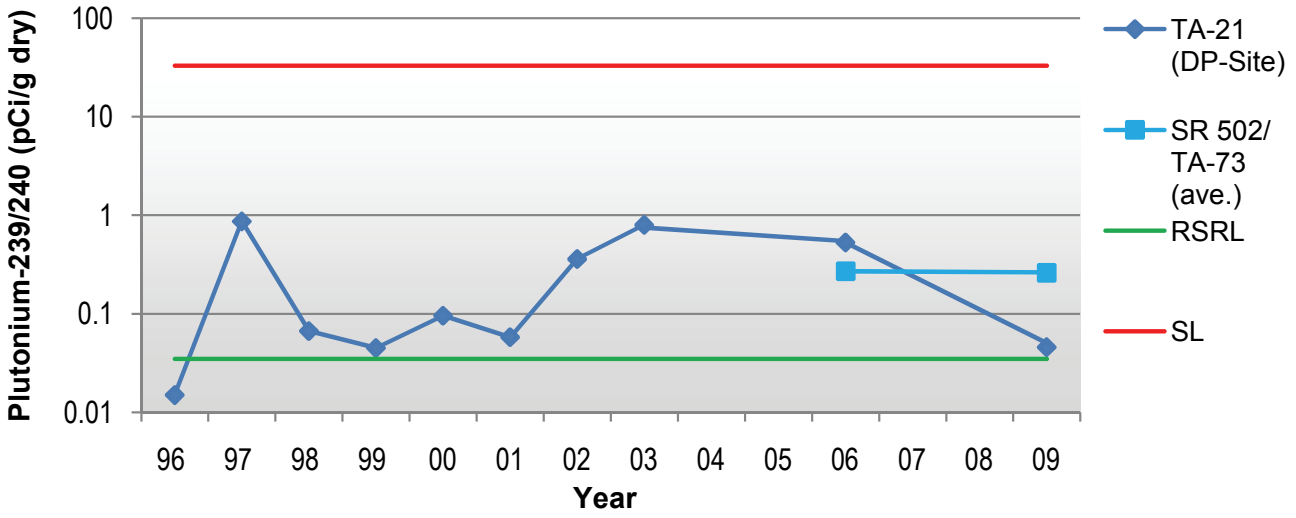


Figure 7-3. **Plutonium-239/240 concentrations in soil samples collected from the TA-21 (DP Site) and SR 502 at TA-73 (average) stations from 1996 through 2009 as compared with the regional statistical reference level (RSRL) and the screening level (SL). Note the logarithmic scale on the vertical axis.**

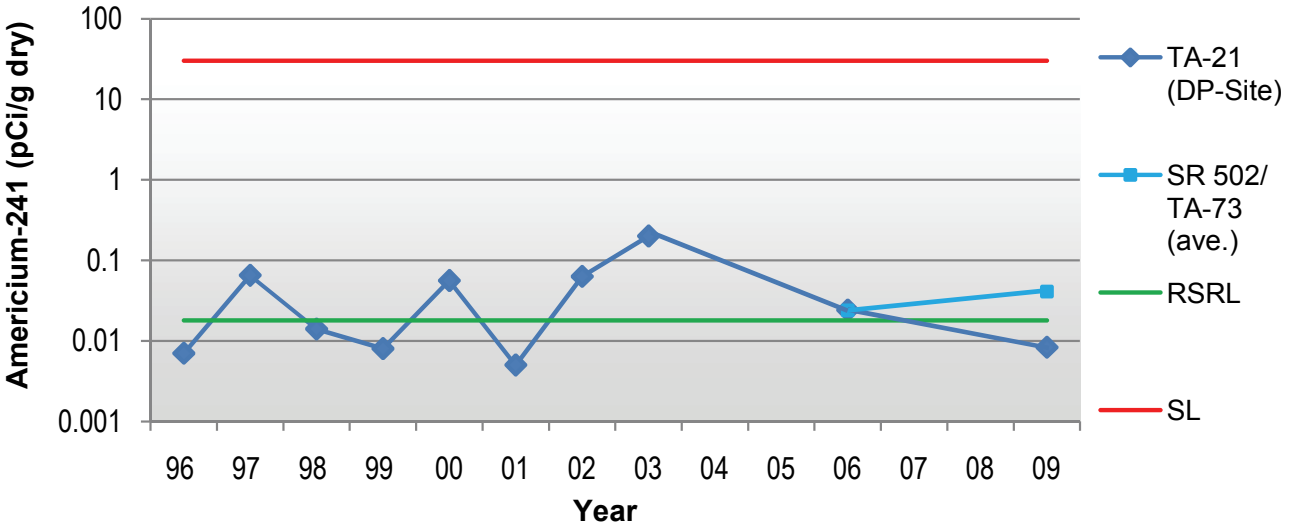


Figure 7-4. **Americium-241 concentrations in soil samples collected from the TA-21 (DP Site) and SR 502 at TA-73 (average) stations from 1996 through 2009 as compared with the regional statistical reference level (RSRL) and the screening level (SL). Note the logarithmic scale on the vertical axis.**

The other on-site area where levels of plutonium-239/240 and americium-241 were detected above the RSRLs was located near the eastern portion of the Laboratory downwind of Area G at TA-54. Plutonium-238 was also detected in higher concentrations above the RSRL at this location. In general, all radionuclide concentrations in the area downwind of Area G are far below the residential SLs and are not increasing over time. For a more detailed description of potential contaminants measured directly around the perimeter of Area G, which is the source of the downwind measurements mentioned above, see Section D.1 of this chapter.

4. TAL Elements

Supplemental data Table S7-2 shows the results of the TAL element analyses in surface soil collected from regional, perimeter, and on-site areas in 2009. Nearly all of the TAL elements in soil collected from perimeter and on-site areas were below the RSRLs; and only one, manganese (3,600 mg/kg), was slightly above the residential SL of 3,590 mg/kg at one on-site location—Two Mile Mesa at TA-06. It is not known why there is a spike in the manganese levels from 390 mg/kg in 2006 to 3,600 mg/kg in 2009 at this on-site monitoring station because there are no physical disturbances nor are there any operations using manganese-containing chemicals in the immediate area; and a review of past data at this site since 1992 shows only normal levels that average around 500 mg/kg. Moreover, there is no evidence of widespread manganese contamination within the Laboratory since all of the other on-site (and perimeter) stations were at typical levels.

As per our protocol, we will follow up with the collection of more soil samples at this site in 2010 to determine the reason for this SL exceedance; however, at the present time, the risk to members of the general public from potential manganese contamination would be minimal as there is no access to this area nor is it located by any public road. Moreover, the risk to workers would also be minimal as the concentrations are far below the industrial/occupational levels of 48,400 mg/kg.

With respect to the potential risk to biota, the amounts of manganese in the soil samples would exceed the ecological SL for three of the 10 receptors: the deer mouse (>1,200 mg/kg), desert cottontail (>1,700 mg/kg), and shrew (>1,300 mg/kg) (LANL 2008). Again, the relatively high levels of manganese in soil at this location will be reevaluated, but the overall average (500 mg/kg) over the years is well below the ESLs and does not appear to be widespread.

5. HE, PCBs, and SVOC Chemicals

Concentrations of HEs, PCBs (Aroclors), and SVOCs in soils collected from regional, perimeter, and on-site locations can be found in Tables S7-3, S7-4, and S7-5, respectively. No HEs were detected above the reporting level of quantification in any soil collected from regional, perimeter, or on-site locations. And, only trace amounts of a few PCB Aroclors (Aroclor 1254 and 1260) and SVOCs (aniline and fluoranthene) in soil from a few sites were detected; however, these levels were far below the residential SLs and no trends are evident.

D. FACILITY MONITORING

1. Monitoring Network for Area G at TA-54

The Laboratory conducts facility-specific soil monitoring on an annual basis at Area G (Lopez 2002). Area G is a 63-acre radioactive waste processing area located on the east end of Mesa del Buey at TA-54 (see Figure 7-1). Established in 1957, Area G is the Laboratory's primary low-level radioactive solid waste burial and storage site (Hansen et al. 1980, Soholt 1990). Tritium, plutonium, americium, uranium, and a variety of fission and activation products are the main radionuclides in waste materials disposed at Area G (DOE 1979).

Section D.2, below, reports on the 13 surface soil samples collected in 2009 at designated locations around the perimeter of Area G and one surface soil sample (site #T3) collected at the LANL/Pueblo of San Ildefonso boundary line approximately 800 ft northeast of Area G (Figure 7-5).

All samples were analyzed by Paragon Analytics, Inc., for tritium, americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. The results from these samples are presented in supplemental Table S7-6.

TAL elements were not analyzed in 2009 because previous sampling in 2006 showed no concern. Results from that sampling period showed that most metals (478 out of 483 measurements) were similar to RSRLs (Fresquez 2007), and the few detected above RSRLs were far below the residential SLs and no trends were evident.

2. Radionuclide Analytical Results for Area G

a. Perimeter Results

Tritium, americium-241, plutonium-238, and plutonium-239/240 were detected at concentrations above the RSRLs in several of the 13 soil samples collected around the perimeter of Area G in 2009 (Table S7-6).

Specifically, tritium was detected above the RSRL (0.80 pCi/mL) in 23% of the samples collected around Area G. The highest concentration (1,720 pCi/mL) occurred in the southern portion (around site #29-03) where the tritium shafts are located. Although these data are within the range of concentrations detected in past years (Fresquez et al. 2004, Fresquez and Lopez 2004, Fresquez et al. 2005, Fresquez 2007) they are quite variable from year to year (Figure 7-6).

The degree of variability in tritium concentrations in surface soil from year to year may be influenced by engineering (leaking underground storage shafts) and environmental factors (geology, precipitation, temperature, and barometric pressure) (Purtymun 1973, Abeele and Nyhan 1987, Vold 1997, Childs and Conrad 1999, Budd et al. 2004). Nonetheless, with the exception of 2002 and 2003, the concentrations of tritium in soil at Area G have been mostly below the residential SL of 5,400 pCi/mL (equivalent to 750 pCi/g), and the migration of tritium from the Area G boundary, at least at surface depths, is not extensive. In a 2003 study, the measurement of tritium in trees at the southern portion of Area G, starting from the perimeter fence line outward (approximately 33, 165, 330, 490, and 660 ft), showed that the concentrations of tritium decreased greatly with distance; and at about 330 ft away, the concentrations were similar to the RSRL (Fresquez et al. 2003).

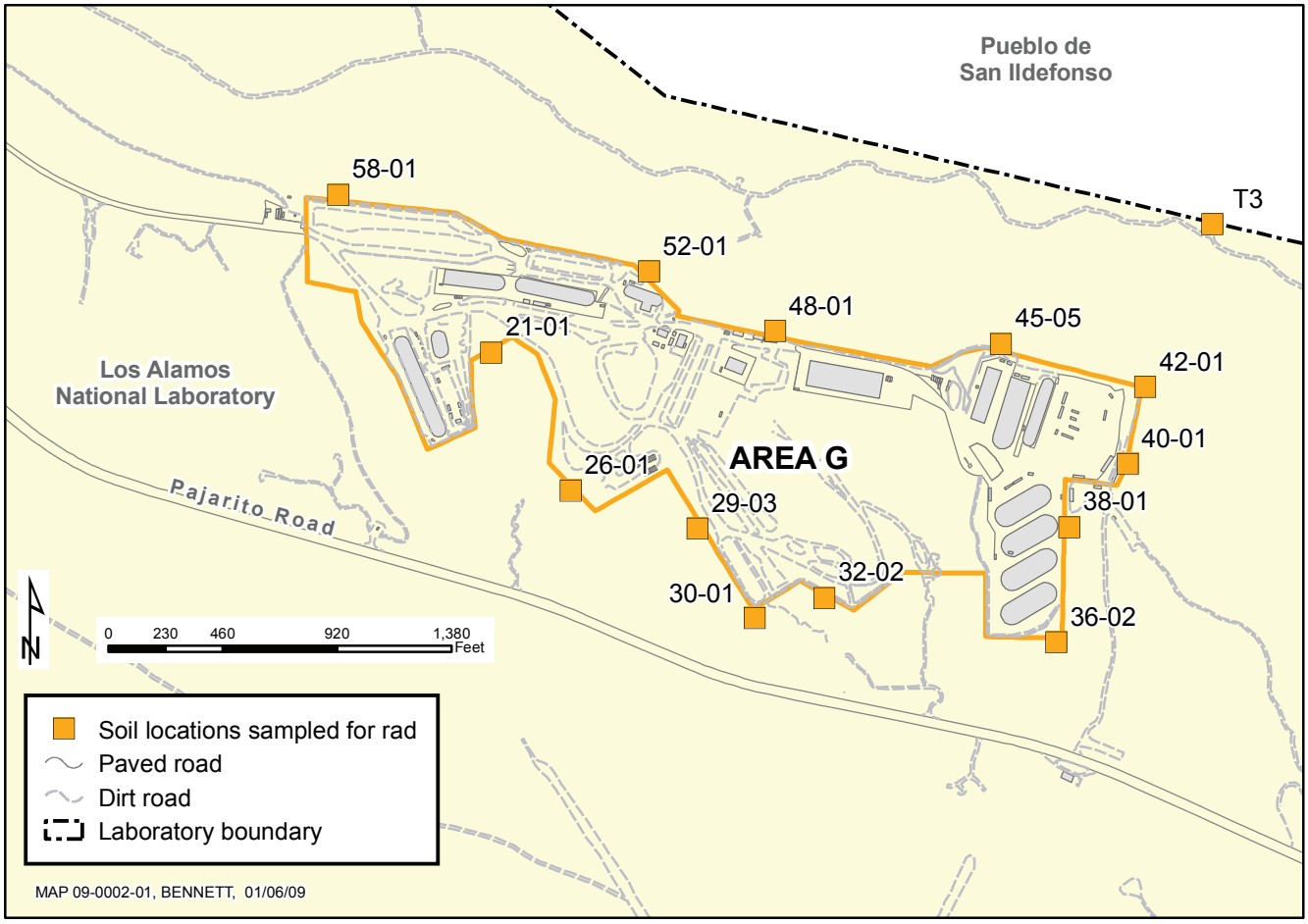


Figure 7-5. Locations of soil samples collected around Area G in 2009.

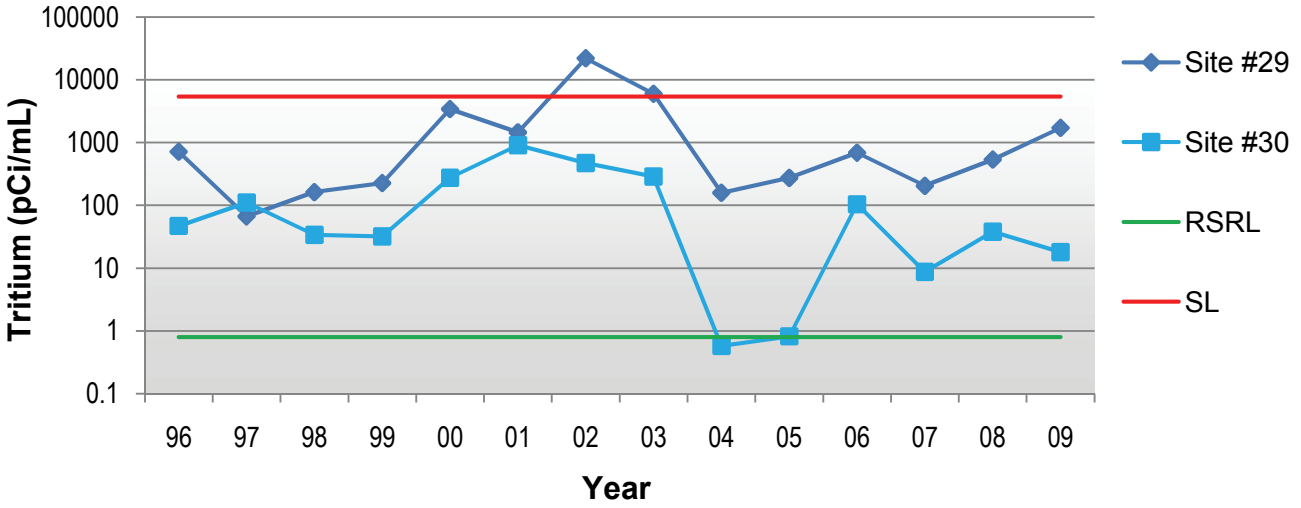


Figure 7-6. Tritium in surface soil samples collected from the southern portions of Area G at TA-54 from 1996 through 2009 as compared with the regional statistical reference level (RSRL) and the residential screening level (SL). Note the logarithmic scale on the vertical axis.

With respect to the concentrations of americium-241, plutonium-238, and plutonium-239/240 in soil collected around the perimeter of Area G, over 50% of the samples contained higher amounts than their respective RSRLs, particularly around the perimeter of the northern, northeastern, and eastern sections (Table S7-6). The highest concentrations of americium-241 (0.32 pCi/g dry at site #40-01), plutonium-238 (6.4 pCi/g dry at site #40-01), and plutonium-239/240 (1.3 pCi/g dry at site #38-01) were detected in soil samples located on the perimeter of the eastern side of Area G near the Transuranic Waste Inspection Project domes. Although the concentrations of these radionuclides in soil collected around the perimeter of Area G are higher than the RSRLs, all levels are still below residential SLs and, except for being highly variable from year to year at some points, they are generally not increasing over time (Figures 7-7, 7-8, and 7-9).

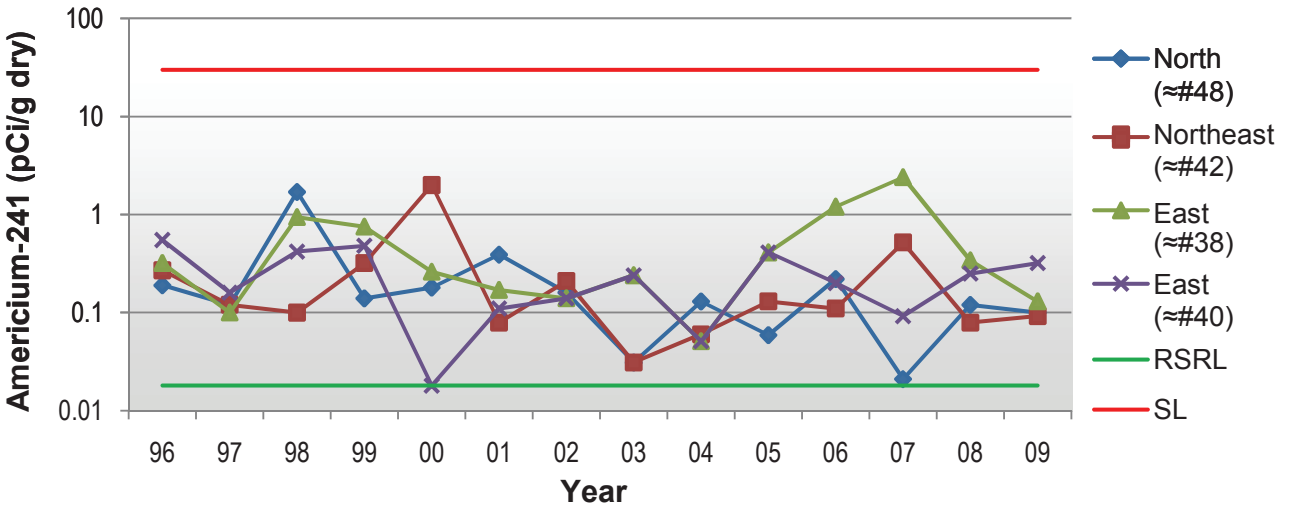


Figure 7-7. Americium-241 in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 through 2009 as compared with the regional statistical reference level (RSRL) and the residential screening level (SL). Note the logarithmic scale on the vertical axis.

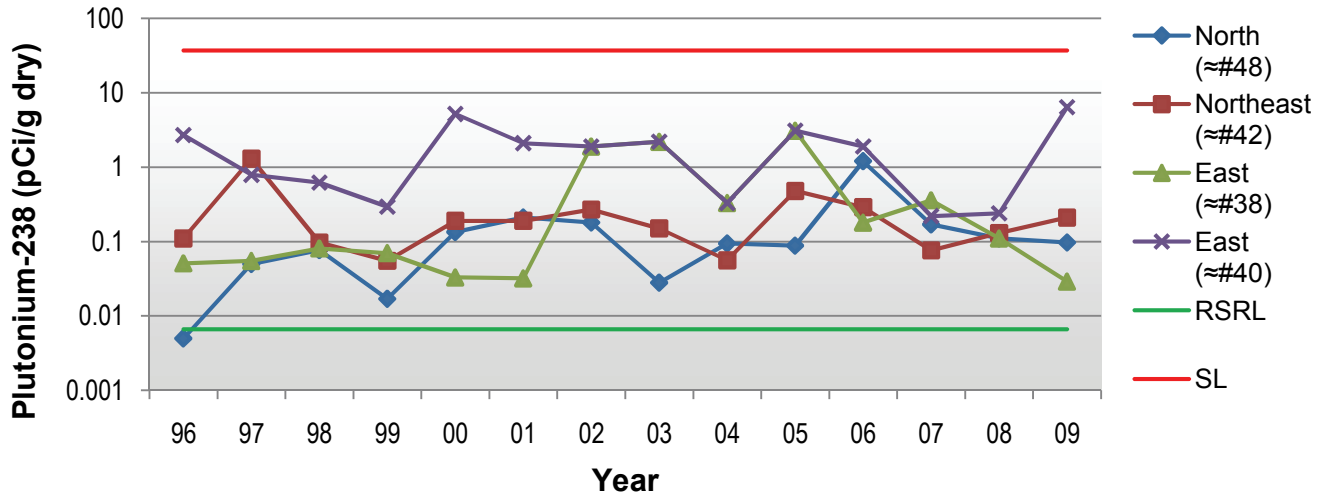


Figure 7-8. **Plutonium-238 in surface soils collected from the northern, northeastern, and eastern portions of Area G at TA-54 from 1996 through 2009 as compared with the regional statistical reference level (RSRL) and the residential screening level (SL). Note the logarithmic scale on the vertical axis.**

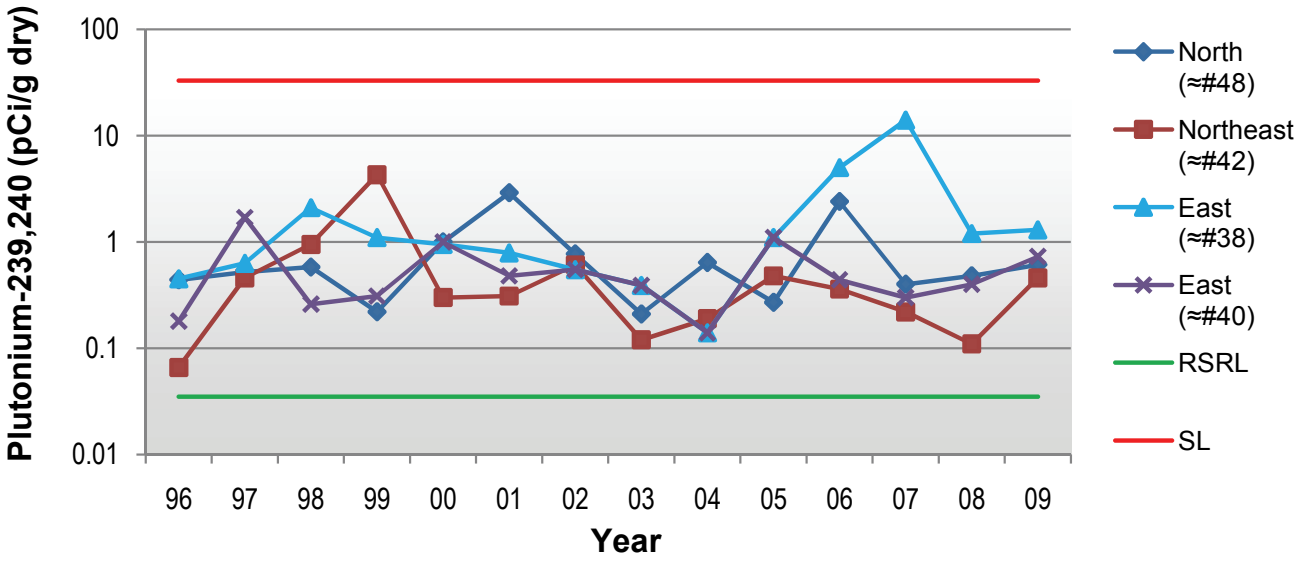


Figure 7-9. **Plutonium-239/240 in surface soils collected from the northern, northeastern and eastern portions of Area G at TA-54 from 1996 through 2009 as compared with the regional statistical reference level (RSRL) and the residential screening level (SL). Note the logarithmic scale on the vertical axis.**

b. Results at the Pueblo de San Ildefonso Boundary

Americium-241 and plutonium-238 in a soil sample collected at the LANL/Pueblo de San Ildefonso boundary northeast and down gradient of Area G (Site #SI-T3) were detected at concentrations just above the RSRLs in 2009 (Table S7-6). However, the levels of these radionuclides were far below the residential SLs and have generally remained stable over the four-year time period of study (Figures 7-10 and 7-11).

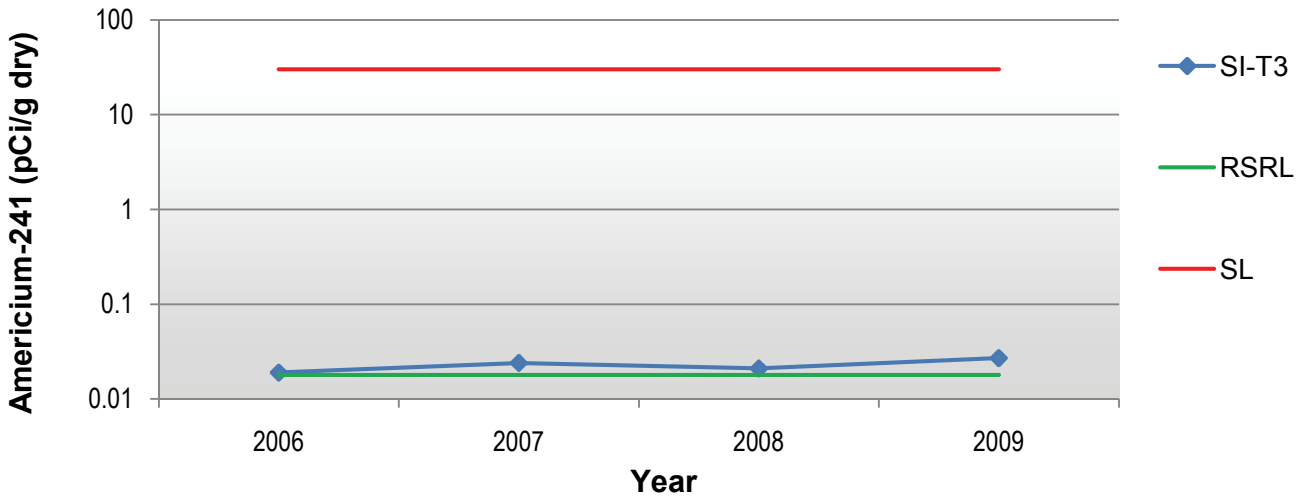


Figure 7-10. **Americium-241 in surface soil collected from the LANL/Pueblo of San Ildefonso boundary (SI-T3) northeast of Area G at TA-54 from 2006 through 2009. Note the logarithmic scale on the vertical axis.**

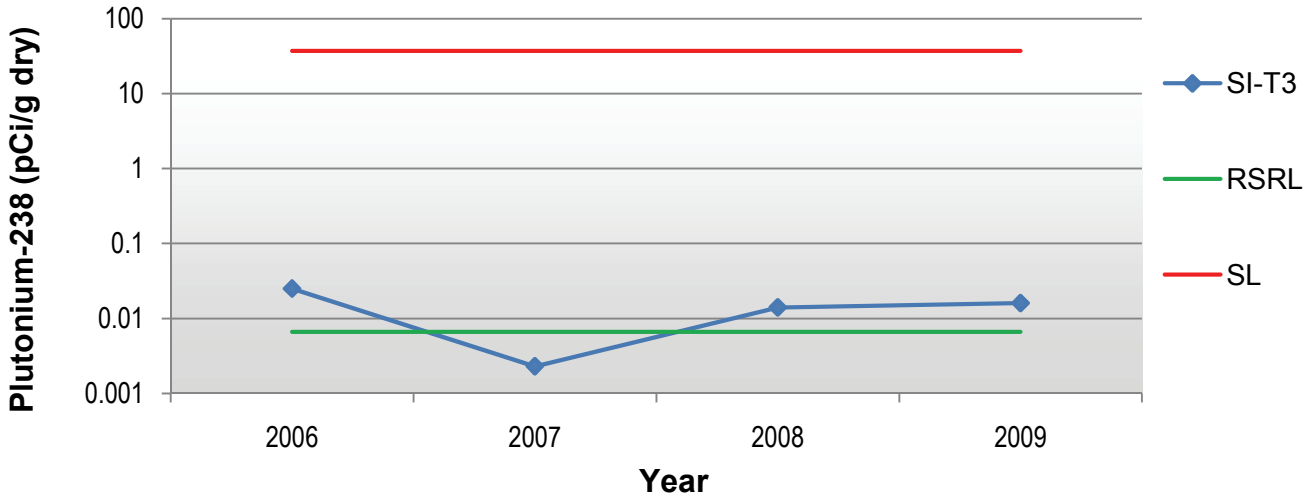


Figure 7-11. **Plutonium-238 in surface soil collected from the LANL/Pueblo of San Ildefonso boundary (SI-T3) northeast of Area G at TA-54 from 2006 through 2009. Note the logarithmic scale on the vertical axis.**

3. Monitoring Network for DARHT at TA-15

The Laboratory conducts facility-specific soil and sediment monitoring on an annual basis at DARHT (Nyhan et al. 2001). Approximately 20 acres in size, DARHT is located at R-Site (TA-15) at the Laboratory's southwestern side (see Figure 7-1). Activities at DARHT include the use of very intense X-rays to radiograph a full-scale non-nuclear mock-up of a nuclear weapon's primary during the late stages of the explosively driven implosion of the device (DOE 1995). Open-air detonations occurred from 2000 to 2006; detonations using foam mitigation were conducted from 2002 to 2006; and detonations within closed steel containment vessels were conducted starting in 2007 (three in FY 2007, two in FY 2008, and none in FY 2009) (DOE 2009, 2010). Potential contaminants include radionuclides, beryllium (and other heavy metals), and organic chemicals like PCBs, SVOCs, and HEs.

Soil samples analyzed for radionuclides and TAL elements were collected around the perimeter of the DARHT facility on the north, east, south, and west sides (Figure 7-12). An additional soil sample was collected on the north side near the firing point. Sediment samples were collected on the north, east, south,

and southwest sides. All samples were analyzed for tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, uranium-238, TAL elements, and HEs. Although not analyzed in 2009, PCBs and SVOCs were not detected in soil and sediment samples collected within and around the perimeter of the DARHT facility in 2007 (Fresquez et al. 2008). (Note: We report on the analyses of vegetation, small mammals, bees, and birds collected around the DARHT facility in Chapter 8, Section B.4.b.)

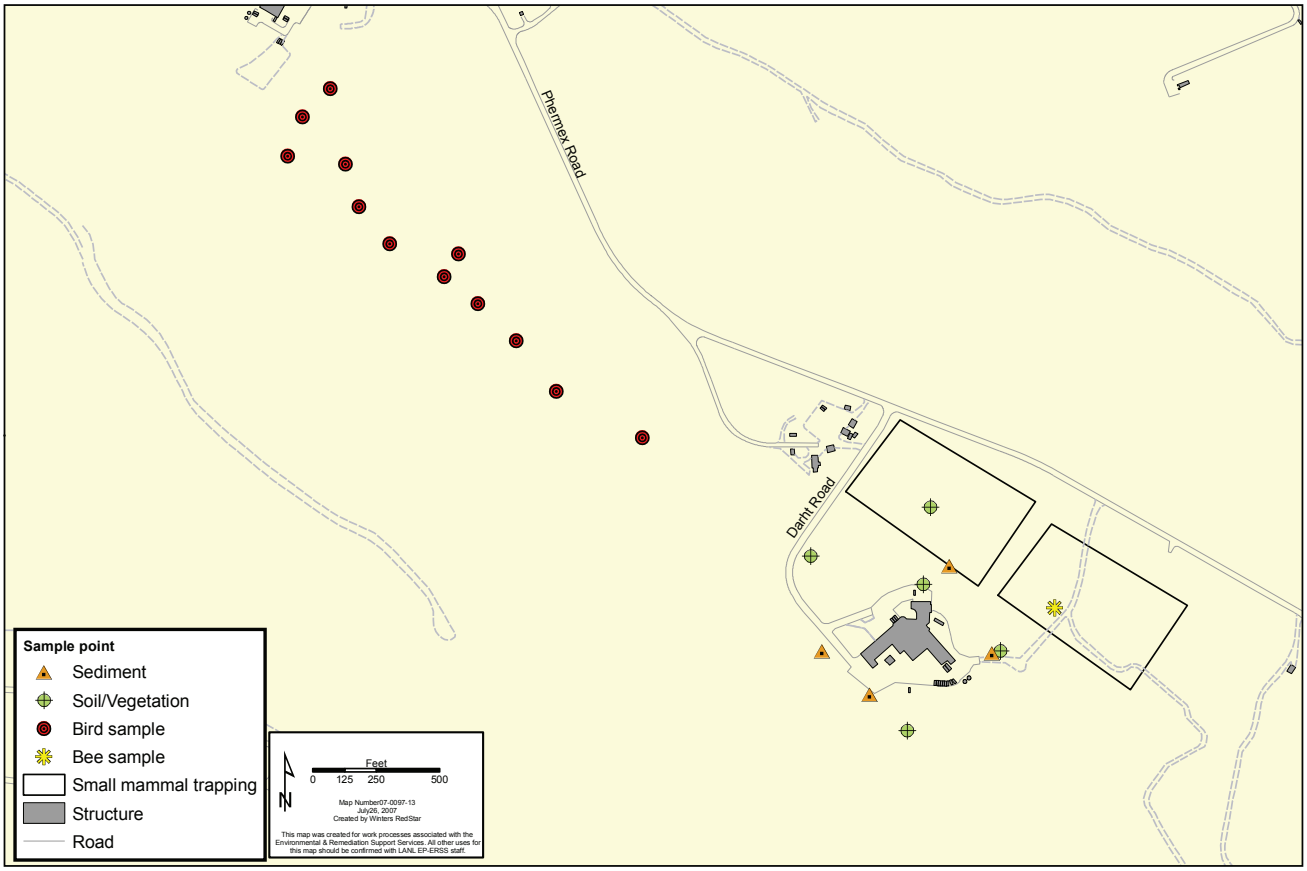


Figure 7-12. Soil, sediment, and biota sample locations at DARHT in 2009.

We compared the radionuclide and TAL element results in soil and sediment from the DARHT sampling to both RSRLs and baseline statistical reference levels (BSRLs). BSRLs are the concentrations of radionuclides and inorganic chemicals (mean plus three standard deviations) in soil and sediment collected from around the DARHT facility from1996 through 1999 before the start-up of operations (Fresquez et al. 2001), per the DARHT Mitigation Action Plan (DOE 1996). Both reference levels are employed because the BSRLs for some elements may be biased as a result of changes in pre- and post-sampling locations and a change in analytical techniques. A comparison of BSRLs with RSRLs, for example, shows some baseline radionuclide concentrations, like (fallout) cesium-137, may be biased low and some baseline inorganic chemical concentrations, like silver, may be biased high irrespective of DARHT activities. Moreover, some TAL elements analyzed recently have no baseline levels at all. To accommodate parking spaces and storage areas within the DARHT complex after operations began, soil sampling locations had to be moved from within the fenced perimeter boundary (<100 ft from the facility) to sites located outside the perimeter fence boundary (>300 ft from the facility). This may have affected the concentrations of some radionuclides, particularly (fallout) cesium-137, because the pre-operation samples were collected in mostly disturbed soil and the post-operation samples were collected in mostly undisturbed soil.

Higher amounts of fallout radionuclides would be expected in the undisturbed soil rather than the disturbed soil because of the mixing associated with disturbed soil. Moreover, the change in analytical techniques may have improved detection capabilities for some metals. The use of inductively coupled plasma mass spectrometry instrumentation to analyze post-operation samples, for example, substantially decreased the detection limits of silver, from 2 to 0.2 mg/kg.

4. Radionuclide and Chemical Analytical Results for DARHT

Most radionuclides, with the exception of uranium isotopes, in soil and sediment collected from within and around the perimeter of the DARHT facility were either not detected or below the statistical reference levels (Table S7-7). Uranium isotopes, but predominantly uranium-238, were detected above the BSRL in over 50% of the soil samples collected from within and around the perimeter of the DARHT facility. The highest amount of uranium-238 was detected in a soil sample collected just north of the firing point (5.7 pCi/g dry) (the firing point has since been paved); however, this amount was dramatically lower than the three previous years, particularly in 2008 (55 pCi/g dry), and far below the residential SL (Figure 7-13). The general decrease in concentration of uranium-238 in soil collected around the perimeter since 2006 and the significant decrease near the firing point since 2008 may be due to the following factors: a change in the contaminant mitigation procedures at the DARHT facility from open and/or foam mitigation (2000–2006) to closed steel containment (vessel) mitigation starting in 2007, a decrease in the number of detonations in the latter years (three in FY 2007, two in FY 2008, and none in FY 2009), and/or to the paving over of the firing site point thereby reducing the potential for further soil contamination and, actually, has made it easier for post-detonation cleanups.

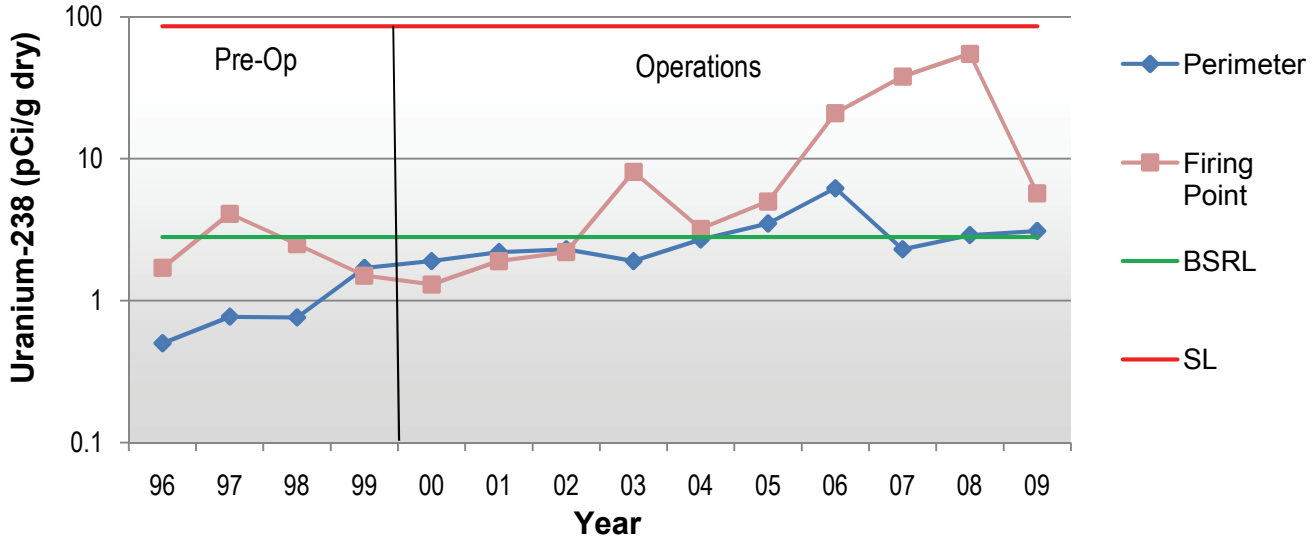


Figure 7-13. Uranium-238 concentrations in surface soil collected within (near the firing point) and around the DARHT perimeter (north, west, south, and east side average) at TA-15 from 1996–1999 (pre-operations) to 2000–2009 (during operations) as compared with the baseline statistical reference level (BSRL) and the residential screening level (SL). Note the logarithmic scale on the vertical axis.

Most of the TAL elements, with the exception of sodium, in soil and sediment samples collected within and around the DARHT facility were below both the statistical reference levels (Table S7-8). It is not clear why there would be an elevated level of sodium around the perimeter of the DARHT facility (it was also high in past 2007 and 2008 years); perhaps it is associated with deicing operations around the parking lot grounds, but, in any case, the levels are not considered hazardous as there are no SLs for sodium.

Beryllium, listed as a chemical of concern prior to the start up of operations at DARHT (DOE 1995), was not detected in any of the soil or sediment samples above reference levels. Also, beryllium concentrations in soil over the 10-year operations period has been mostly below the BSRL and remains relatively stable over time (Figure 7-14).

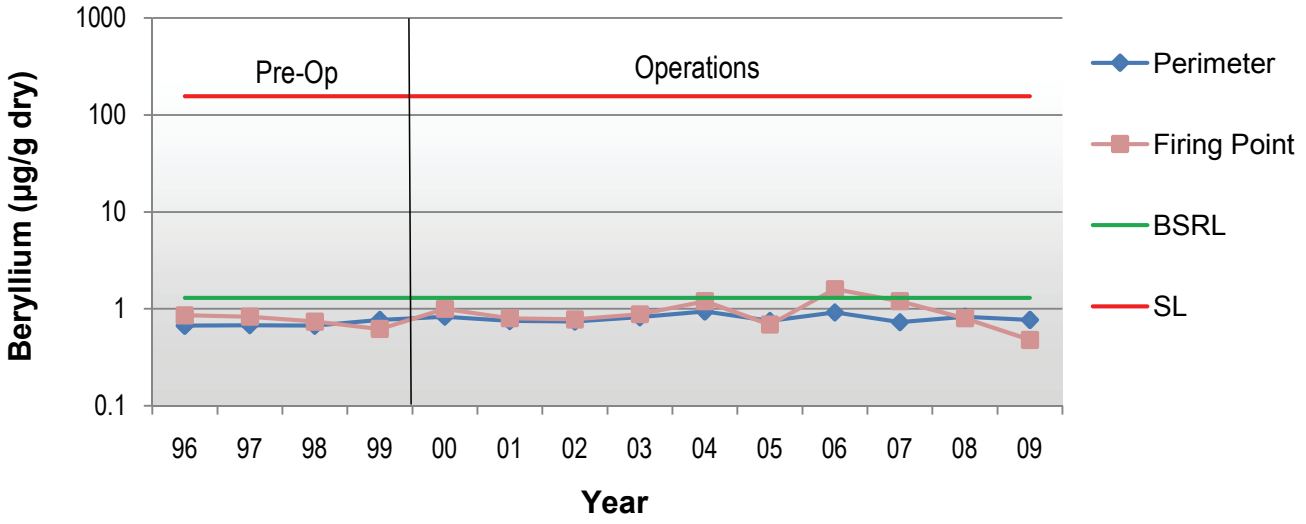


Figure 7-14. **Beryllium concentrations in soil collected within (near the firing point) and around the DARHT perimeter (north, west, south, and east side average) at TA-15 from 1996–1999 (pre-operations) to 2000–2009 (during operations) as compared with the baseline statistical reference level (BSRL) and the residential screening level (SL).**

HEs were not detected in any of the soil or sediment samples collected within and around the perimeter of the DARHT facility, including those closest to the firing point (Table S7-9).

E. SPECIAL MONITORING STUDIES

1. Cesium-137, Plutonium-238, and Plutonium-239/240 Concentrations in Soil Collected along the North Side of East Jemez Road

Recently, there has been considerable interest in the amounts of plutonium-239/240 emitted during the Manhattan Project from the original technical area #1, TA-1, which was situated between Ashley Pond and Los Alamos Canyon. D-building at TA-1, was the world's first plutonium processing facility, and was the primary plutonium facility until the work was moved to DP-West at TA-21 in late 1945.

Plutonium emissions may be estimated from the deposition of plutonium on the ground near the emission point. To do so, the results from nominal emissions are calculated using the CAP88 computer program, and the emissions are deduced by comparing the calculated and expected depositions.

To this end, fourteen soil samples on the north side of East Jemez Road along a 2.25-mile section were collected for the analysis of plutonium-239/240 (and other radionuclides like cesium-137 and plutonium-238) (Figure 7-15). These sites are also located on the south side of historic plutonium processing operations at TA-1 and TA-21.

At each location, a composite soil surface (0- to 2-inch depth) sample (five subsamples within a 33-ft by 33-ft square) was collected from an undisturbed level area, thoroughly mixed, and divided into five separate poly bottle containers so that one cesium-137, plutonium-238, plutonium-239/240 analysis was performed on the sample in one container and plutonium-238 and plutonium-239/240 could be measured from the other four containers. This was accomplished to measure variability within sample locations. Overall, this study resulted in a total of 14 cesium-137 measurements and 70 results each for plutonium-238 and plutonium-239/240. The results can be found in Table S7-10.

Most concentrations of cesium-137 and plutonium-238 in soil collected along the length of the study area were either not detected or below the RSRL. In contrast, most plutonium-239/240 results were higher than the RSRL (>0.035 pCi/g dry) with the highest directly south of TA-1 (average = 0.13 pCi/ g dry) and TA-21 (average = 0.16 pCi/g dry). All concentrations of plutonium-239/240, however, are far below the residential SLs of 33 pCi/g dry (Figure 7-16).

In general, the concentrations of plutonium-239/240 between sites are within about a factor of three, which indicates that the historical emissions from these two historical facilities were similar within about a factor of three. Detailed calculations and results of historical emissions will be published later in 2010 (Mike McNaughton, personal communication, May 25, 2010).

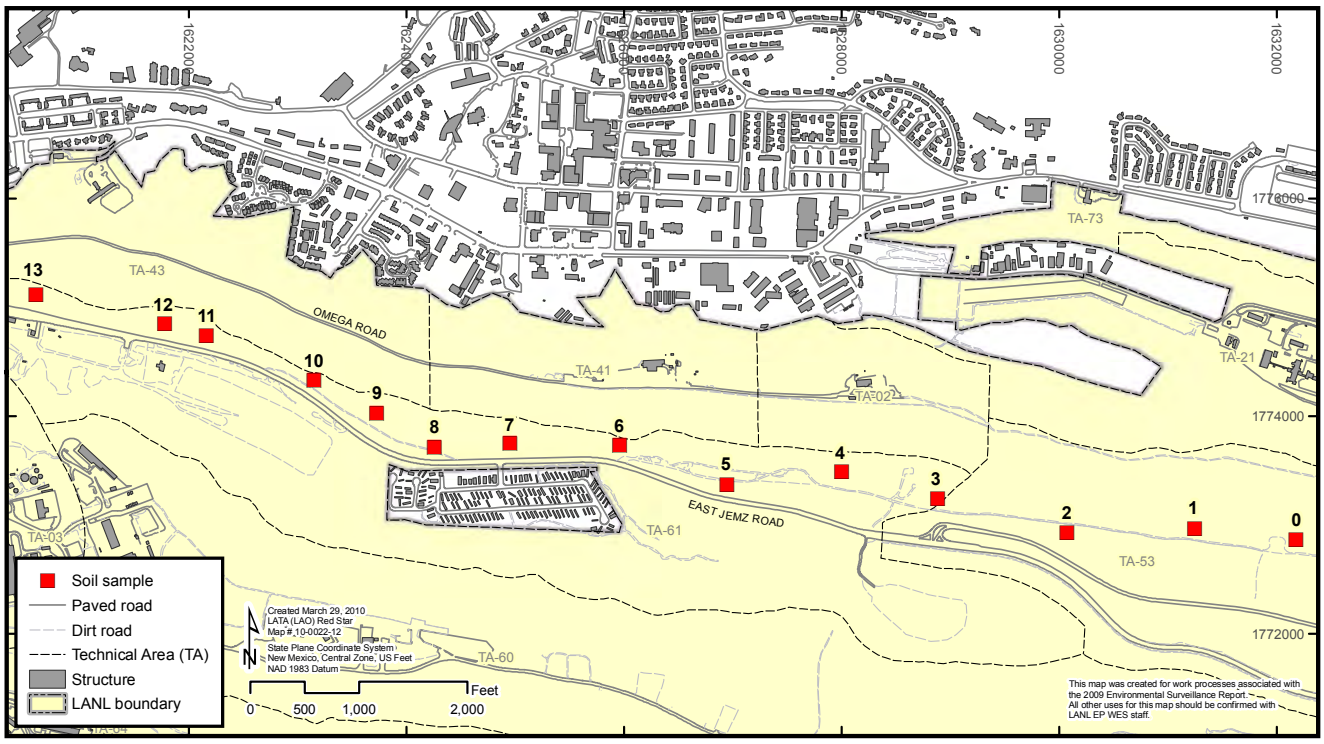


Figure 7-15. **Soil sample locations along a 2.25-mile section on the north side of East Jemez Road (and on the south side of major historic plutonium processing facilities TA-1 and TA-21). (Note: TA-1 is not shown but is north of TA-41/TA-43; and D-building at TA-1 was directly north of #9).**

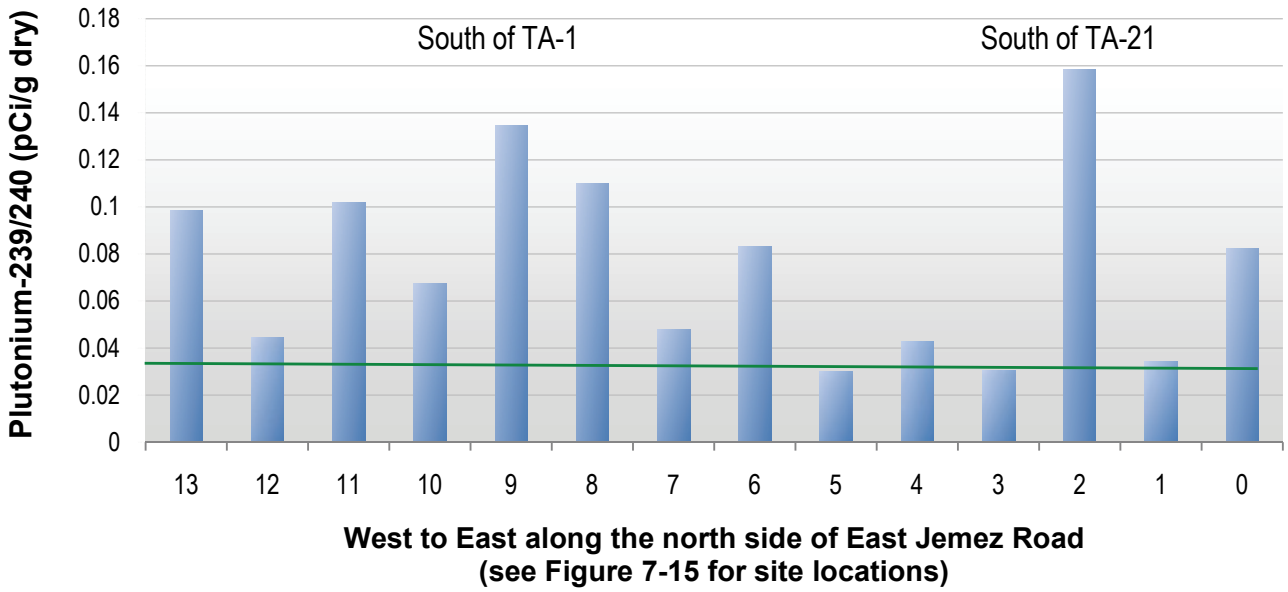


Figure 7-16. **Mean plutonium-239/240 concentrations in soil collected along a 2.25-mile section on the north side of East Jemez Road (and on the south side of major historic facilities) as compared with the regional statistical reference level (RSRL) (green line). The residential SL (not shown) is 33 pCi/g.**

2. Chemical Concentrations in Soils Collected from Alfalfa Fields Irrigated with Rio Grande Water Upstream and Downstream of LANL

During the early years of LANL operations, some canyon drainage systems received various amounts of untreated radioactive and nonradioactive waste effluents (Purtymun 1974, Hakonson et al. 1980), and although most of the runoff and/or effluent flow in the canyons is lost to the underlying alluvium and to evapotranspiration before leaving LANL lands (Stevens et al. 1993), some flow resulting from excessive storm events may eventually reach the Rio Grande (Abeele et al., 1981). As a result, we vigorously sample biota in the Rio Grande for possible pollutants—fish (Fresquez et al. 2009), crayfish (see chapter 8), and benthic macroinvertebrates (see chapter 8)—and crops from downstream farms have been collected for nearly 30 years (Fresquez et al. 2007).

This follow-up study investigates whether potential contaminants, particularly PCBs (using a more sensitive analysis), detected in LANL canyons are impacting soil resources downstream of LANL. Past results can be found in Fresquez et al. (2001b).

Soil samples were collected from alfalfa fields irrigated with Rio Grande water from two general locations—upstream and downstream—from LANL. The upstream locations (background) were collected from three fields that were located just north of Española and one field was located on Pueblo of San Ildefonso land on the west side of the Rio Grande; and the five downstream locations were located below Cochiti Reservoir starting from Cochiti Pueblo to Peña Blanca (there are no agricultural fields between LANL and Cochiti reservoir). The study sites are described in more detail in Table 7-2.

Table 7-2
Location of Alfalfa Fields Sampled for PCBs

Location	General Description	Mode of Irrigation
Upstream of LANL	**Below the confluence of the Rio Chama (RC) and Rio Grande (RG) to the Otowi Bridge**	
Ranchitos Farm 1	On east side of Rio Grande between RC/RG confluence and Española	Flood irrigated
Ranchitos Farm 2	On east side of Rio Grande between RC/RG confluence and Española	Flood irrigated
Ranchitos Farm 3	On east side of Rio Grande between RC/RG confluence and Española	Flood irrigated
Pueblo de San Ildefonso Farm 4	On west side of Rio Grande between Española and Otowi Bridge/	Pumped from the Rio Grande to a cement-lined ditch/Flood irrigated
Downstream of LANL	**Below Cochiti reservoir starting at Cochiti Pueblo to Peña Blanca (Note: There are no agricultural fields directly downstream of LANL to Cochiti reservoir.)**	
Cochiti Pueblo Farm 5	On east side of the Rio Grande	Flood irrigated
Cochiti Pueblo Farm 6	On west side of the Rio Grande	Flood irrigated
Sile Farm 7	On west side of the Rio Grande	Flood irrigated
Sile Farm 8	On west side of the Rio Grande	Flood irrigated
Peña Blanca Farm 9	On east side of the Rio Grande/newly leveled field (two years old)/flood irrigated	Flood irrigated

At each study site, a soil composite sample (five subsamples per site) for radionuclide and TAL element analysis and two grab samples for organic analysis were collected with a disposable polystyrene scoop at the 0- to 6-inch depth. (Note: The fields were plowed to a depth of at least one foot at one time or another.)

The soil composite sample, after mixing, was placed into a pre-labeled 500-mL polyethylene bottle; the two soil grab samples, one for the analysis of SVOCs and HEs and the other for the analysis of PCB congeners, were

placed directly into pre-labeled 500-mL amber-colored glass jars. All sample containers were secured with chain-of-custody tape, placed into Ziploc bags, and cooled to 4° C.

The composite samples were shipped under full chain-of-custody procedures to Paragon Analytics, Inc., for the analysis of tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, uranium-238, and for 23 TAL elements (aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, antimony, arsenic, cadmium, lead, selenium, silver, thallium, and mercury). Samples for SVOC and HE analysis were shipped under full chain-of-custody procedures to GEL Analytics, Inc., and samples for PCB congener analysis were shipped to Vista Analytical.

Results show that the mean concentration of all radionuclides (Table S7-11) and TAL elements (Table S7-12) in soil collected from alfalfa fields downstream of LANL (below Cochiti Reservoir south) were not statistically different ($p > 0.05$) from radionuclides and TAL element levels in soil collected from fields upstream of LANL. In addition, there were no HEs (Table S7-13) or SVOCs (Table S7-14) detected in any of the field soils regardless of location. These data confirm past results (Fresquez et al. 2001b).

PCB congeners detected in soil from alfalfa fields irrigated with Rio Grande water upstream and downstream of LANL can be found in Table S7-15. In general, the concentrations of total PCBs in soils irrigated with upstream (ave. = 1,921 pg/g) and downstream (ave. = 180 pg/g) waters relative to the location of LANL were very low as compared to the SL (1,120,000 pg/g) and the mean levels between locations, albeit the upstream sites were highly variable, were not statistically different ($p>0.05$) from one another (Figure 7-17). Total PCBs in soils collected from upstream fields ranged in concentration from 126 to 6,080 pg/g, indicating some possible point source contamination.

The mean PCB homolog distributions in soil from both upstream and downstream locations relative to LANL, but especially in soil from the upstream location, were similar to the Aroclor 1260 profile (Figure 7-18).

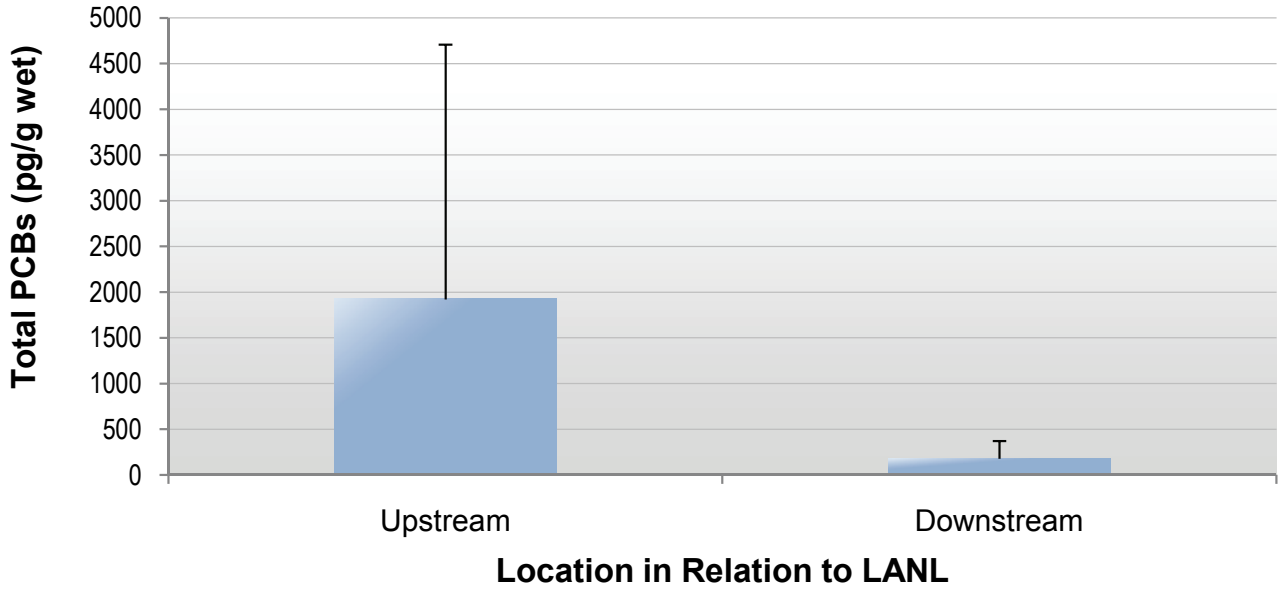


Figure 7-17. Mean total PCBs (± one standard deviation) in soil collected from alfalfa fields irrigated with Rio Grande water upstream (≈Española) and downstream (below Cochiti reservoir) of LANL in 2009.

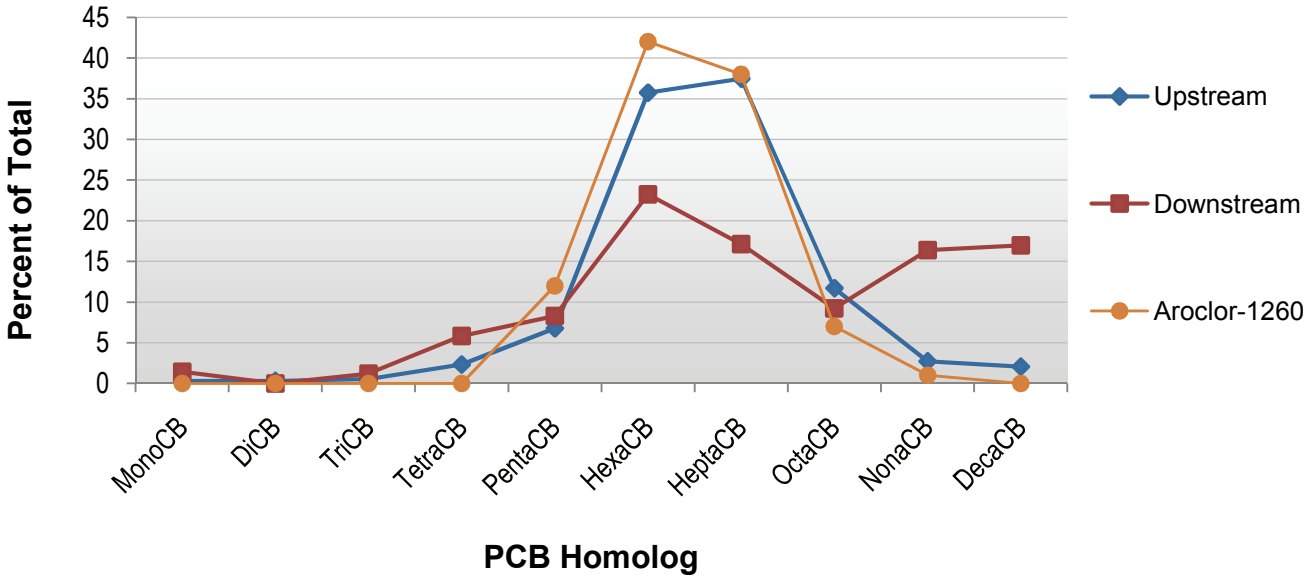


Figure 7-18. The mean PCB homolog distribution in soil collected from alfalfa fields irrigated with Rio Grande water upstream (≈Española) and downstream (below Cochiti Reservoir) of LANL in 2009 as compared with the Aroclor profile for 1260.

F. QUALITY ASSURANCE FOR THE SOIL, FOODSTUFFS, AND BIOTA MONITORING PROGRAM

1. Quality Assurance Program Development

The sampling team collects soil, foodstuffs, and biota (SFB) samples according to written, standard quality assurance and quality control procedures and protocols. These procedures and protocols are identified in the LANL Quality Assurance Project Plan for the Soil, Foodstuffs, and Biota Monitoring Project and in the following LANL standard operating procedures:

- Collection of Soil and Vegetation Samples for the Environmental Surveillance Program
- Sampling Soil and Vegetation at Facility Sites
- Analytical Chemistry Data Management and Review for Soil, Foodstuffs, and Biota
- Analytical Data Verification/Validation Process

These procedures, which are available on the LANL public website (http://www.lanl.gov/environment/all/qa.shtml), ensure that the collection, processing, and chemical analysis of samples, the validation and verification of data, and the tabulation of analytical results are conducted in a manner consistent from year to year. Locations and samples have unique identifiers to provide chain-of-custody control from the time of collection through analysis and reporting.

2. Field Sampling Quality Assurance

Overall quality of field sampling is maintained through the rigorous use of the carefully documented procedures, listed above, which govern all aspects of the sample-collection program.

The team collects all samples under full chain-of-custody procedures to minimize the chances of data transcription errors. Once collected, we hand-deliver the samples to the LANL Sample Management Office, which ships them via express mail directly to an external analytical laboratory under full chain-of-custody control. The project leader tracks all samples. Upon receipt of data from the laboratory (electronically and in hard copy), the completeness of the field-sample process and other variables are assessed. A quality assessment document is created, attached to the data packet, and provided to the project leader.

3. Analytical Laboratory Quality Assessment

Specific statements of work are written to govern the acquisition and delivery of analytical services after the Data Quality Objective process has identified and quantified the program objectives. These statements of work are sent to qualified analytical laboratories, which undergo a pre-award, on-site assessment by experienced and trained quality systems and chemistry laboratory assessors. Statement of work specifications, professional judgment, and quality-system performance at each laboratory (including recent past performance on nationally conducted performance-evaluation programs) are the primary criteria used to award contracts for specific types of radiochemical, inorganic chemical, and organic chemical analyses.

Each analytical laboratory conducts chain-of-custody and analytical processes under its own quality plans and analytical procedures. Each laboratory returns data by email in an electronic-data deliverable with a specified format and content. The analytical laboratory also submits a full set of paper records that serves as the legal copy of the data. Each set of records contains all the internal quality control data the analytical laboratory generates during the analyses (including laboratory control standards, method blanks, matrix spikes, duplicates, and replicates, when applicable). The electronic data are uploaded into the database and immediately subjected to a variety of quality and consistency checks. Analytical completeness is determined, tracking and trending of all blank and control-sample data are performed, and all the data are included in the quality assessment document mentioned in the field sampling section. We track all parts of the data management process electronically and prepare periodic reports to management.

4. Field Data Quality Assessment Results

Field data completeness for SFB in 2009 was near 99%.

5. Analytical Data Quality Assessment Results

Analytical data completeness for all SFB sampling programs was near 99% in 2009. We track, trend, and report all quality control data in specific quality evaluation memos, which we submit to project staff along with each set of analytical data received from our chemistry laboratories. Overall results of the 2009 quality program indicate that all analytical laboratories maintained the same high level of control observed in the past several years.

6. Analytical Laboratory Assessments

During 2009, three external laboratories performed all analyses reported for SFB samples:

- Paragon Analytics, Inc., Fort Collins, Colorado, provided radiological and TAL element (mostly metals) analysis of soil, sediment, and biota.
- Vista Analytical Laboratory, Inc., El Dorado Hills, California, provided PCB analysis of biota.
- General Engineering Laboratories, Charleston, South Carolina, provided SVOC and HE analysis of soils and sediments.

We performed an assessment of Paragon Analytics, Inc., in 2004. The laboratory participated in national performance-evaluation studies in 2004 and 2005. Detailed results of these performance evaluations are included in the assessment report. Overall, the study sponsors judged the analytical laboratory to have acceptable performance for almost all analytes attempted in all matrices.

7. Program Audits

In 2005, we hosted a data quality assessment and evaluation to evaluate whether the procedures in various programs were being implemented as written. The auditors (Time Solutions 2) were professional external quality assurance experts (ISO 9000 and 14000 certified) and they examined all aspects of the SFB program procedures. While it was noted that improvements had been made to the SFB program following a previous audit (performed by auditors external to the sampling group but internal to LANL), several observations led to recommendations on improving processes for keeping procedures up to date and meeting internal commitments made in quality assurance plans. Since the data quality assessment, we have implemented all of the recommendations.

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8. Foodstuffs and Biota Monitoring



contributing authors:
Philip Fresquez, Chuck Hathcock, Dave Keller

To Read About **Turn to Page**

Foodstuffs Monitoring 279
Biota Monitoring 286
Special Monitoring Studies 293
Quality Assurance for the Soil, Foodstuffs and Biota Program 300
References 300

A. FOODSTUFFS MONITORING

1. Introduction

A wide variety of wild and domestic crops, including vegetables, fruits, berries, nuts, and grains are grown and/or are harvested at many locations surrounding Los Alamos National Laboratory (LANL or the Laboratory). Also, many food products from domestic livestock (e.g., milk, eggs, and meats) and apiaries (honey) are available, and fishing and hunting for small and big game animals (e.g., rabbits, turkey, deer, and elk) on neighboring properties around LANL are a common occurrence.

These foodstuffs within and around LANL may become contaminated through air stack emissions and fugitive dust (inhalation by animals; deposition on plant surfaces), soil contamination sites (ingested and/or dermal contact by animals; splash and root uptake by plants), and storm and irrigation water (ingested and/or dermal contact by animals; root uptake by plants) exposures (i.e., food web transfer). Elk and deer, for example, may graze through areas on LANL land or drink from water catchments that may contain radioactive and/or chemical contamination, and fish can be exposed to potential contaminants entering the Rio Grande from runoff discharging from the many canyons that cross Laboratory property. The ingestion of these foods constitutes an important exposure pathway by which radionuclides (Whicker and Schultz 1982) and other chemicals (Gough et al. 1979) may be taken in by humans.

The purpose of the foodstuff monitoring program is to determine whether Laboratory operations are impacting human health via the food chain. US Department of Energy (DOE) Orders 450.1A (DOE 2008) and 5400.5 (DOE 1993) define the framework and requirements for this monitoring program, and we accomplish this effort through the following tasks:

1. Measuring radioactive and (other) chemical concentrations in foodstuffs on Laboratory land, if available, and from neighboring communities and comparing these results to regional background levels, screening levels, and, if available, standards;
2. Determining concentration trends over time; and
3. Providing data used to estimate potential dose from the consumption of the foodstuffs (see Chapter 3 for dose estimates to individuals from the ingestion of foodstuffs).

In general, soil (plus native vegetation) and major foodstuffs like crops and fish are collected on a three-year rotating schedule (i.e., a triennial basis). Other foodstuffs like honey, milk, eggs, wild edible plants, livestock, and small and large game animals are analyzed as they become available and an adequate number of samples can be submitted to the laboratory. We collected domestic crops (along with wild edible plants and goat milk) in 2007 (Fresquez et al. 2008) and fish in 2008 (Fresquez et al. 2009). This year, we present the results of radionuclides and chemicals in crayfish collected from the Rio Grande upstream and downstream of LANL and several (road killed) deer that were collected along roads that cross LANL and Pueblo of San Ildefonso lands.

2. Foodstuffs Comparison Levels

In general, radionuclides and chemicals in foodstuffs potentially impacted by LANL operations are compared to the same in foodstuffs collected from regional background locations away from the influence of the Laboratory. The concentrations of radionuclides and chemicals in foodstuffs collected from regional background areas are a result of worldwide fallout and natural processes (e.g., elements in soil to plants to animals).

Depending on the number of samples collected from potentially impacted areas, comparisons to background are made by either employing a statistical test (>three samples from a defined population) or to a Regional Statistical Reference Level (RSRLs) (individual sample). RSRLs for each radionuclide or chemical are derived from background data (mean plus three standard deviations = 99% confidence level) over at least the last five sampling events.

If any mean or individual radionuclide or chemical concentration in a foodstuff exceeds either the statistical test or the RSRL(s), respectively, we would then compare the concentrations to screening levels (SLs). For radionuclides, the SLs, in concentration units, are based on 4% (= 1 mrem/yr) of the 25-mrem/yr DOE single-pathway constraint (DOE 1999) so that potential concerns may be identified in advance of the standard, i.e., a "yellow flag." If a radionuclide concentration exceeds an SL, the basis for that increase is investigated. For target analyte list (TAL) elements, with the exception of mercury in aquatic animals, there are no SLs for the majority of foodstuffs collected around LANL. The SL for mercury in aquatic animals, based on US Environmental Protection Agency (EPA) guidelines, is 0.30 mg/kg wet (parts per million) (EPA 2001). (Note: Although not SLs, per se, there are EPA guidelines for limited consumption of fish based on the amounts of mercury, cadmium, selenium, and arsenic [EPA 2007].) Similarly, for polychlorinated biphenyls (PCBs) we used EPA guidelines for SLs; in this case, we compared Toxicity Equivalent Quotients (TEQs), which are calculated from the 12 dioxin-like PCB compounds (Van den Berg et al. 2006) to the EPA risk-based consumption limits for human health (EPA 2007).

If radionuclides, mercury, or PCB concentrations exceed an SL, they would then be compared to the applicable action limit. In the case of radionuclides, a dose to a person would be calculated from all the radionuclides measured within a single pathway and compared with the 25-mrem/yr DOE single-pathway dose constraint (DOE 1999). In the case of mercury and PCBs, the concentrations would be compared to the Food and Drug Administration (FDA) action limits of 1 ppm and 3 ppm, respectively (FDA 2000). Note: A summary of the RSRLs, SLs, and the standards used to evaluate the results of radionuclides, mercury, and PCBs in foodstuffs is presented in Table 8-1.

3. Crayfish Monitoring

a. Monitoring Network

Crayfish (crawfish, crawdads, or mudbugs) (*Orconectes* spp.) samples were collected from the Rio Grande within two reaches relative to the location of LANL: upstream and downstream (Figure 8-1). Upstream (or background) samples were collected starting from the Otowi Bridge north to the Black Mesa area (about a three-mile stretch) and downstream samples were collected from the Los Alamos Canyon confluence south (about a one-mile stretch). Of the major drainages that cross LANL lands, the majority of LANL contaminants that reach the Rio Grande are carried by storm water flow down Los Alamos Canyon (Gallaher and Efurd 2002, Reneau and Koch 2008, Fresquez et al. 2008). Note that other non-Laboratory sources may also contribute contaminants to the Los Alamos Canyon drainage; these include constituents from roads and grounds from the Los Alamos town site, treated effluent from the Los Alamos sewage treatment plant, atmospheric fallout of radionuclides, and some naturally occurring and anthropogenic materials in ash from the Cerro Grande Fire in May 2000 (Miranda 2009).

b. Methods and Analysis

Within each reach, crayfish traps were randomly set using pieces of fresh fish as bait at the one-foot depth. Traps were checked every day until an adequate sample amount was collected (Figure 8-2).

Table 8-1
Standards and Other Reference Levels Applied to Fish

Constituent	Media	Standard	Screening Level	Background Comparison Test or Level
Radionuclides	All foodstuffs	25 mrem/yr	1.0 mrem/yr	Statistical or RSRLs
Mercury	Aquatic Animals	FDA: 1 ppm (wet) in edible portion (complete consumption restrictions)	EPA: 0.30 ppm (wet) in edible portion	Statistical or RSRLs
TAL Elements per EPA Risk-Based Consumption Limits of Edible Portions				
Mercury	Fish		0.029–1.9 ppm (wet)	Statistical or RSRLs
Cadmium	Fish		0.088–5.6 ppm (wet)	
Selenium	Fish		1.5–94 ppm (wet)	
Arsenic	Fish		0.002–0.13 ppm (wet)	
Polychlorinated Biphenyls (PCBs)				
	Red Meat and Poultry	FDA (complete consumption restrictions). Total PCBs = 3 ppm		Statistical or RSRLs
	Fish		EPA (limited consumption restrictions). Total PCBs = 0.0015–0.094 ppm or TEQs = 0.019–1.2 ppt from 12 dioxin-like PCB congeners	Statistical or RSRLs

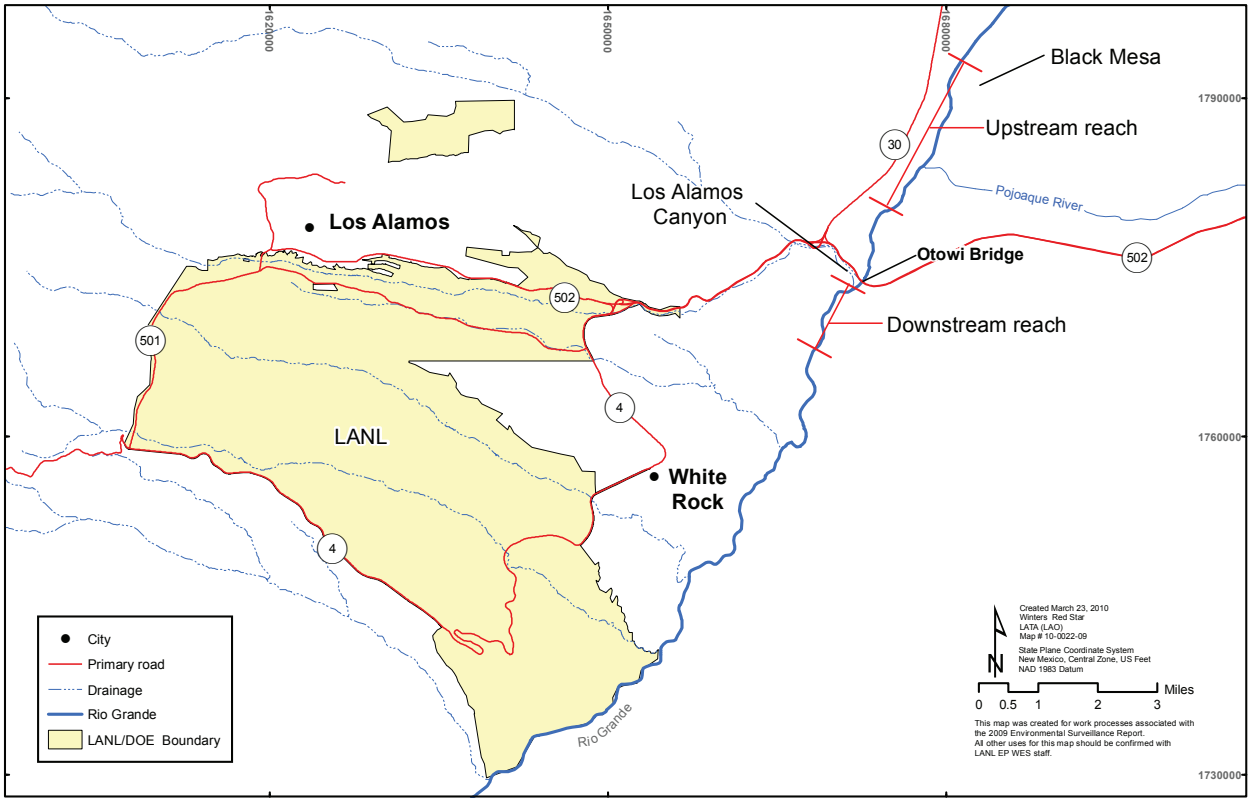


Figure 8-1. **Location of (crayfish and macroinvertebrate) sampling reaches within the Rio Grande in relation to the location of LANL. The upstream reach is above the Otowi Bridge north to BlackMesa and the downstream reach starts below the Los Alamos Canyon confluence south.**



Figure 8-2. Collection of crayfish samples from the Rio Grande.

One composite sample (five crayfish) was collected from each of the two reaches for radionuclide analysis; three crayfish from each of the two reaches were collected for the analysis of TAL elements; and six samples of crayfish were collected from each of the two reaches for PCBs analysis.

Samples of whole body crayfish for radionuclide and TAL element analysis were placed into Ziploc bags and samples for PCB analysis were placed into 500-mL amber glass jars. All samples were cooled to ˚4 C and submitted under full chain-of-custody procedures to our Sample Management Office (SMO) where they were then sent to Paragon Analytics, Inc., for radionuclide and TAL element analysis and to Vista Analytical, Inc., for PCB analysis.

The radionuclides analyzed were tritium, strontium-90, cesium-137, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. Tritium concentration results are reported on a per mL of water basis. Results of the other radionuclides were reported in pCi/g ash. (Note: Because foodstuffs typically contain very small amounts of radionuclides in the tissue portions, samples are commonly ashed to 500˚ C to concentrate the radioisotope.)

TAL elements analyzed were aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, antimony, arsenic, cadmium, lead, selenium, silver, thallium, and mercury. These elements are reported on a wet weight basis in mg/kg (parts per million wet).

PCBs were analyzed for 209 possible chlorinated structures or congeners. A congener is a specific PCB compound with a certain number of chlorine atoms in certain positions and is reported on a pg/g (parts per trillion) wet weight basis.

TEQs, a measure of the degree of toxicity based on the similarity of the 12 dioxin-like PCB congeners (# 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, and 189) to the most toxic dioxin, tetrachlorodibenzodioxin, was calculated for each crayfish sample by multiplying the concentration of each of the 12 dioxin-like PCBs by a toxicity equivalency factor and then summing the values (Van den Berg et al. 2006).

c. Radionuclides

All radionuclides in a composite (whole body) crayfish sample collected from the Rio Grande directly downstream of the Los Alamos Canyon confluence were either not detected or were detected below the RSRLs (Table S8-1). A nondetected value is one in which the result is lower than three times the counting uncertainty and is not significantly different (α = 0.01, or 99% confidence level) from zero (Keith 1991, Corely et al. 1981) or less than the minimum detectable activity. These data are similar in concentrations to bottom-feeding fish collected from these same upstream and downstream reaches in past years (Fresquez et al. 1999a, 1999b, 2009).

d. TAL Elements

Most of the 23 TAL elements in (whole body) crayfish collected from upstream (n = 3) and downstream (n = 3) reaches relative to the location of potential LANL impacts were statistically similar ($p>0.05$) to one another (Table S8-2). The few exceptions were aluminum, barium, beryllium, chromium, cobalt, magnesium, vanadium, and arsenic (Figure 8-3).

Although based on a small sample set, the concentration differences, albeit also small, in these eight TAL elements in whole body crayfish collected from upstream and downstream reaches may either reflect possible contributions from the Los Alamos Canyon drainage (Laboratory operations, Los Alamos town site, Cerro Grande fire) or to, most likely, the different geological conditions along the Rio Grande. Reneau and Kuyumjian (2009), for example, attributed many of these same (elevated) TAL elements to regional differences in sediment background along the Rio Grande and to other non-LANL sources.

Regardless of source, the risk from the ingestion of these crayfish because of the slightly higher TAL elements to humans is probably minimal because the majority of these elements are most likely associated with the nonedible portions (e.g., shell and gut) rather than the edible portions (e.g., tail). Most of these elements analyzed in the edible portions of bottom-feeding fish collected from these same downstream locations in 2008, for example, were not even detected (Table S8-4 in Fresquez et al. 2009).

As per our protocol, we will follow up with the collection of more crayfish samples from upstream and downstream reaches in 2010 in an effort to better define the concentrations in TAL elements between reaches and between edible and nonedible portions.

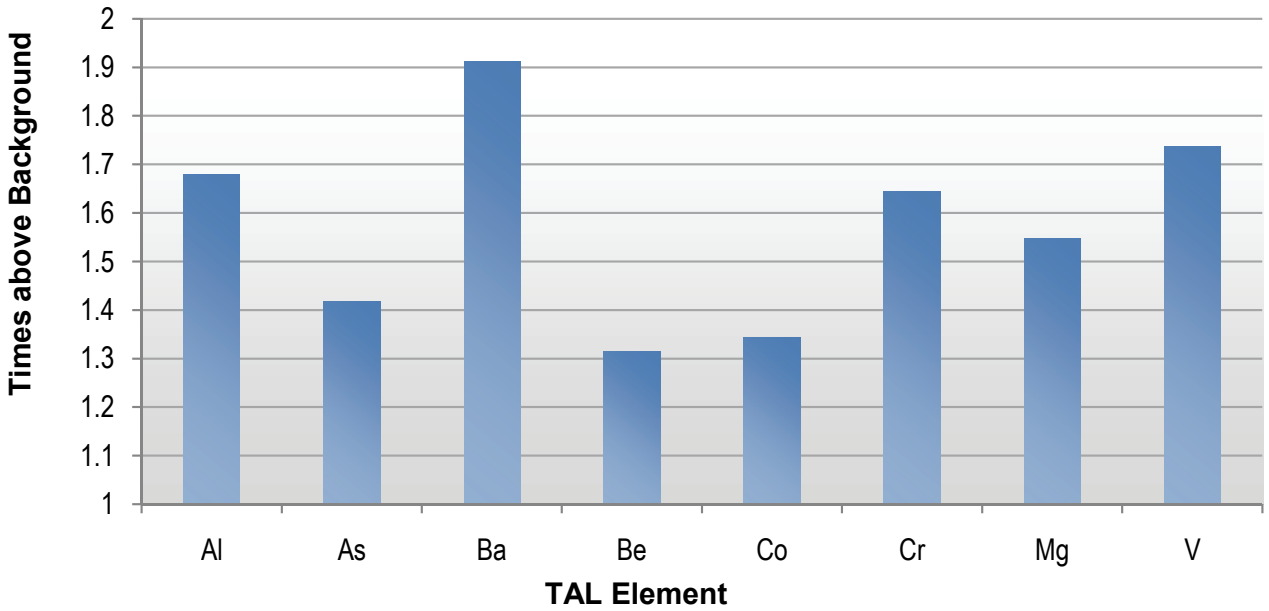


Figure 8-3. Times above the background of some TAL elements in whole body crayfish samples (n=3) collected from the Rio Grande directly downstream of LANL (Los Alamos Canyon) in 2009.

e. Polychlorinated Biphenyls

i. History of Use.

PCBs are a category of toxic, long-lived synthetic organic chemicals manufactured in the United States between 1930 and 1976 (ATSDR 2001). They were developed predominantly for use as coolants and lubricants because of their general chemical inertness and heat stability in electrical equipment such as capacitors and transformers (EPA 1996, 2002). Also, they have been used in oil in motors and hydraulic systems, flame retardants, inks, adhesives, carbonless copy paper, paints, wood-floor finishes, pesticide extenders, plasticizers, polyolefin catalyst carriers, slide-mounting mediums for microscopes, surface coatings, wire insulators, and metal coatings. Although banned over three decades ago, PCBs continue to enter the environment from various sources (e.g., landfills, urban runoff, sewage sludge, incineration of municipal refuse, and illegal disposal). At LANL, spills and releases from transformers, capacitors, generators, dielectric fluids, contaminated solvents and oils are the source of PCBs in the environment (ATSDR 2006). The most commonly detected PCBs in surface waters, sediments, and biota within Los Alamos Canyon at LANL are Aroclors 1254 and 1260 (Reneau and Kuyumjian 2009, Fresquez et al. 2008, Fresquez et al. 2009).

Aroclor was the trade name for mixtures of PCBs manufactured in the United States; nine Aroclor mixtures were produced with the bulk being Aroclor 1016 (13%), 1242 (52%), 1248 (7%), 1254 (16%), and 1260 (11%); each was prepared to a specific chlorine weight percentage given in the last two digits of its name, with the exception of Aroclor 1016, which contains 41% chlorine by weight; each contains a specific mixture of 209 congeners—a congener is a specific PCB compound with a certain number of chlorine atoms in certain positions on the molecule (EPA 1996).

In the aquatic environment, PCBs are hydrophobic and tend to accumulate in the sediment (Ashley and Baker 1999), are highly soluble in lipids (lipophilic), and are absorbed and retained by fish (Gonzales and Fresquez 2006, Grafton et al. 2008).

ii. Results

A summary table showing physical (weight), chemical (percent lipids, total PCBs [pg/g], total PCBs [pg] per crayfish, total PCBs in lipids [pg] per crayfish, TEQ [pg/g]), and EPA fish consumption limits for each of the six (whole body) crayfish collected from upstream and downstream reaches relative to the location of LANL are presented in Table S8-3A. Individual PCB congener (209 total) and homolog (10 groups of congeners with the same number of chlorine substituents) data for all crayfish samples (pg/g) can be found in Table S8-3B.

In general, the mean total PCBs (pg/g) in crayfish from both upstream and downstream reaches were low as compared to the fish consumption limit (<1,500 pg/g) (EPA 2007); also, there were no statistical differences ($p>0.05$) in PCB concentrations in crayfish between the two reaches (Figure 8-4). These data are similar to other studies involving bottom-feeding fish (Gonzales and Fresquez 2008, Fresquez et al. 2009), stationary semipermeable membrane devices (e.g., artificial fat bags) (Gonzales and Montoya 2005), and sediment (Reneau and Koch 2008, Reneau and Kuyumjian 2009) that showed similar PCB concentrations between upstream and downstream locations.

With respect to overall PCB concentrations regardless of site, crayfish (≈940 pg/g) contained much lower amounts than bottom-feeding fish (≈21,000 pg/g) (Gonzales and Fresquez 2008, Fresquez et al. 2009). The large differences in PCB concentrations between crayfish and bottom-feeding fish may be due to differences in food type and/or feeding strategies and to the amount of PCB accumulating lipids (1.5% vs 6.0%) between the two species. Because of the lower amounts of PCBs in crayfish, the number of "fish" (crayfish) meals per month, according to the EPA fish consumption limit based TEQs, are greater than 16 (i.e., no restrictions).

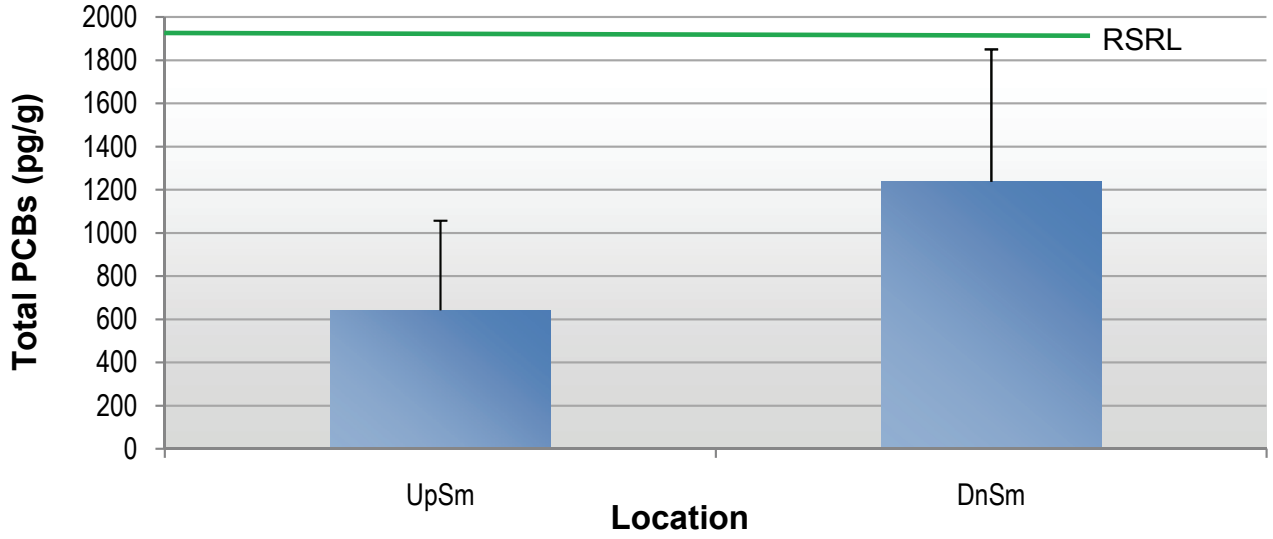


Figure 8-4. **Mean (±1 standard deviation of results from six samples) total PCBs in whole body crayfish collected directly upstream (UpSm) and downstream (DnSm) of LANL (Los Alamos Canyon) in 2009. There is no statistical difference between sites at the 0.05 probability level. Also, the Regional Statistical Reference Level is presented for general comparison.**

A comparison of the mean PCB homolog distributions in crayfish collected from upstream and downstream reaches relative to LANL show that the profiles are nearly identical to one another with both profiles peaking at the hexachlorinated biphenyl level (Figure 8-5). Based on the homolog distribution, the profiles from both upstream and downstream locations intersect the patterns of Aroclor 1254 and Aroclor 1260—more of the Aroclor 1260 than the Arochlor 1254. These data agree with the bottom-feeding fish results obtained in 2002 (Gonzales and Fresquez, 2008) and 2008 (Fresquez et al. 2009) and with sediments in 2009 (Reneau et al. 2010); and indicate that there is no significant contributions to PCBs in the Rio Grande from the Los Alamos Canyon watershed.

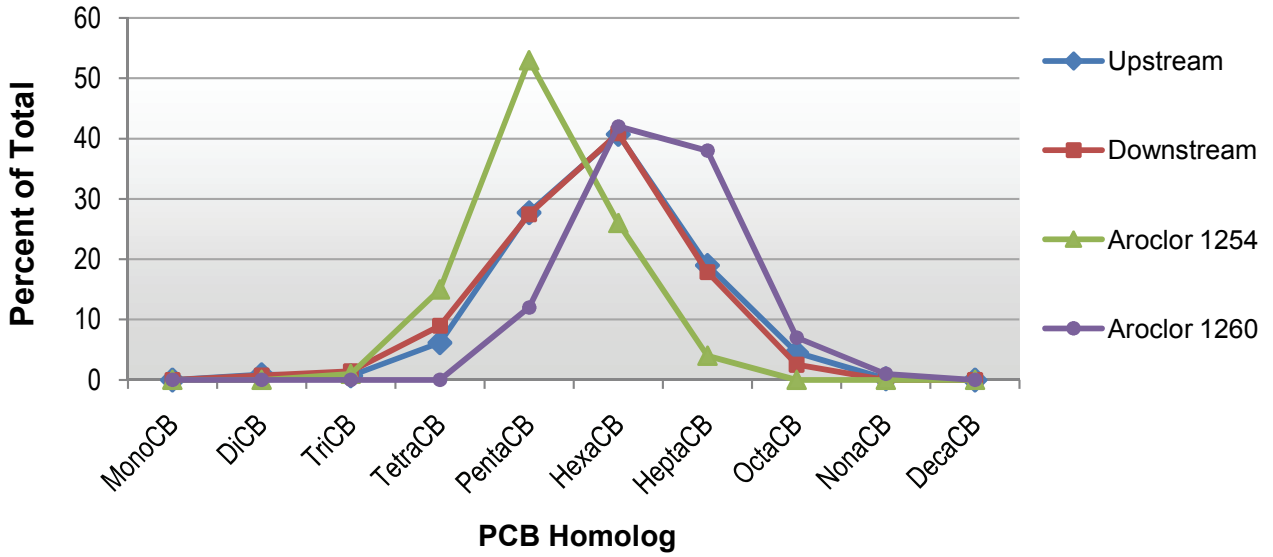


Figure 8-5. **The mean PCB homolog distribution in whole body crayfish collected directly upstream and downstream of LANL (Los Alamos Canyon) in 2009 compared with various Aroclor profiles.**

4. Deer Monitoring

a. Monitoring Network

Elk and deer are routinely picked up as road kills along highways within and around LANL since 1991 (Fresquez et al. 1998). This year, one road killed deer was collected along the Pajarito roadway within Technical Area (TA) 46 at LANL and another road killed deer was collected along State Road 4 as it passes through the Pueblo of San Ildefonso property. At each kill site, the muscle and bone from one of the front shoulders of the animal were collected for analysis. Samples were placed into the appropriate containers and submitted under chain-of-custody procedures to the SMO; samples were submitted to Paragon Analytics for the analysis of radionuclides and TAL elements and to Vista Analytical for the analysis of PCB congeners.

b. Analysis

Radionuclides analyzed were tritium, strontium-90, cesium-137, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. Tritium concentration results are reported on a per mL of water basis. Results of the other radionuclides were reported in pCi/g dry after being converted from pCi/g ash (Fresquez et al. 2007a). TAL elements analyzed were aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, antimony, arsenic, cadmium, lead, selenium, silver, thallium, and mercury. These elements are reported on a mg/kg wet weight basis (parts per million). PCBs were analyzed for 209 possible chlorinated structures or congeners and reported as pg/g (parts per trillion) wet weight basis.

c. Radionuclides

Most all radionuclides in both muscle and bone tissues from deer collected on LANL and Pueblo of San Ildefonso lands were either not detected or below the RSRLs (Table S8-4). Only one radionuclide, uranium-234, at a concentration of 0.0050 pCi/g dry in the leg bone of the deer collected along side of State Road 4 on Pueblo of San Ildefonso lands was higher than the corresponding RSRL of 0.0025 pCi/g dry. However, the amounts were far below the SL of 0.56 pCi/g dry. Also, the uranium was of natural origin (i.e., 1:1 ratio) and the amount in the edible muscle portion of this same deer was below the RSRL. These data agree with past results (Fresquez et al. 1998).

d. TAL Elements

Results of TAL elements in muscle and bone tissues from two road-killed deer collected along State Road 4 and Pajarito Road as they pass through Pueblo of San Ildefonso and LANL lands, respectively, can be found in Table S8-5. Since this is the first time that TAL elements have been assessed in muscle and bone tissues of deer, we do not have a comparable data set from background deer and an evaluation cannot be made at this time. These data are given at this time for future reference.

e. Polychlorinated Biphenyls

PCB congeners, homologs, totals, and TEQs in muscle and bone tissues of a road kill deer collected alongside Pajarito Road at TA-46 can be found in Table S8-6. Although the comparison of PCBs in deer from LANL with background cannot be made at this time because of the lack of background data, there are some general inferences that can be made between the two types of tissues being studied. These include the concentrations of total PCBs (and TEQs) in muscle and bone of this deer appear to be rather low; the amounts of PCBs in bone material are twice the amount than in the muscle tissue; and, the types of PCBs, based on the homolog signatures, appear to be different between the muscle and bone tissues of the same deer (Figure 8-6). These data are given at this time for future reference and discussion. No comparison values (PCBs in mule deer tissues) in the literature could be found.

B. BIOTA MONITORING

1. Introduction

DOE Orders 450.1A (DOE 2008) and 5400.5 (DOE 1993) define requirements for the monitoring of biota (plants and animals not normally ingested by humans) for the protection of ecosystems. Monitoring of biota, mostly in the form of facility-specific or site-specific studies, began in the 1970s with the Environmental Surveillance Program, while site-wide native vegetation monitoring started in 1994. Presently, in addition to native vegetation, we also monitor small mammals, amphibians, reptiles, birds, and bees within and around LANL

on a systematic basis or for special studies. Detection of contaminants in biota may indicate that these animals may be entering contaminated areas (e.g., burrowing in waste burial grounds) or that material is moving out of contaminated areas (e.g., blowing dust, transported soil/sediment via storm water, or food-chain transport).

The three objectives of the biota program are as follows:

1. Determine radionuclide and chemical concentrations in biota from on site (LANL property) and perimeter areas and compare these results to regional (background) areas,
2. Determine concentration trends over time, and
3. Estimate potential radiation dose to plants and animals. (Chapter 3 presents the results of the 2009 biota dose assessments at LANL.)

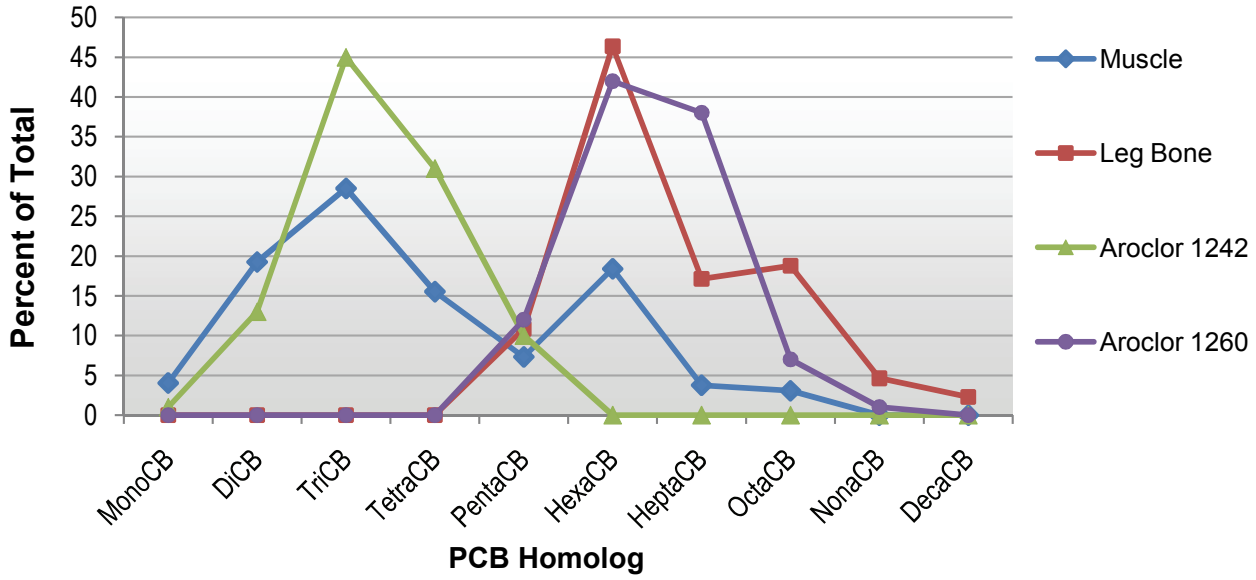


Figure 8-6. The PCB homolog distribution in muscle and bone tissues of a road-killed deer collected alongside Pajarito Road at TA-46 in 2009 compared with Aroclor 1242 and 1260 formulations.

2. Biota Comparison Levels

Like the foodstuffs data, radionuclides and chemical concentrations in biota from Laboratory areas are first compared with the same in biota from non-impacted areas using either a statistical test (greater than three samples per site) or a statistical reference level (individual samples are compared to RSRLs). If the levels of potentially impacted areas are higher than the levels of non-impacted areas, then we would compare the concentrations to SLs, if available, and then to standards, if available. More information about comparison levels are summarized below and presented in Table 8-2:

- Regional background levels: RSRLs are the upper-level background concentrations (mean plus three standard deviations) for radionuclides and chemicals calculated from biota data collected from regional locations away from the influence of the Laboratory (over nine miles away) (DOE 1991) over the past five sampling periods. RSRLs represent natural and fallout levels; they are calculated annually and presented in Tables S8-11 through S8-25 of this report.
- Screening Levels: SLs are set below DOE dose standards so that potential concerns may be identified in advance, i.e., a "yellow flag." If a constituent exceeds an SL, then the reason for that exceedance is thoroughly investigated. For radionuclides in biota, SLs were set at 10% of the standard by the dose assessment team at the Laboratory to identify the potential contaminants of concern (McNaughton 2006). For chemicals, there are no SLs based on biota tissue concentrations. Instead, if a chemical in

biota tissue exceeds the RSRL (or Baseline Statistical Reference Levels [BSRLs]), then the chemical concentrations in the soil at the place of collection are compared with ecological screening levels (ESLs) (LANL 2008a).

- Standards: Based on the concentrations of radionuclides in biota, we calculate a dose and compare it with the 1-rad/day DOE dose standard for terrestrial plants and aquatic biota and 0.1-rad/day for terrestrial animals (DOE 2002).

Table 8-2
Locations, Types, and Numbers of Fish Collected

Constituent	Sample Location	Media	Standard	Screening Level	Background Level
Radionuclides	On-site and perimeter	Terrestrial plants	1 rad/d	0.1 rad/d	RSRLs
	DARHT	Terrestrial plants	1 rad/d	0.1 rad/d	RSRLs/BSRLs[a]
	On-site and perimeter	Terrestrial animals	0.1 rad/d	0.01 rad/d	RSRLs
	DARHT	Terrestrial animals	0.1 rad/d	0.01 rad/d	BSRLs
Chemicals	On-site and perimeter	Biota	na[b]	ESLs[c]	RSRLs
	DARHT	Biota	na	ESLs	RSRLs/BSRLs

[a] Baseline Statistical Reference Levels and a discussion of these levels can be found in Section 4.b.i.

[b] na = Not available.

[c] Ecological Screening Levels are based on the concentration in the soil.

3. Institutional Monitoring

a. Monitoring Network

Native vegetation, either from understory (grasses and forbs) or overstory (trees) resources, are collected on a triennial basis at the same time and at the same locations (17 on-site, 11 perimeter, and six regional locations) as the soil sampling program described in Chapter 7, Section C.1 (Figure 7-1). The last vegetation sampling effort, conducted in 2006, concentrated on understory plants (Fresquez et al. 2007a). This year, we collected samples from overstory trees. In general, samples of branches plus needles from mostly ponderosa pine trees at the five foot height are collected and placed into the appropriate containers and submitted to Paragon Analytics for the analysis of the same radionuclides and TAL elements (mostly metals) as the soils. Branches and needles, in particular, because of their sticky nature, tend to filter and concentrate airborne contaminants and generally have higher concentrations of some radionuclides and chemicals than the trunk portions.

b. Radionuclides

For the majority of radionuclides tested (98%), concentrations (activity) in trees collected from both perimeter and on-site areas were either not detected or below RSRLs (Table S8-7). The few radionuclides, namely tritium at the "east of TA-53 and TA-73/SR 502 (east)" site, strontium-90 at the "San Ildefonso, TA-16 (S-Site), and West of TA-53" sites, plutonium-238 at the "East of TA-54" site, plutonium-239/240 at the "TA-21 (DP site)" site, and uranium-238 at the "TA-73/SR 502 (east)" site, that were above the RSRLs were still well below SLs and do not result in adverse impacts to the plants themselves. These data agree with past results and no increasing trends are evident (Gonzales et al. 2000, Fresquez and Gonzales 2004).

c. TAL Elements

As with the radionuclides, the majority of TAL elements in trees from both perimeter and on-site locations were below the RSRLs; and the few elements that were above the reference levels, namely antimony and selenium at some on-site locations, were far below levels considered toxic to the plant (Table S8-8) (Gough et al. 1979).

4. Facility Monitoring

a. Area G at TA-54

i. Monitoring Network

Native overstory vegetation (branches and needles) around Area G was collected at the same general locations as the soil samples described in Chapter 7, section D.1 (Figure 7-4). Radionuclides analyzed by Paragon Analytics, Inc., included tritium, americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. Results for tritium in vegetation are reported on a pCi/mL basis; results for the other radionuclides are reported on a pCi/g ash basis; and results for the TAL elements are reported on a mg/kg dry basis.

ii. Vegetation at Area G

With the exception of tritium, all of the other radionuclides in trees collected around the perimeter of Area G were mostly not detected or below the RSRLs (Table S8-9). Tritium, on the other hand, was detected above the RSRL in most all tree samples collected around the perimeter of Area G with the highest amounts (45 to 55,900 pCi/mL) occurring in trees growing in the southern sections near the tritium storage shafts. These levels, however, are still below the SL and are generally not increasing over time, albeit they are highly variable from year to year (Figure 8-7).

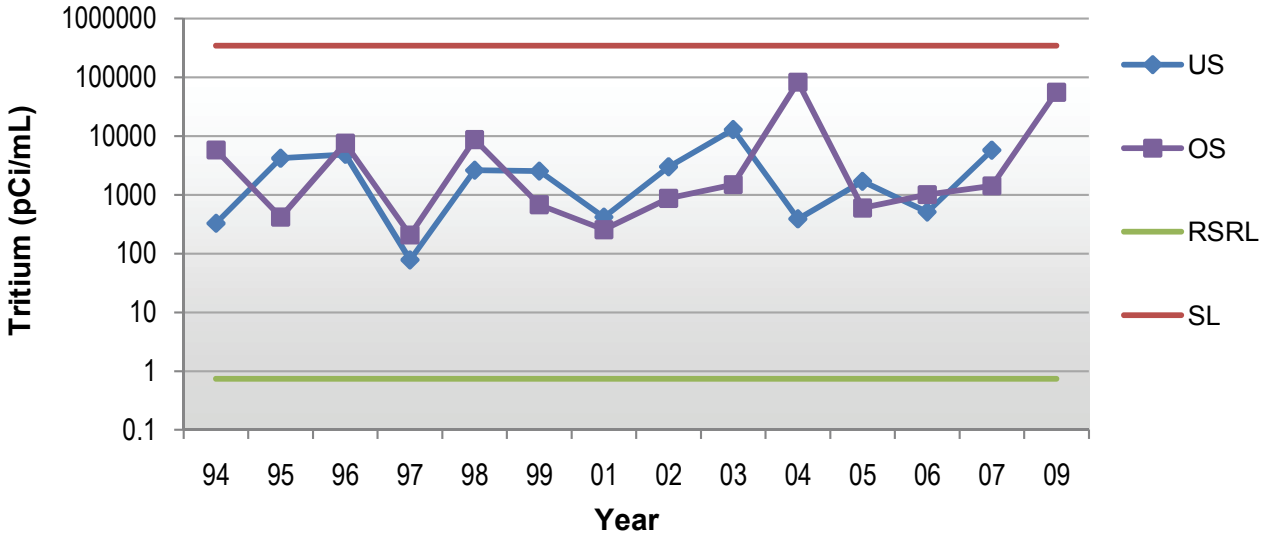


Figure 8-7. Tritium in understory (US) and overstory (OS) vegetation collected from the south side of Area G at TA-54 from 1994 through 2009 compared with the regional statistical reference level (RSRL) and the screening level (SL). Note the logarithmic scale on the vertical axis.

Other radionuclides in trees around Area G that were detected above the RSRLs included americium-241, plutonium-238, and plutonium-239/240 in tree samples collected mostly on the northwestern section of Area G (around site #58-01). These levels, however, are far below the SLs and do not pose an unacceptable dose to the trees.

b. Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility at TA-15

i. Monitoring Network

The Laboratory conducts facility-specific biota monitoring on an annual basis at the DARHT facility—the principal firing site at LANL—as per the Mitigation Action Plan (MAP) resulting from the environmental impact statement for the construction and operation of the DARHT facility (DOE 1996). The history of operations at the site have included open air detonations from 2000–2006; detonations using foam mitigation from 2002–2006; and detonations within closed steel containment vessels starting in 2007 to present (three in FY 2007, two in FY 2008, and none in FY 2009). Another factor that may influence the amount of potential contamination around the DARHT site (and cleanup) is that the firing point was paved with an asphalt surface.

The biota samples collected at DARHT include overstory vegetation (tree), field mice, bees, and birds (see Chapter 7, Figure 7-8, for sample locations). Vegetation, field mice, and bee samples are collected for radionuclide and TAL element analysis, whereas birds are mostly collected (and released) for population, composition, and diversity estimates. Sometimes, however, birds are inadvertently caught on the field mice traps and, in these cases, the birds will be used for contaminant analysis. This year, three birds—two spotted towhees and one western scrub jay—were submitted for TAL analysis.

Overstory samples (branches plus needles) were collected on the north, south, west, and east sides of the DARHT perimeter; small mammals, mostly deer mice (*Peromyscus* spp.), were collected on the north and northeast side of the DARHT perimeter; bee samples were collected from three hives located on the northeast side of the DARHT perimeter; and bird samples were collected using 12 mist capture net traps spaced about 200 ft to 1,600 ft outward from the west side of the DARHT facility (spacing of the nets was about 150 ft from one another).

Vegetation, field mice, and bee samples were submitted to Paragon Analytics, Inc., where they were processed and analyzed for tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, uranium-238, and TAL elements. Results for tritium are reported on a pCi/mL basis; results for the other radionuclides are reported on a pCi/g ash basis; results for the TAL elements in vegetation are reported on an mg/kg dry basis; and results for the TAL elements in field mice and bees are reported on an mg/kg wet basis.

Results of the biota chemical analysis were compared with BSRLs as per the MAP (DOE 1996). BSRLs are the upper-limit baseline data established over a four-year period (1996–1999) before the start-up of DARHT operations in 2000 (Nyhan et al. 2001). The BSRLs, at the three sigma level, are based on summaries provided by Fresquez et al. (2001a) for vegetation, Haarmann (2001) for bees, and Bennett et al. (2001) for small mammals. Similarly, the population, composition, and diversity of birds collected from DARHT were compared with bird samples collected before the operation of the DARHT facility (Fresquez et al. 2007b). In cases where there are no BSRLs, then a comparison to RSRLs will be made.

ii. Vegetation at DARHT

Most radionuclide concentrations in overstory vegetation collected from around the perimeter of the DARHT facility were either not detected or detected below the BSRLs (or RSRLs when BSRL data were not available) (Table S8-10). The only radionuclides in vegetation that were above the statistical levels at DARHT were plutonium-239/240 in one sample collected from the west side and uranium-238 in two samples collected from the north and east sides. All radionuclides, however, were orders of magnitude below the SLs and the amounts of uranium-238 over time show a decrease to BSRLs after the change in contaminant mitigation procedures from open and/or foam mitigation (2000–2006) to closed steel containment (vessel) mitigation starting in 2007 (Figure 8-8). Also, there were fewer detonations over the latter years.

Based on the isotopic distribution of uranium-234 to uranium-238, all tree samples contained depleted uranium. Depleted uranium, which is used as a substitute for enriched uranium in weapon components tested at LANL, has also been detected in soil (Fresquez 2004), bees (Hathcock and Haarmann 2004), small mammals (Fresquez 2005, Fresquez 2007), and birds (Fresquez et al. 2007b) near DARHT.

The TAL element results, including metals like beryllium, in overstory vegetation collected from around the DARHT facility are summarized in Table S8-11. All of the metals were either not detected or below the BSRLs (or below the RSRLs).



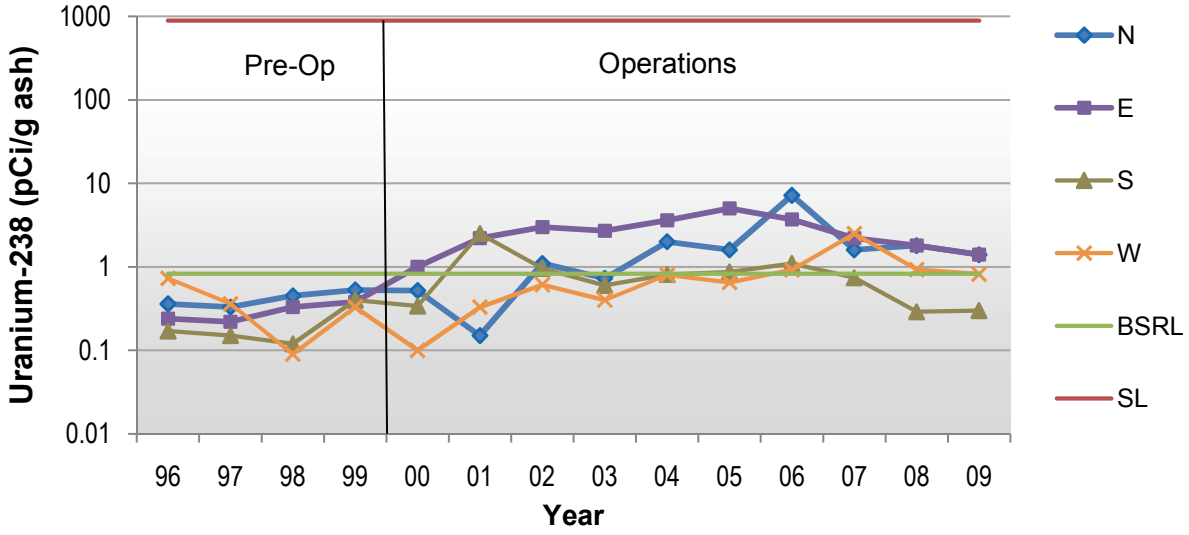


Figure 8-8. **Uranium-238 in overstory vegetation collected from the north (N), east (E), south (S), and west (W) side of the DARHT facility at TA-15 from 1996–1999 (pre-operations) through 2000–2009 (during operations) compared with the baseline statistical reference level (BSRL) and the screening level (SL). Note the logarithmic scale on the vertical axis.**

iii. Small Mammals at DARHT

Most radionuclides were either not detected or below the BSRLs in a composite field mouse sample (five mice per sample) collected from the north and northeast side of the DARHT facility (Table S8-12). Uranium-234 and uranium-235 concentrations were just slightly above the BSRLs but the amounts were orders of magnitude below the SL.

The isotopic distribution of uranium-234 to uranium-238 in the field mouse sample collected from the north-northeast side of DARHT indicates the type of uranium is depleted uranium.

Using uranium-238 concentrations to model trends over time, the amounts, as seen with vegetation (Figure 8-7), exhibit an increase to 2007 and then decrease thereafter to the BSRL; this is concurrent with the change in detonation mitigation practices from open and/or foam-mitigated detonations during the 2000–2006 period to closed vessel containment starting in 2007 (Figure 8-9). Also, there were fewer detonations over the latter years.

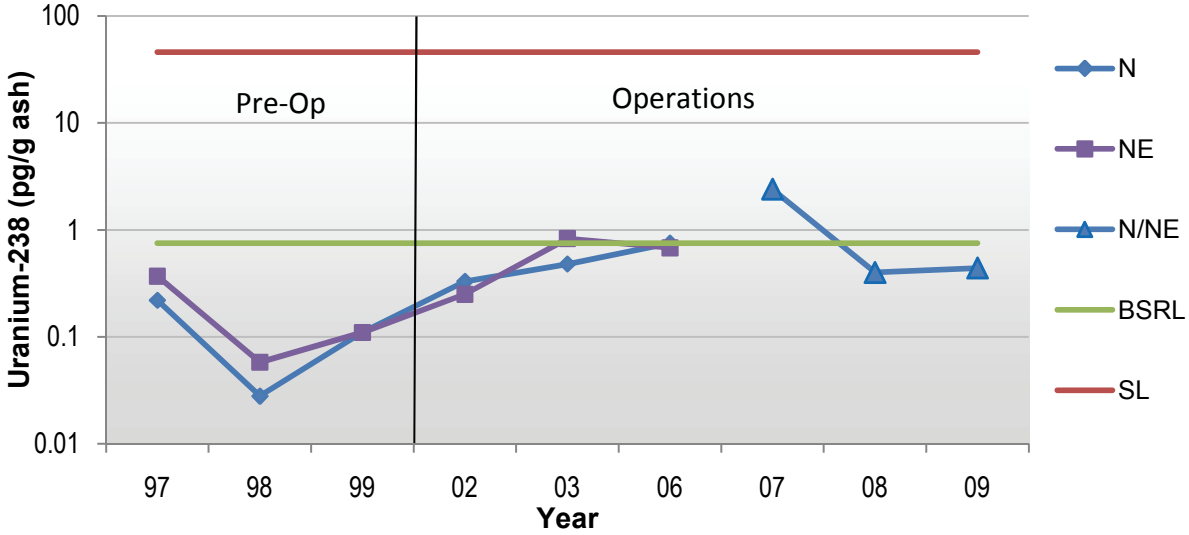


Figure 8-9. **Uranium-238 concentrations in (whole body) mice (n = 5) collected from the north (N) and northeast (NE) side of the DARHT facility at TA-15 from 1997–1999 (pre-operations) through 2002–2009 (during operations) compared with the baseline statistical reference level (BSRL) and the screening level (SL). Note the logarithmic scale on the vertical axis.**

With respect to TAL elements in field mice, only one element, barium, was higher than the RSRL (Table S8-13). However, using the highest barium concentration in soil around the DARHT facility (Table S7-5), the levels did not exceed the ESL for the field mouse (LANL 2008a).

iv. Bees at DARHT

Most concentrations of radionuclides, with the exception of tritium in bee samples collected from the two hives located northeast of the DARHT facility, were either not detected or detected below the BSRLs (Table S8-14).

Tritium increased in concentration from an average of 0.11 pCi/mL in 2008 to 12 pCi/mL in 2009. The reason for the increase in tritium concentrations in bees near DARHT is not completely known because the amounts of tritium in the soil (Table S7-7), vegetation (Table S8-10), and field mice (Table S8-12) samples collected directly around the perimeter of the DARHT facility were not elevated. Nevertheless, the amounts of tritium in bee samples collected on the northeast side of the DARHT facility in 2009 are still far below the SL of 3.5E05 pCi/mL and are not expected to pose a potentially unacceptable dose to the bees.

The isotopic distribution of uranium-234 to uranium-238 in one of the two bee samples indicate that the uranium is in a depleted form.

A comparison of uranium-238 in bee samples over the pre- and operational period at DARHT reveals the same general trend observed with the other biotic media; that there is an increase in activity to around 2006 and then a sharp decrease concurrent with the change in detonation mitigation practices from open/foam (2000–2006) to closed vessel containment starting in 2007 (Figure 8-10). Also, there were fewer detonations over the latter years.

The TAL elements in bee samples from hives northeast of the DARHT facility show that barium and copper exceeded the BSRL and agree with past results (Table S8-15). There are no ESLs listed for barium and copper in soil for bees, but the highest levels of barium and copper in soil around the grounds at DARHT (Table S7-5) are far below ESLs for other indicator biota receptors.

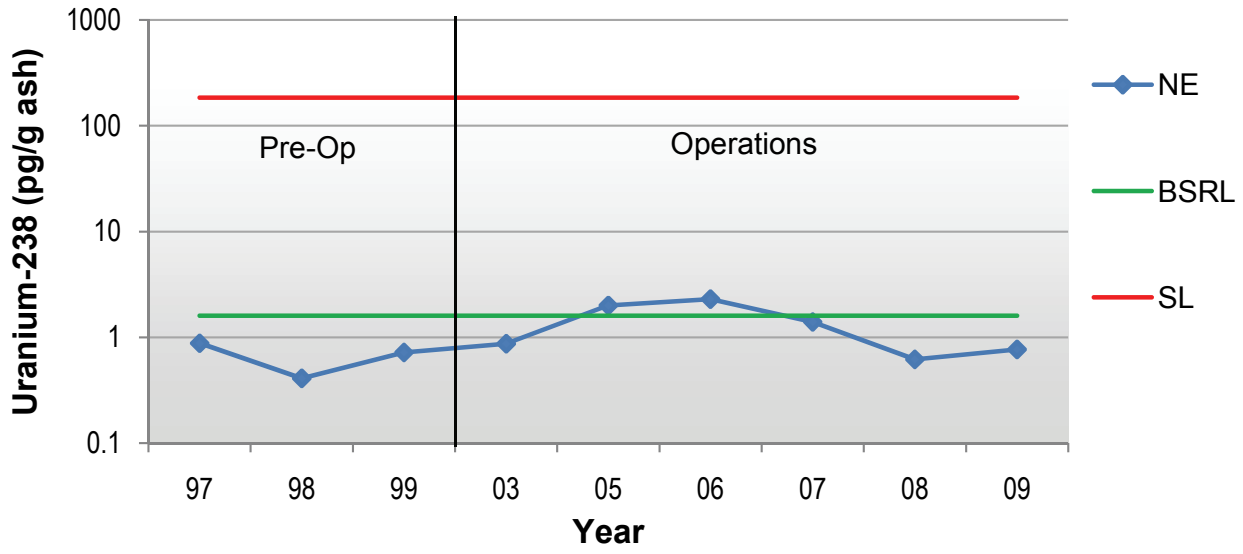


Figure 8-10. Uranium-238 concentrations in bees collected from the northeast (NE) side of the DARHT facility at TA-15 from 1997–1999 (pre-operations) through 2003–2009 (during operations) compared with the baseline statistical reference level (BSRL) and the screening level (SL). Note the logarithmic scale on the vertical axis.

v. Birds at DARHT

Populations, composition, and the diversity of birds collected just west of the DARHT facility in 2009 compared with 1999 (preoperational phase) are presented in Table S8-16. The purpose of the bird monitoring project is to determine the general ecological stress levels around the vicinity of DARHT that would be caused by facility operations (e.g., noise, disturbance, traffic, etc.). The number of birds, number of bird species, diversity, and

evenness (distribution) collected in 2009 are similar to the same collected before the start-up of operations at DARHT in 1999 (Figure 8-11). The most common bird species collected regardless of time periods were the broad-tailed hummingbird (*Selasphorus platycercus*), chipping sparrow (*Spizella passerina*), Virginia's warbler (*Vermivora virginiae*), and western bluebird (*Sialia mexicana*).

Three birds collected from the northwestern side of the DARHT facility were submitted for TAL element analysis and the results can be found in Table S8-17. Most TAL elements in bird samples were below the RSRLs. The few TAL elements in two or more birds that were above the RSRLs were barium, antimony, and silver; however, the slightly higher elements in these birds are probably from sources along their migratory routes rather than from DARHT operations because these elements are not elevated in soil or sediment around the facility (Table S7-8).

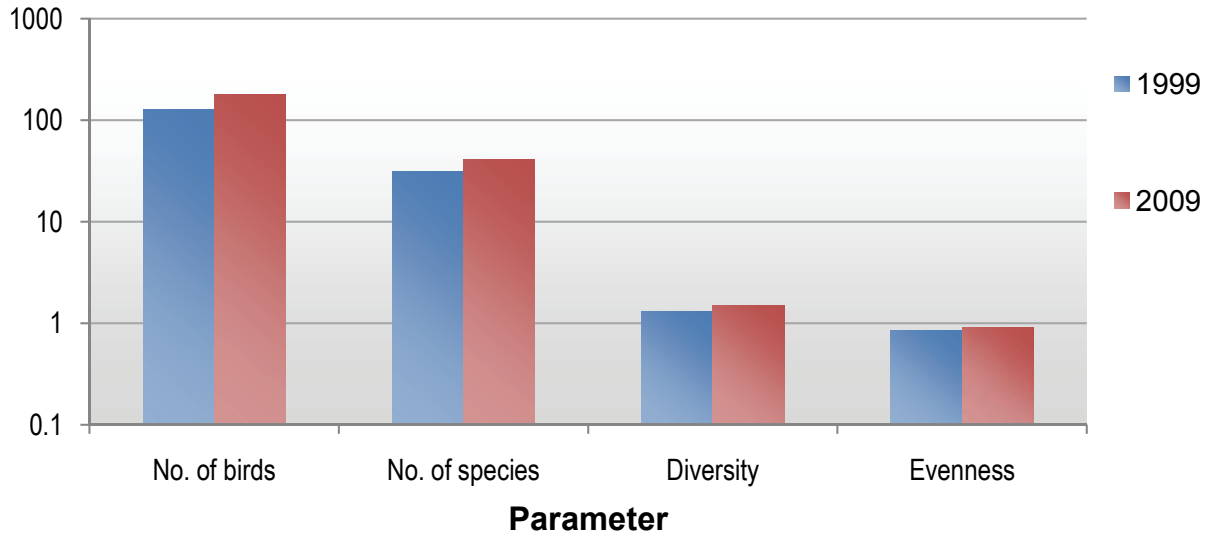


Figure 8-11. Populations, number of species, diversity, and evenness of birds occurring before (1999) and during (2009) operations at DARHT. Note the logarithmic scale on the vertical axis.

C. SPECIAL MONITORING STUDIES

In general, special studies are conducted when there is a lack of data concerning a contaminant that has the potential to impact human health and/or the environment. The following special studies were conducted in 2009 in support of MAPs and the Environmental Surveillance Program.

1. Radionuclide and Chemical Concentrations in Biota Collected from Water/Silt Retention Areas: Los Alamos Canyon Weir and the Pajarito Flood Control Retention Structure

In May 2000, a prescribed burn at Bandelier National Monument went out of control and burned nearly 43,000 acres of federal and pueblo land, including approximately 7,500 acres on LANL property. Because the Cerro Grande fire burned substantial amounts of vegetative cover, the Laboratory became concerned about increased sediment (and potential contaminant) transport from LANL to off-site locations. As a preventive measure, the US Army Corps of Engineers constructed two large erosion control structures to control storm water and sediment runoff from burned areas. These structures consist of (1) a low-head, rock-filled gabion weir that lies across the streambed in Los Alamos Canyon near the junction of NM State Road 4 and NM State Road 502 and (2) a large cement flood retention structure located downstream of the confluence of Two-Mile and Pajarito Canyons

As part of the Special Environmental Analysis of actions taken in response to the Cerro Grande fire at LANL (DOE 2000), the DOE identified various mitigation measures that must be implemented under the MAP as an extension of the fire suppression, erosion, and flood control actions. One of the tasks identified in the Plan

Section 2.1.7, "Mitigation Action for Soil, Surface and Ground Water, and Biota," mandates the monitoring of soil, surface water, groundwater, and biota at areas of silt or water retention upstream (upgradient) of flood control structures, within silt retention basins, and within sediment traps to determine if there has been an increase in contaminant concentrations in these areas and to determine to what extent they impact the biota.

To this end, we collect native understory vegetation (grasses and forbs) and field mice (mostly deer mice, *Peromyscus* spp.) in the areas upgradient of the Los Alamos Canyon Weir (LACW) and the Pajarito Canyon Flood Retention Structure (PCFRS). Native plants are monitored because it is the primary food source of biota and field mice are monitored because they have the smallest home range of the mammals.

Both vegetation and field mice were collected at the PCFRS this year; however, because the sediment was excavated and removed behind the LACW in the summer of 2009, no vegetation or field mice samples were collected at this particular location this year. Instead, we collected field mice samples from the downgradient side of the LACW at two locations: (1) the immediate downgradient side and (2) approximately 4.5 miles downgradient in Los Alamos Canyon.

Paragon Analytics, Inc., analyzed the field mice (whole body) samples for radionuclides and TAL elements. PCBs (congeners, homologs, and totals) in whole body field mice were analyzed by Vista Analytical Laboratory, Inc. The following two sections report the 2009 results of this monitoring.

a. Los Alamos Canyon Weir

The concentrations of radionuclides and TAL elements in whole body field mice samples collected from the immediate downgradient side of the LACW can be found in Tables S8-18A and S8-18B, respectively.

Most concentrations of radionuclides in a composite field mouse sample (five mice per sample) collected on the immediate downgradient side of the LACW were either not detected or below the RSRLs (Table S8-18A). The only radionuclides that were detected in higher concentrations than the RSRLs were americium-241 and plutonium-239/240. All concentrations of these radionuclides, however, were below the SLs and all radionuclides generally compare well with those of field mice collected from the upgradient side of the LACW in past years (Figure 8-12). Since the home range of a field mouse (≈0.8 acres) overlaps the two study sites (upgradient and downgradient), it is difficult to assess the efficiency of the weir in preventing the migration of radionuclides to the downgradient side.

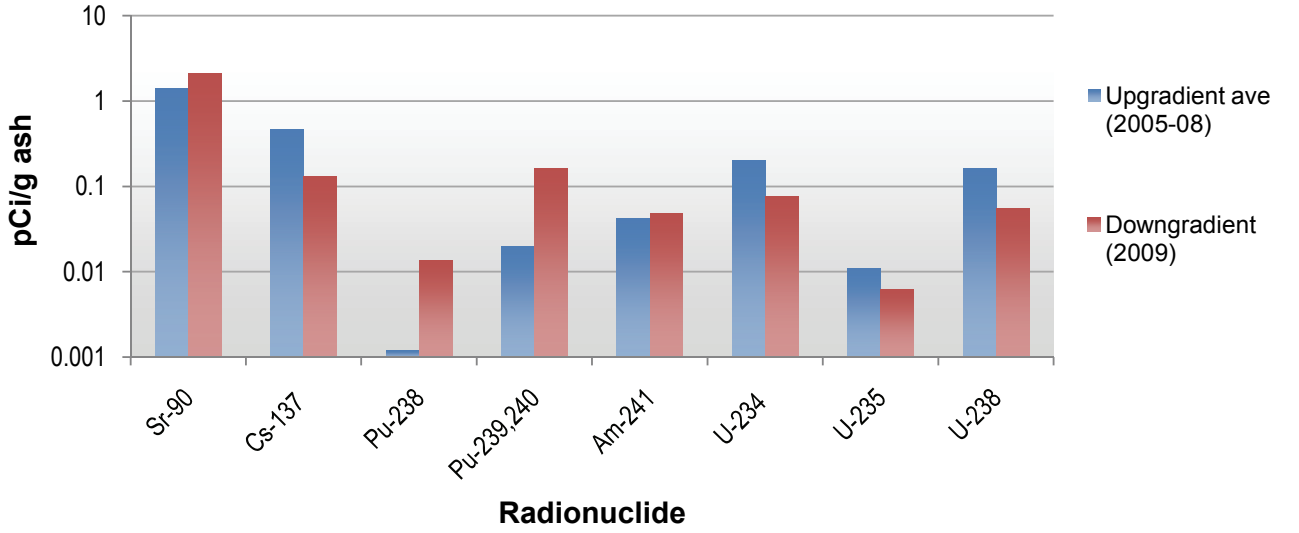


Figure 8-12. Radionuclide concentrations in whole body field mice samples collected on the upgradient (2005 through 2008) and downgradient (2009) side of the Los Alamos Canyon Weir. Note the logarithmic scale on the vertical axis.

A statistical comparison of the mean TAL element concentrations in field mice collected on the immediate downgradient side of the LACW (n = 3) with the mean concentrations of TAL elements in field mice collected from regional background locations (n = 9) (Fresquez 2010) show that all elements were statistically similar ($p>0.05$) to one another (Table S8-18B). Also, the TAL elements in field mice collected from the downgradient side of the LACW appear to be similar to those in field mice collected from the upgradient side in past years (Figure 8-13).

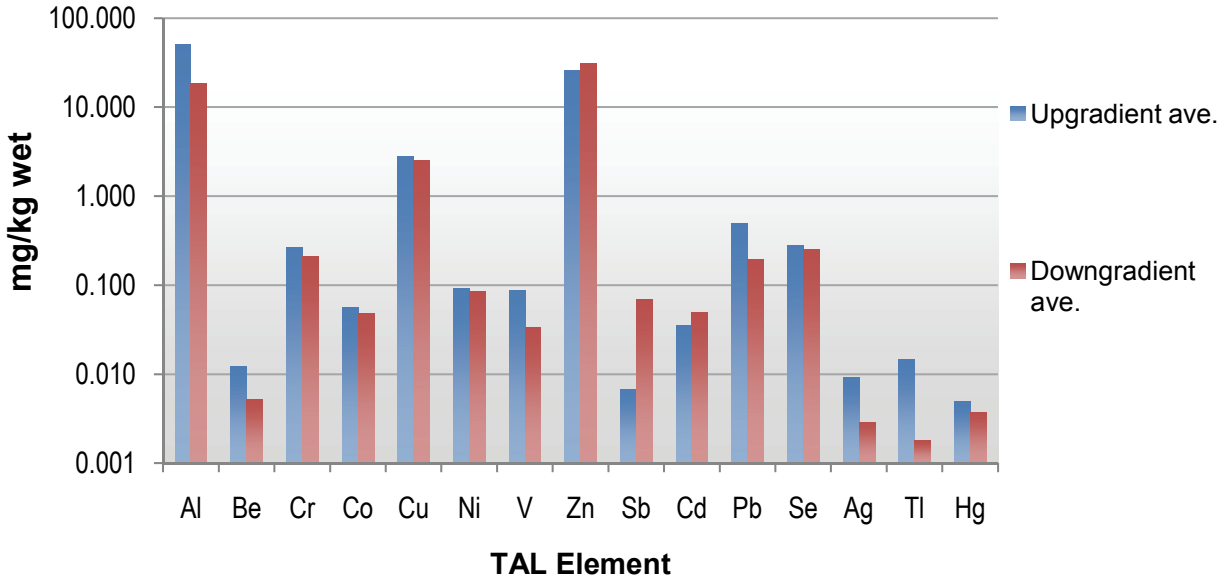


Figure 8-13. Mean concentrations of some of the TAL elements (mostly metals) in whole body mouse samples collected on the upgradient (2007-2008; n = 6) and downgradient (2009; n = 3) side of the Los Alamos Canyon Weir. Note the logarithmic scale on the vertical axis.

This year, field mice samples for PCB (congener) analysis were collected at two locations relative to the downgradient side of the LACW: the first set of samples (n = 3) were collected immediately below the LACW and the second set of samples (n = 3) were collected approximately 4.5 miles further downgradient of the LACW (and about 0.75 miles above the Rio Grande) in Los Alamos Canyon (Table S8-19). Results show that the concentration of PCBs in field mice collected immediately below the LACW were generally lower but statistically similar ($p>0.05$) to the levels of PCBs in field mice collected from the upgradient side in past years (Figure 8-14). PCBs in field mice collected from both sides of the LACW are statistically higher ($p<0.05$) than in field mice from regional background locations. Though there are no direct SLs for PCBs in tissues, ESLs for PCBs in animals are derived from soil concentrations. Based on the highest PCB concentrations in sediments at the LACW (0.22 ppm) in 2007 (Fresquez et al. 2008), the level was well below ESLs for field (deer) mice (20 ppm) (LANL 2008a), and are not expected to significantly impact the field mice population.

With distance from the LACW, however, the levels of PCBs in field mice significantly decrease—the levels of PCBs in field mice collected approximately 4.5 miles downgradient of the LACW were statistically lower ($p<0.05$) than the concentrations of PCBs in field mice collected from both sides of the LACW by a factor of nearly ten. Although the amounts of PCBs in field mice collected approximately 4.5 miles downgradient from the LACW were an order of magnitude lower than in field mice collected from areas around the LACW, the levels were still statistically higher ($p<0.05$) than in field mice collected from regional background locations.

A comparison of the mean PCB homolog distribution of field mice collected at the two downgradient site locations show that, although they peak at different chlorinated biphenyl levels, they both fit well within the Aroclor 1260 profile formulation; and more so from the field mice collected further downgradient than the LACW sites (Figure 8-15). Aroclor 1260 has been the most consistently detected PCB formulation in sediment collected upgradient of the LACW (Fresquez et al. 2007c, Reneau and Koch 2008).

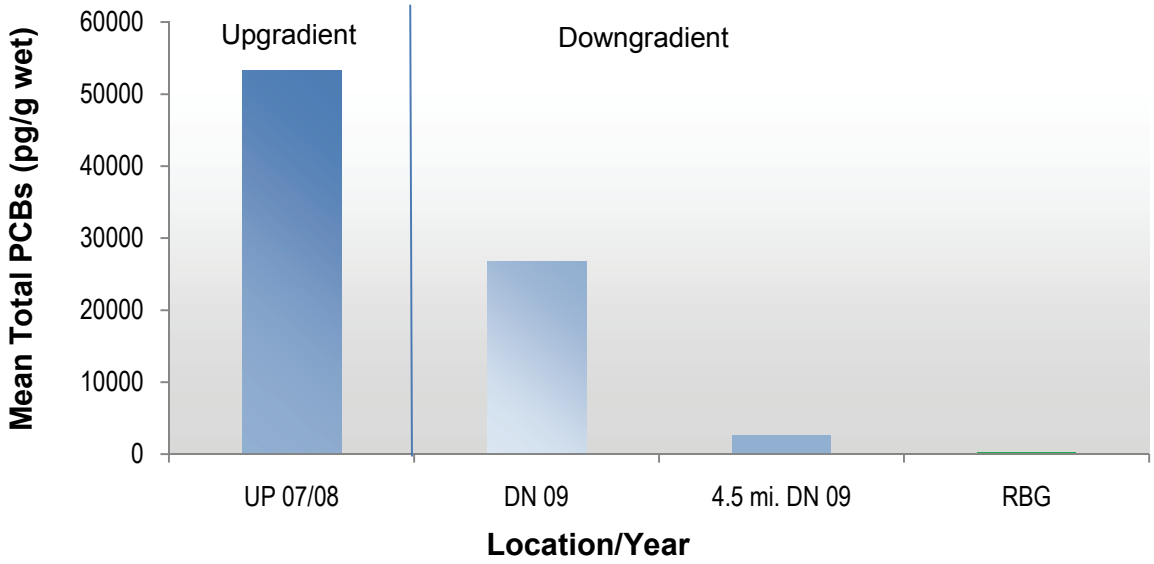


Figure 8-14. **Mean total PCB concentrations in whole body field mice collected on the upgradient side in 2007/08 and at various distances downgradient (2009) of the Los Alamos Canyon Weir compared to the regional background (RBG).**

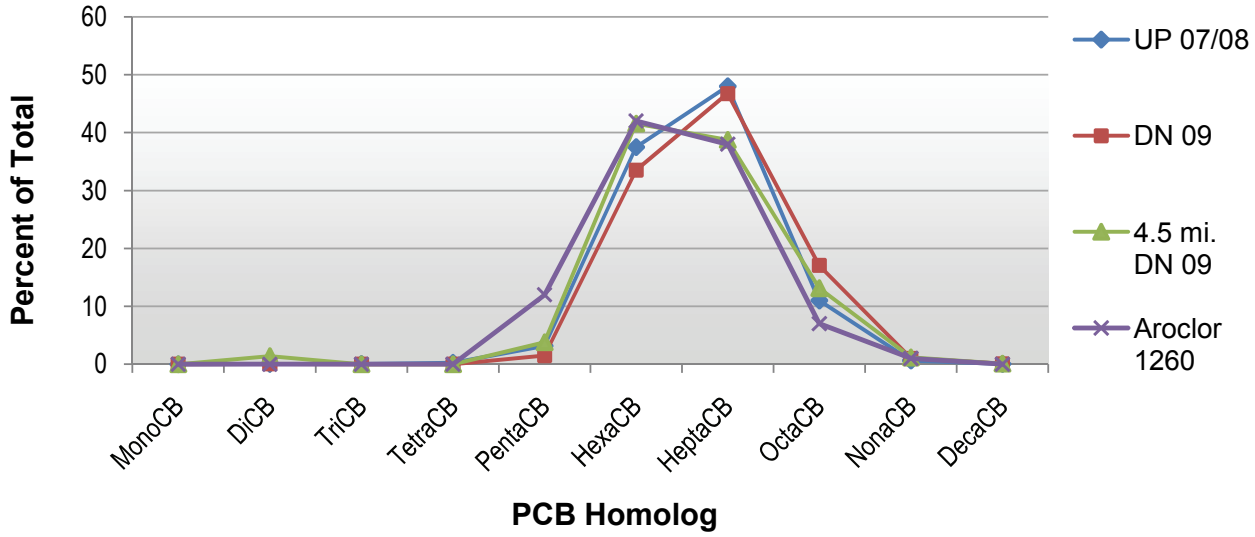


Figure 8-15. **Mean PCB homolog distribution for whole body field mice samples collected upgradient (2007/08; n = 6) and at various distances downgradient (2009; n = 3 each) of the Los Alamos Canyon Weir compared with Aroclor 1260.**

b. Pajarito Canyon Flood Retention Structure

Concentrations of radionuclides, TAL elements, and PCBs in native understory vegetation (grasses and forbs) and field mice samples collected from the upgradient side and within the silt retention area of the PCFRS in 2009 are presented in Tables S8-20 through S8-22.

All of the radionuclides in native understory and small mammal samples collected on the upgradient side of the PCFRS were either not detected or below the RSRLs (Table S8-20).

All of the heavy metals in understory vegetation collected on the upgradient side of the PCFRS were below the RSRLs (Table S8-21). Similarly, all of the TAL element mean concentrations in field mice collected upgradient of the PCFRS (n = 3) were statistically similar ($p>0.05$) with the levels in field mice collected from regional background locations (n = 9) (Fresquez 2010).

As a group, the field mice samples collected on the upgradient side of the PCFRS contained total PCB concentrations statistically higher ($p<0.05$) than mice collected from regional background locations (Table S8-22). These data are generally similar to past years (Figure 8-16). Based on the highest amounts of PCBs in sediment in 2008 (Fresquez et al. 2009), the levels do not exceed ESLs for field mice (LANL 2008a).

The mean PCB homolog distribution of the field mice collected in 2009 (and 2008) overlaps the distribution pattern of Aroclor 1260 almost identically (Figure 8-17). Trace amounts of Aroclor 1254 and Aroclor 1260 have been detected in sediment collected upgradient (Fresquez et al. 2009, Reneau and Koch 2009) and downgradient of the PCFRS in past years (LANL 2008b).

Overall, the concentrations of all radionuclides, TAL elements, and PCBs in all biotic media sampled upgradient of the PCFRS were below SLs and/or ESLs and do not pose an unacceptable dose from radionuclides or risk from chemicals to the biota sampled.

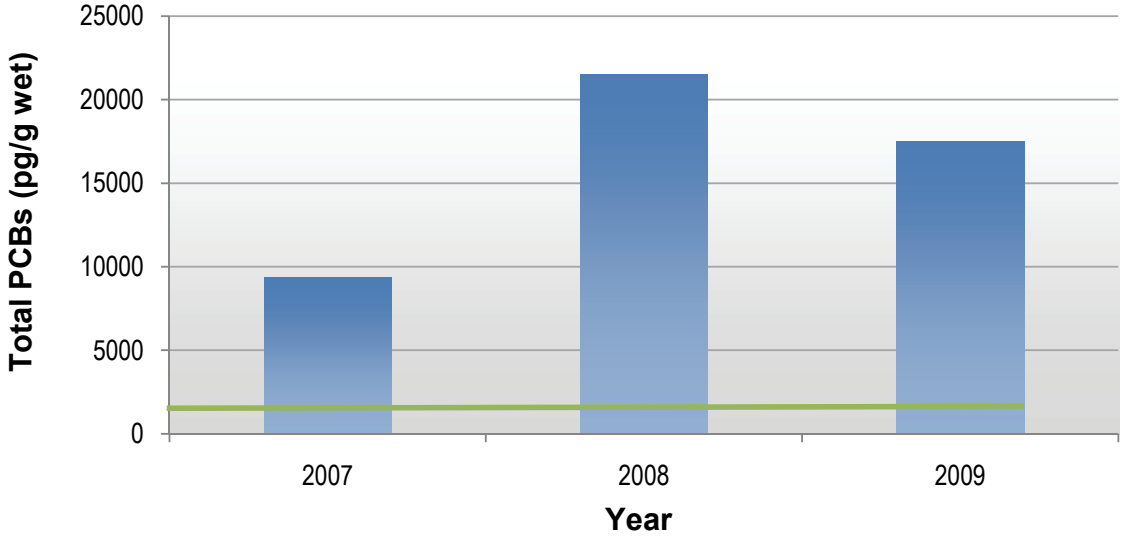


Figure 8-16. Mean total PCB concentrations in whole body field mice samples collected on the upgradient side of the Pajarito Canyon Flood Retention Structure from 2007 through 2009 compared with the regional statistical reference level (green line).

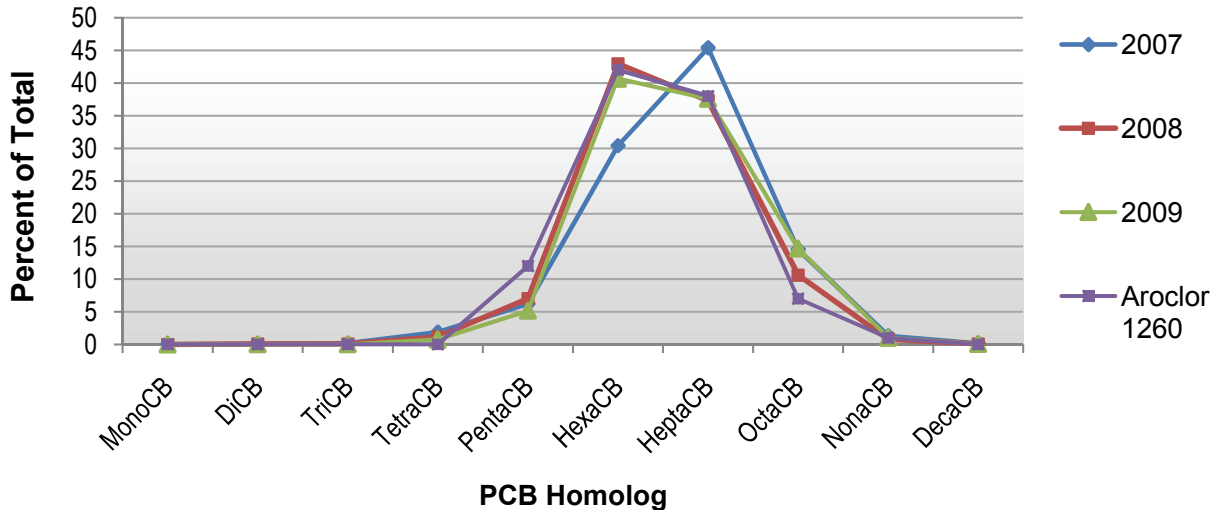


Figure 8-17. Mean PCB homolog distribution of whole body field mice samples collected on the upgradient side of the Pajarito Canyon Flood Retention Structure from 2007 through and 2009 compared with Aroclor 1260.

2. Radionuclide and Chemical Concentrations in Alfalfa Forage Irrigated with Rio Grande Water Upstream and Downstream of LANL

During the early years of LANL operations, some canyon drainage systems received various amounts of untreated radioactive and nonradioactive waste effluents (Purtymun 1974, Hakonson et al. 1980), and although most of the runoff and/or effluent flow in the canyons is lost to the underlying alluvium and to evapotranspiration before leaving LANL lands (Stevens et al. 1993), some flow resulting from excessive storm events may eventually reach the Rio Grande (Abeele et al., 1981). As a result, we vigorously sample biota in the Rio Grande for possible pollutants—fish (Fresquez et al. 2009), crayfish (see section A.3), and benthic macroinvertebrates (see section C.3)—and crops from downstream farms have been collected for nearly 30 years (Fresquez et al. 2007).

This follow-up study investigates whether potential contaminants (radionuclides and TAL elements) detected in LANL canyons are impacting crop resources downstream of LANL. Past results can be found in Fresquez et al. (2001b).

Alfalfa forage samples collected from fields located downstream of LANL (below Cochiti Reservoir to Peña Blanca) and irrigated with Rio Grande water were collected and analyzed for radionuclides and TAL elements in conjunction with the soil samples reported in Chapter 7, section E.2. The mean concentrations of all radionuclides (Tables S8-23) and TAL elements (S8-24) in alfalfa forage plants collected from downstream samples were similar ($p>0.05$) to alfalfa plants collected from regional background locations upstream of LANL. These data confirm past results (Fresquez et al. 2001b).

3. Benthic Macroinvertebrates Collected from the Rio Grande Upstream and Downstream of LANL

Benthic macroinvertebrates (BMI) are defined as insects, oligochetes, leeches, molluska, and crustaceans that live on the river bottom and are retained by a Standard No. 35 sieve (0.50-mm opening). The numbers and types of organisms, quantified by metrics or indices, may provide an indication of water quality within a stream system (EPA 1998). Because they are continually exposed during their life cycles to extremes in the environment, BMIs can serve as effective indicators of environmental changes and stress (Hilsenhoff 1987).

Five artificial substrate samplers (rock baskets) each were placed in the Rio Grande in late July of 2009 at two reaches (a total of ten baskets)—upstream (north of the Otowi Bridge to the Black Mesa area) and downstream (south of the LAC confluence)—relative to the location of LANL in an effort to determine the potential effects of Laboratory operations on the populations and communities of BMIs (see Figure 8-1). (Note: These samplers were placed in the same reaches as the crayfish reported in A.3.a.)

The rock basket samplers, which were constructed of PVC coated galvanized wire mesh, 7 by 11 inches in size, and containing 45 two- to three-inch-diameter river rock (Figure 8-18), were attached to t-posts in about two- to two and one half-foot-deep pools (Figure 8-19). They were set on top of a one inch flat rock in a vertical position on the bottom of the river. After approximately six weeks (late July to early September), the rock basket samplers were carefully lifted out of the water with the aid of a large net (9 by 18 inches in size with 0.50-mm mesh opening) and placed into a five-gallon bucket. Each rock, basket, and net was gently scrubbed and rinsed clean of BMIs; and then the contents in the bucket were separated by pouring the water plus organisms onto a Standard No. 35 sieve. All organisms remaining on the sieve were placed into a 500-mL poly bottle and preserved with 70% ethanol; after 24 hours, the old ethanol was replaced with a fresh mix.

Samples were submitted under chain-of-custody procedures to Jacobi Environmental Consulting for the identification and classification of BMIs to the lowest practical taxonomic level.



Figure 8-18. An artificial substrate (rock basket) sampler used to collect benthic macroinvertebrates in the Rio Grande.



Figure 8-19. An artificial substrate (rock basket) sampler is attached to a t-post set within pools in the Rio Grande; the sampler slides down the t-post and sits in a vertical position on the bottom of the river.

Temperature, conductivity, dissolved oxygen, pH, and turbidity of the water at each location were measured during the midpoint of the study in August 2009 (Table S8-25). There were no statistical differences ($p>0.05$) in any of the parameters measured between downstream and upstream reaches.

The numbers and types of organisms collected from rock basket samplers upstream and downstream of LANL can be found in Table S8-26 and a summary of some standard (bioassessment) metrics calculated from the data can be found in Table S8-27.

In general, the total number of organisms were statistically higher ($p<0.05$) in the downstream reach than from the upstream reach. Both reaches were dominated by *Hydropsyche occidentalis*, a caddisfly, and the percent composition of the most pollution intolerant species within the orders of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT) were high and very similar between the two reaches (upstream = 81% and downstream = 86%). Moreover, other metrics such as species richness (39 and 39), diversity (2.7 and 2.2), and the Hilsenhoff Biotic Index (5.0 and 4.9) showed similar results between upstream and downstream sites, respectively. These data indicate that potential Laboratory contributions, if any, via the Los Alamos Canyon system to the Rio Grande are not significantly impacting the aquatic BMI community.

D. QUALITY ASSURANCE FOR THE SOIL, FOODSTUFFS AND BIOTA PROGRAM

This program uses the same quality assurance (QA) protocols (QA program development, field sampling QA, analytical laboratory quality assessment, field data, analytical, and analytical laboratory quality assessment, and program audits); some of the SOPs, and analytical laboratories described in Chapter 7 plus the following SOPs.

- Produce Sampling
- Fish Sampling
- Game Animal Sampling
- Collection of Crawfish in the Rio Grande
- Collection of Macroinvertebrates in the Rio Grande
- Processing Biota Samples for Analysis

These procedures, which are available on the LANL public website (http://www.lanl.gov/environment/all/qa.shtml), ensure that the collection, processing, and chemical analysis of samples, the validation and verification of data, and the tabulation of analytical results are conducted in a manner consistent from year to year. Locations and samples have unique identifiers to provide chain-of-custody control from the time of collection through analysis and reporting.

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9. Environmental Restoration



contributing author:
Rich Mirenda, Daniel Romero

To Read About **Turn to Page**

Introduction 307
Corrective Actions Program Accomplishments 317
TA-54 Closure Project Accomplishments 331
TA-21 Closure Project Accomplishments 333
Quality Assurance Program 338
References 340

A. INTRODUCTION

The Los Alamos National Laboratory (LANL or the Laboratory), through the Environmental Programs (EP) Directorate, identifies, investigates, and remediates, if appropriate, environmental hazards associated with past Laboratory operations. Corrective actions at the Laboratory are subject to the Compliance Order on Consent (the Consent Order) issued pursuant to the New Mexico Hazardous Waste Act [New Mexico Statutes Annotated (NMSA) 1978, § 74-4-10] and the New Mexico Solid Waste Act [NMSA 1978, §74-9-36(D)]. Radionuclides are regulated under US Department of Energy (DOE) Order 5400.5, "Radiation Protection of the Public and the Environment," and DOE Order 435.1, "Radioactive Waste Management."

The general process for evaluating and remediating sites is called the corrective action process. There are two potential outcomes when site remediation is performed: (1) the site is restored by removing contamination to acceptable levels that protect human health and the environment or (2) the site is stabilized, which may include removal of some contaminants, and long-term stewardship activities are implemented, such as containing the contaminants on the site, restricting access to contaminants on the site, restricting access to the site, and/or performing surveillance and monitoring the site as long as necessary.

Corrective actions are complete at a site when LANL has demonstrated and documented to the regulatory authority's satisfaction that the site poses no unacceptable risk or dose to humans and ecological resources, such as plants and animals. An investigation includes the collection and evaluation of existing data and information about the sites; determination of which sites need to be investigated further; development of a plan to collect and evaluate data at the site; and identification of what, if any, contaminants have been released. If a release has occurred, the investigation determines the "nature" (the origin, type, and amount of chemicals, either natural or man-made, that are present in the environment) and "extent" (the way a chemical is distributed in the environment) of the contamination. Once the nature and extent of contamination have been determined, risk assessments are conducted, and if necessary, appropriate/approved clean-up activities are implemented, and long-term surveillance and monitoring activities are conducted, as appropriate.

1. Programs and Projects

The Laboratory conducts investigation and remediation activities under three primary programs or projects: Corrective Actions, Technical Area (TA)-21 Closure, and TA-54 Closure. The sites under investigation are designated as consolidated units, solid waste management units (SWMUs), or areas of concern (AOCs). The projects under each program collect samples and manage and report data, which are utilized to support site decisions.

The Corrective Actions Program addresses consolidated units, SWMUs, and AOCs intermixed with active Laboratory operations as well as sites located within the Los Alamos townsite (property currently owned by private citizens, businesses, or Los Alamos County) and property administered by the US Forest Service

(USFS), the National Park Service, and the DOE. The Corrective Actions Program also includes the canyons investigations, the groundwater monitoring program (implemented through the Interim Facility-Wide Groundwater Monitoring Plan), storm water and surface water monitoring, and the installation of control measures to minimize erosion.

The TA-21 Closure Project involves all of the sites associated with TA-21 and includes Material Disposal Areas (MDAs) A, B, T, U, and V; various process waste lines; a radioactive waste treatment system; and the Delta Prime (DP) Site Aggregate Area sumps, outfalls, leach fields, historic container storage areas, and other former facilities. In addition, the Laboratory received funding for environmental cleanup projects as part of the American Recovery and Reinvestment Act of 2009. The Laboratory's Recovery Act projects include the decontamination and demolition of 21 buildings at TA-21, removal and remediation of early Laboratory waste from MDA B, and installation of groundwater monitoring wells.

The TA-54 Closure Project involves all of the sites associated with TA-54 and includes MDAs G, H, and L. Activities involve periodic monitoring of the groundwater and vadose zone as well as the development and implementation of corrective measures for the MDAs.

2. Work Plans and Reports

These programs developed and/or revised 26 work plans and 22 reports, which were submitted to NMED during 2009. A work plan proposes investigation activities designed to characterize SWMUs, AOCs, consolidated units, aggregate areas, canyons, or watersheds. The data are presented in an investigation report, which presents and evaluates the results, determines the site status, and recommends additional investigation, remediation, monitoring, or no further action, as appropriate.

Tables 9-1 and 9-2 summarize the work plans and reports submitted and approved in 2009, the work plans and reports submitted prior to 2009 but approved in 2009, and the work plans and reports submitted in 2009 but not yet approved. Table 9-3 summarizes other reports, plans, and documents submitted in 2009. The remainder of this section presents summaries of the investigations for which activities were started, continued, and/or completed in 2009 and those investigations for which reports were submitted in 2009. Figures 9-1 and 9-2 show the locations where significant environmental characterization and/or remediation work was performed in 2009.

Table 9-1
Work Plans Submitted and/or Approved in 2009

Document Title	Date Submitted	Date Approved[a]	Status
Los Alamos Site Monitoring Area 2 Interim Measure and Monitoring Plan	11/03/2008	05/05/09	Remove contamination from the drainage below SWMU 01-001(f); prevent contaminants from the mesa top from migrating into the drainage below SWMU 01-001(f); construct two connected surface water retention basins
Delta Prime Site Aggregate Area Phase II Work Plan, Revision 1	12/12/08	01/12/09	Work conducted in 2009 and 2010
Work Plan for Installation of Storm Water Controls [Corrective Action with Controls for AOC 00-030(f)]	02/17/09	03/26/09	Phase II report for Pueblo Canyon Aggregate Area due by June 2010
Phase II Investigation Work Plan for Middle Los Alamos Canyon Aggregate Area, Revision 1	02/27/09	03/25/09	Report due March 2011
Phase III Investigation Work Plan for Material Disposal Area T at Technical Area 21	04/17/09	05/26/09	Report submitted 9/18/09; continue quarterly vapor sampling

Table 9-1 (continued)

Document Title	Submitted	Approved	Status
Sampling and Analysis Plan for Direct-Push Technology at Material Disposal Area B	04/23/09	05/04/09	Sampling completed
Investigation Work Plan for Lower Sandia Canyon Aggregate Area	04/30/09	n/a[b]	Revised
Historical Investigation Report for Lower Sandia Canyon Aggregate Area	04/30/09	n/a	n/a
Investigation Work Plan for Potrillo/Fence Canyons Aggregate Area	04/30/09	n/a	Revised
Historical Investigation Report for Potrillo/Fence Canyons Aggregate Area	04/30/09	n/a	n/a
Vadose Zone Subsurface Characterization and Vapor-Monitoring Well Installation Work Plan for Material Disposal Area V, Consolidated Unit 21-018(a)-99	05/18/09	n/a	Revised
Phase II Investigation/Remediation Work Plan for Material Disposal Area A, Solid Waste Management Unit 21-014, at Technical Area 21	06/15/09	n/a	Revised
Investigation Work Plan for Lower Sandia Canyon Aggregate Area, Revision 1	07/23/09	08/06/09	Report due by March 2011
Investigation Work Plan for Potrillo/Fence Canyons Aggregate Area, Revision 1	07/23/09	07/30/09	Report due by May 2011
Vadose Zone Subsurface Characterization and Vapor-Monitoring Well Installation Work Plan for Material Disposal Area V, Consolidated Unit 21-018(a)-99, Revision 1	08/21/09	09/03/09	Conduct quarterly vapor monitoring
Vapor-Monitoring Well Installation Work Plan for Material Disposal Area H, Solid Waste Management Unit 54-006, at Technical Area 54	08/28/09	09/16/09	Continue to collect quarterly subsurface vapor samples
Bayo Canyon Aggregate Area Strontium-90 Removal Field Implementation Plan	09/04/09	—[c]	Additional remediation and sampling required
Sampling and Analysis Plan for Sediment Monitoring in the Pajarito Canyon Watershed	09/29/09	11/13/09	Conduct annual sediment sampling
Investigation Work Plan for Delta Prime Site Aggregate Area Delayed Sites	09/30/09	n/a	Revised
Phase II Investigation/Remediation Work Plan for Material Disposal Area A, Solid Waste Management Unit 21-014, at Technical Area 21, Revision 1	09/30/09	11/13/09	Phase II report due May 2012
Monitoring Plan for Los Alamos and Pueblo Canyons Sediment Transport Mitigation Project	10/15/09	—	Continue to monitor storm water; inspect and maintain erosion and sediment control structures and monitoring stations; measure infilling that occurs in each basin located behind the Los Alamos Canyon Low-Head Weir; inspect for geomorphic changes; approved in 2010

Table 9-1 (continued)

Document Title	Submitted	Approved	Status
Investigation Work Plan for Lower Mortandad/ Cedro Canyon Aggregate Area	10/29/09	n/a	Revised; approved in 2010
Historical Investigation Report for Lower Mortandad/Cedro Canyon Aggregate Area	10/29/09	n/a	n/a
Work Plan for Supplemental Soil Vapor Extraction Pilot Study Test Implementation/Reporting at Material Disposal Area G	10/29/09	n/a	Revised; approved in 2010
Grouting Plan for the Corrective Measures Implementation for Consolidated Unit 16-021(c)-99	11/02/09	—	Process completed.
Investigation Work Plan for the Chaquehui Canyon Aggregate Area	11/30/09	—	Under review in 2009
Historical Investigation Report for the Chaquehui Canyon Aggregate Area	11/30/09	n/a	n/a
Investigation Work Plan for Delta Prime Site Aggregate Area Delayed Sites, Revision 1	12/21/09	—	Under review in 2009; approved in 2010
Nest Box Monitoring Plan for the Upper Pajarito Canyon Watershed	12/21/09	—	Under review in 2009
Accelerated Corrective Action Work Plan for Upper Los Alamos Canyon Aggregate Area, Former Technical Area 32	12/21/09	—	Under review in 2009; approved in 2010

[a] Work plans typically approved with modifications or directions.

[b] n/a = Not applicable.

[c] "—" = Approval not received or required.

Table 9-2
Reports Submitted and/or Approved in 2009

Document Title	Date Submitted	Date Approved[a]	Status
Investigation Report for Middle Canada del Buey Aggregate Area	01/14/09	n/a[b]	Revised
Phase II Investigation Report for the TA-16-340 Complex [Consolidated Units 13-003(a)-99 and 16-003(n)-99 and Solid Waste Management Units 16-003(o), 16-026(j2), and 16-029(f)], Revision 1	01/22/09	02/09/09	Continue to monitor surface water and groundwater as well as inspect and maintain erosion control best management practices
Pilot Test Report for Evaluating Soil-Vapor Extraction at Material Disposal Area G at Technical Area 54, Revision 1	01/30/09	—[c]	Work plan for supplemental soil vapor extraction study provided
Pilot Test Report for Comparing Packer and FLUTe Vapor-Monitoring Systems at Material Disposal Area H, Revision 1	02/18/09	—	Continue to collect subsurface vapor data from the three existing boreholes
Los Alamos Canyon Low-Head Weir Ecological Risk Screening	02/20/09	n/a	Continue to monitor storm water and determine the effectiveness of the controls
Numerical Analysis of the Soil-Vapor Extraction at Material Disposal Area G at Technical Area 54	03/11/09	n/a	Analyses show that the soil vapor extraction (SVE) test was effective in removing subsurface volatile organic compounds; supplemental SVE pilot study test to be conducted in 2010

Table 9-2 (continued)

Document Title	Date Submitted	Date Approved[a]	Status
Status Report on Actions Completed to Date on the Interim Measure Work Plan to Mitigate Contaminated Sediment Transport in Los Alamos and Pueblo Canyons	03/31/09	n/a	Continue to monitor storm water and determine the effectiveness of the controls
Investigation Report for Middle Canada del Buey Aggregate Area, Revision 1	04/06/09	04/27/09	Investigation complete
Phase II Investigation Report for Material Disposal Area C, Solid Waste Management Unit 50-009, at Technical Area 50	05/07/09	n/a	Revised
Investigation Report for Upper Los Alamos Canyon Aggregate Area	06/10/09	n/a	Revised
North Canyons Investigation Report	06/30/09	n/a	Revised
Design Drawing for the Cross-Vane Structures in Pueblo Canyon	06/30/09	08/11/09	Continue to monitor storm water and determine the effectiveness of the controls
Completion Documentation on Sediment Removal Activities at the Los Alamos Canyon Low-Head Weir	07/23/09	n/a	Continue to monitor storm water and determine the effectiveness of the controls
Documentation of Installation of Stormwater Controls at Los Alamos Site Monitoring Area 2	08/28/09	n/a	Continue to monitor storm water and determine the effectiveness of the controls
Pajarito Canyon Investigation Report, Revision 1	08/31/09	11/03/09	Additional monitoring of sediment, surface water, groundwater, and cavity-nesting birds and their food
Investigation Report for Canada del Buey	08/31/09	n/a	Revised
Engineering Report and Design Drawing for DP Canyon and Pueblo Canyon Grade-Control Structures	08/31/09	n/a	Continue to monitor storm water and determine the effectiveness of the controls
Documentation of Completion for Construction of the Wing Ditch in Pueblo Canyon	08/31/09	n/a	Continue to monitor storm water and determine the effectiveness of the controls
Phase III Investigation Report for Material Disposal Area T, Consolidated Unit 21-016(a)-99, at Technical Area 21	09/18/09	n/a	Revised
Corrective Measures Evaluation Report for Material Disposal Area G, Consolidated Unit 54-013(b)-99, at Technical Area 54, Revision 1	09/18/09	—	Establish an effective groundwater monitoring well network and collect additional groundwater data
Investigation Report for Upper Mortandad Canyon Aggregate Area	09/29/09	—	Under review in 2009
Completion Documentation for Construction of Three-Cross Vane Structures in Pueblo Canyon	09/29/09	n/a	Continue to monitor storm water and determine the effectiveness of the controls
Investigation Report for North Ancho Canyon Aggregate Area	09/29/09	n/a	Revised
Investigation Report for Direct-Push Sampling Material Disposal Area B, Solid Waste Management Unit 21-015, at Technical Area 21	09/30/09	—	Under review in 2009
Phase II Investigation Report for Material Disposal Area C, Solid Waste Management Unit 50-009, at Technical Area 50, Revision 1	10/01/09	n/a	Phase III investigation work plan submitted in 2010

Table 9-2 (continued)

Document Title	Date Submitted	Date Approved[a]	Status
North Canyons Investigation Report, Revision 1	10/29/09	11/13/09	Investigation completed; continue to monitor storm water per the individual permit and groundwater in well R-24
Investigation Report for Canada del Buey, Revision 1	11/20/09	11/24/09	Investigation completed; additional groundwater investigation as it pertains to TA-54 and continued storm water monitoring
Asphalt Monitoring and Removal Report for Area of Concern C-00-041, Guaje/Barrancas/Rendija Canyons Aggregate Area	12/17/09	—	Under review in 2009
Phase III Investigation Report for Material Disposal Area T, Consolidated Unit 21-016(a)-99, at Technical Area 21, Revision 1	12/23/09	—	Under review in 2009

[a] Reports typically approved with modifications or directions.

[b] n/a = Not applicable.

[c] "—" = Approval not received or required.

Table 9-3
Additional Plans and Reports Submitted in 2009

Document Title	Date Submitted
Periodic Monitoring Reports	
Los Alamos Watershed	02/26/09
Pajarito Watershed	02/26/09
White Rock Watershed	02/26/09
Mortandad Watershed	02/26/09
Sandia Watershed	02/26/09
Water Canyon/Cañon de Valle Watershed	02/26/09
Ancho Watershed	05/29/09
Mortandad Watershed	05/29/09
Sandia Watershed	05/29/09
Los Alamos Watershed	05/29/09
Pajarito Watershed	05/29/09
Mortandad Watershed	08/31/09
Sandia Watershed	08/31/09
Pajarito Watershed	08/31/09
Water Canyon/Cañon de Valle Watershed	08/31/09
White Rock Watershed	08/31/09
Ancho Watershed	08/31/09
Mortandad Watershed	11/30/09
Sandia Watershed	11/30/09
Pajarito Watershed	11/30/09
Los Alamos Watershed	11/30/09

Table 9-3 (continued)

Document Title	Date Submitted
Monthly Groundwater Data Reviews	Monthly
Periodic Monitoring Report for Vapor Sampling Activities at Material Disposal Area L, Solid Waste Management Unit 54-006, at Technical Area 54	Quarterly
Periodic Monitoring Report for Vapor Sampling Activities at Material Disposal Area H, Solid Waste Management Unit 54-004, at Technical Area 54	Quarterly
Periodic Monitoring Report for Vapor Sampling Activities at Material Disposal Area T, Consolidated Unit 21-016(a)-99, at Technical Area 21	Quarterly
Periodic Monitoring Report for Vapor Sampling Activities at Material Disposal Area V, Consolidated Unit 21-018(a)-99, at Technical Area 21	12/21/09
Well Work Plans and Reports	
Status of the Three Shallow Groundwater Wells at Solid Waste Management Units 03-010(a) and 03-001(e)	02/20/09
Work Plan to Plug and Abandon Cañon de Valle Well CdV-16-2(i)	05/01/09
Plugging and Abandonment Summary Report for Well CdV-16-2(i)	08/21/09
Drilling Work Plan for Perched-Intermediate Aquifer Well R-27i	07/31/09
Well Summary Data Sheet R-27i Borehole Stratigraphy and R-27i As-Built Well Construction Diagram	11/16/09
Drilling Work Plan for Perched-Intermediate Aquifer Well CdV-37-1i	07/31/09
Perched Intermediate Well R-47i Well Design	11/05/09
Completion Report for Intermediate Aquifer Well TA-53i	08/21/09
Work Plan to Plug and Abandon Wells 03-B-09 and 03-B-10	07/07/09
Summary Report for Plugging and Abandonment of Wells 03-B-09 and 03-B-10	10/29/09
Summary Report for Aquifer Test Activities at Monitoring Well 03-B-10	11/25/09
As-Built Well Conversion Diagram for R-16	11/25/09
Rehabilitation and Conversion Summary Report for Well R-16	09/15/09
Field Work Plan for Well R-22 Rehabilitation and Conversion	01/30/09
Field Work Plan for Well R-22 Rehabilitation and Conversion, Phase 1	04/27/09
Fieldwork Plan for Well R-22 Redevelopment, Phase I	04/27/09
R-22 Well Redevelopment Phase I Summary Report	08/31/09
Drilling Work Plan for Well R-29	10/16/09
Drilling Work Plan for Well R-30	10/16/09
Status of Regional Aquifer Well R-37 and Request for Deviation from Approved Work Plan	02/25/09
Well Summary Data Sheet R-37 Borehole Stratigraphy and R-37 As-Built Well Construction Diagram	07/06/09
Completion Report for Regional Aquifer Well R-37	09/04/09
Well Completion Report for Well R-38, Revision 1	02/27/09
Completion Report for Regional Aquifer Well R-39	04/22/09
Well Summary Data Sheet R-40 Borehole Stratigraphy and R-40 As-Built Well Construction Diagram	02/04/09
Completion Report for Regional Aquifer Well R-40	06/04/09
Completion Report for Regional Aquifer Well R-41	07/15/09
Well Summary Data Sheet R-41 Borehole Stratigraphy and R-41 As-Built Well Construction Diagram	04/17/09
Completion Report for Regional Aquifer Well R-42	01/26/09

Table 9-3 (continued)

Document Title	Date Submitted
Completion Report for Wells R-43 and SCI-2	03/16/09
Well Summary Data Sheet R-44 Borehole Stratigraphy and R-44 As-Built Well Construction Diagram	02/13/09
Completion Report for Regional Aquifer Well R-44	06/01/09
Well Summary Data Sheet R-45 Borehole Stratigraphy and R-45 As-Built Well Construction Diagram	02/20/09
Completion Report for Regional Aquifer Well R-45	06/01/09
Well Summary Data Sheet R-46 Borehole Stratigraphy and R-46 As-Built Well Construction Diagram	03/19/09
Completion Report for Regional Aquifer Well R-46	03/30/09
Work Plan for Redrilling Well R-47	11/13/09
Well Summary Data Sheet R-48 Borehole Stratigraphy and R-48 As-Built Well Construction Diagram	10/26/09
Well Summary Data Sheet R-49 Borehole Stratigraphy and R-49 As-Built Well Construction Diagram	06/30/09
Completion Report for Regional Aquifer Well R-49	10/29/09
Drilling Work Plan for Regional Aquifer Well R-50	10/16/09
Drilling Work Plan for Regional Aquifer Well R-51	11/06/09
Drilling Work Plan for Regional Aquifer Well R-52	12/15/09
Drilling Work Plan for Regional Aquifer Well R-53	12/15/09
Drilling Work Plan for Regional Aquifer Well R-54	11/06/09
Interim Measures Work Plan for Plugging and Abandonment of Intermediate Groundwater Well MCOBT-4.4	06/12/09
Plugging and Abandonment Summary Report for Well MCOBT-4.4	09/15/09
Drilling Work Plan for Intermediate Aquifer Well PCI-2	02/27/09
Drilling Work Plan for Intermediate Aquifer Well PCI-2, Revision 1	03/20/09
Completion Report for Intermediate Aquifer Well PCI-2	09/29/09
Plugging and Abandonment Work Plan for Test Well TW-1	12/15/09
Plugging and Abandonment Work Plan for Test Well TW-1a	12/15/09
Plugging and Abandonment Work Plan for TW-2	11/06/09
Plugging and Abandonment Work Plan for TW-2a	11/06/09
Plugging and Abandonment Work Plan for TW-2b	11/06/09
TW-8 Pumping Test Work Plan	03/10/09
Plugging and Abandonment Summary Report for Test Well 8 (TW-8)	09/30/09
Drilling Work Plan for Alluvial Wells WCO-1a and WCO-3a	10/29/09
Work Plan for Proposed Aquifer Test Activities at Monitoring Well 03-B-10	08/31/09
Hydrology and Geochemistry of Perched Saturation at Solid Waste Management Unit 03-010(a) and Area of Concern 03-010(e)	07/07/09
Los Alamos National Laboratory Site-Wide Monitoring Program Drinking Water Results for the City of Santa Fe Buckman Water Supply Wells	11/13/09
Los Alamos National Laboratory Sitewide Monitoring Program Drinking Water Results for Los Alamos County Water Supply Well	11/09/09
Miscellaneous Reports/Plans	
General Facility Information (Annual Update)	03/26/09
Interim Facility-Wide Groundwater Monitoring Plan (Annual Update)	06/01/09
Hydrogeologic Site Atlas (Annual Update)	06/30/09
Corrective Measure Study Progress Reports [16-021(c)-99 the 260 Outfall]	Monthly

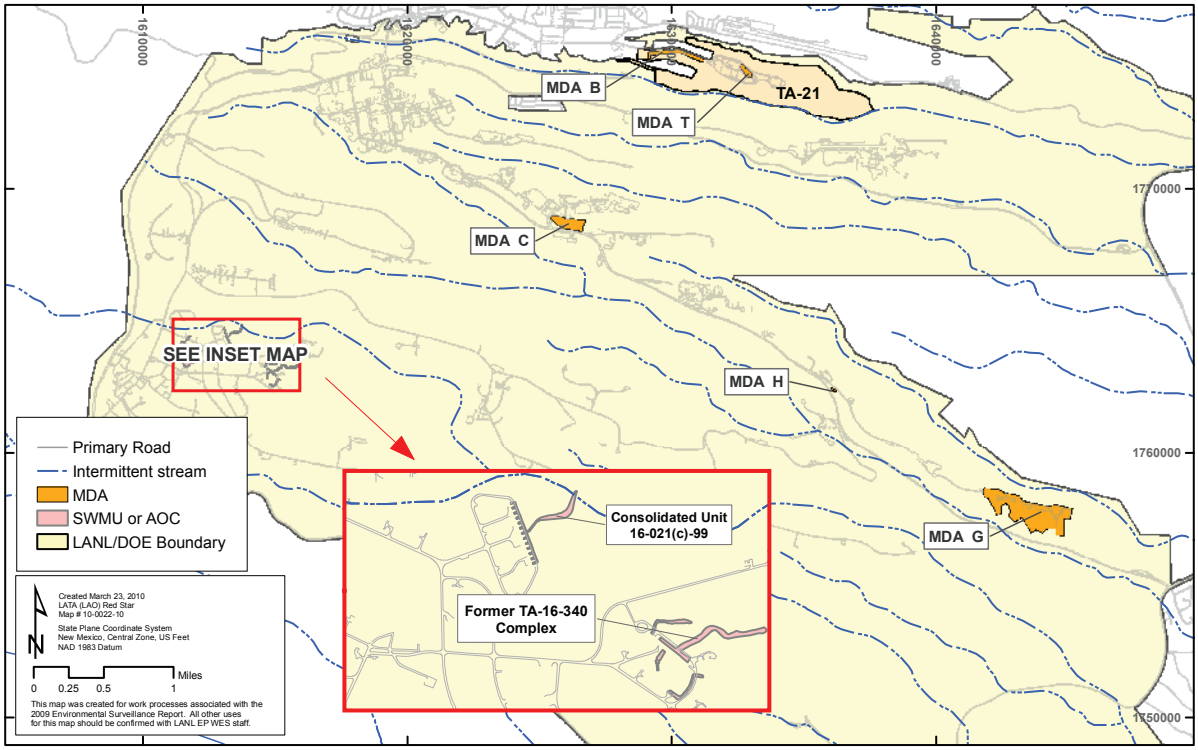


Figure 9-1. **Location of MDAs and other SWMUs or AOCs where remediation and/or characterization work was performed in 2009.**

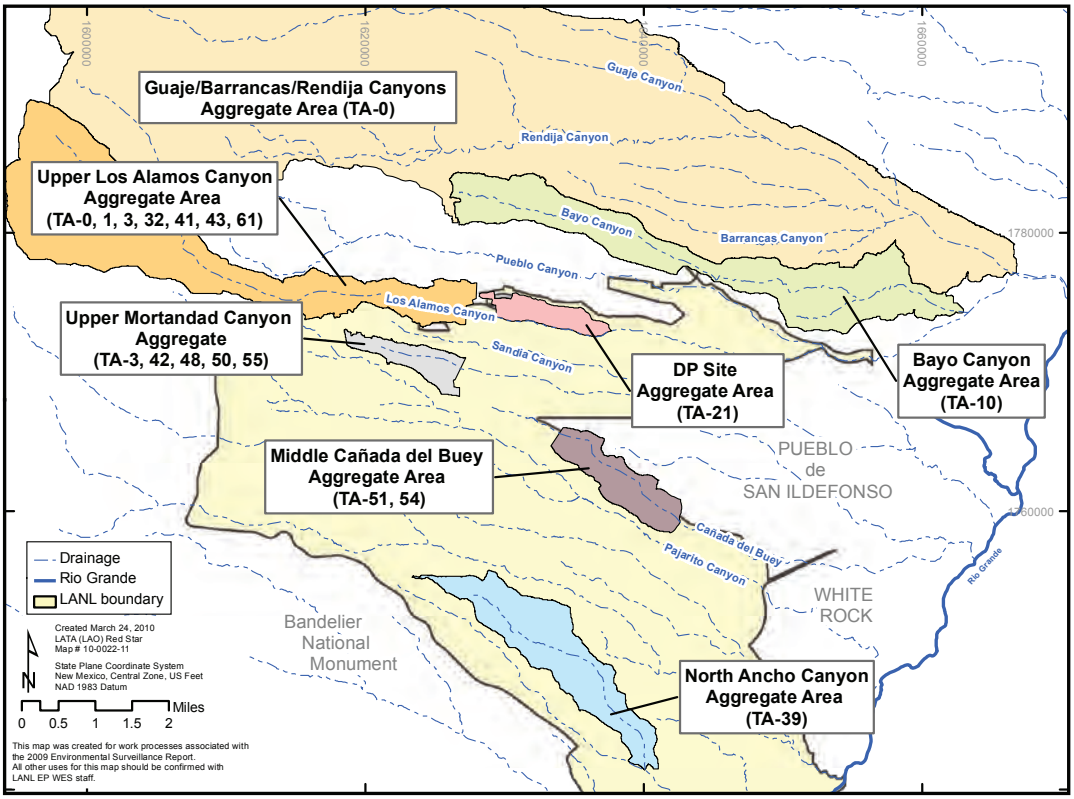


Figure 9-2. **Location of canyons and aggregate areas where remediation and/or characterization work was performed in 2009.**

3. Overview of Vapor Monitoring

In addition to the soil, foodstuffs, biota, groundwater, surface water, and air monitoring discussed in the preceding chapters, subsurface vapor monitoring is conducted as part of corrective action investigations and/or for long-term stewardship activities. Vapor (pore-gas) data collected from vapor monitoring wells are used to help characterize the nature and extent of VOCs and tritium in the vadose zone. By trending vapor phase contaminants detected in the subsurface, we can evaluate the lateral and vertical extent of contamination and determine whether VOCs and tritium may be a potential threat to the groundwater.

Periodic monitoring of pore gas is currently required at MDAs G, H, L, T and V (Figure 9-1). Sampling at MDA C is currently not required; however, monitoring is planned for 2010. The results of the pore gas sampling during 2009 are provided in periodic monitoring reports that we submit to NMED on a quarterly or annual basis as required by the Consent Order. The analytical data are also available on the RACER Data Analysis Tool (http://racernm.com/). No regulatory criteria currently exist for vapor phase contaminants. VOC pore gas data are screened using a groundwater screening evaluation to evaluate whether the pore gas concentration could result in contamination of groundwater above standards. The screening evaluation compares the maximum detected concentrations of VOCs in pore gas to pore-gas screening levels (SLs). The pore gas screening levels are derived from groundwater SLs using the Henry's Law constant.

No applicable screening levels exist for tritium in pore gas.

a. Sampling

Vapor monitoring during 2009 consisted of field screening and sample collection. Field screening includes purging a specific sample interval, at depth, with a gas monitor until gas concentrations stabilize, signifying subsurface air is being collected. In addition to purging, VOC field screening may be performed to estimate VOC concentrations at more locations than are sampled and submitted for laboratory analysis.

Sample collection is carried out using one of three different sampling systems. VOC and tritium samples are collected with stainless steel tubing, down-hole packers, or a FLUTe sampling system. Each system is capable of isolating a specific interval from which pore gas is collected by applying a vacuum at the receiving end. VOC samples are collected in "SUMMA" canisters that capture and contain the air sample for transport to the analytical laboratory for analysis. Tritium samples are obtained by capturing subsurface water vapor in silica gel cartridges. The analytical laboratory analyzes vapor samples according to US Environmental Protection Agency (EPA) Method TO-15 for VOCs and Method 906.0 for tritium.

b. Facility Monitoring

Table 9-4 outlines the number of vapor monitoring wells, number of intervals sampled and/or field screened, type of sampling systems implemented, and the depth to groundwater at each MDA during the 2009 monitoring period. Locations and sampled intervals are determined by NMED-approved work plans.

Table 9-4
Vapor Monitoring Locations

Material Disposal Area	Project	Number of Vapor Monitoring Wells	Number of Sampling Intervals	Type of Sampling System[a]	Approximate Depth to Groundwater[b] (ft bgs)
G	TA-54 Closure	20	131	SS/P	930
H	TA-54 Closure	4	15	SS	1040
L	TA-54 Closure	29	188	SS/P	950
T	TA-21 Closure	5	36	SS	1300
V	TA-21 Closure	1	9	SS/P	1300
C[c]	Corrective Actions	14	129	F/SS	1182

[a] SS= stainless steel, P= Packer, F=FLUTe.

[b] Based on nearest groundwater monitoring well.

[c] MDA C not monitored in 2009. Monitoring is planned for 2010 (LANL 2010c).

VOC and tritium concentration trend analyses are discussed in the periodic monitoring reports available on the LANL public website (http://www.lanl.gov/environment/all/reports.shtml). Monitoring of these sites will continue as directed by NMED.

B. CORRECTIVE ACTIONS PROGRAM ACCOMPLISHMENTS

1. Upper Los Alamos Canyon Aggregate Area

a. Site Description and History.

The Upper Los Alamos Canyon Aggregate Area is located within and south of the Los Alamos town site in TA-0, TA-1, TA-3, TA-32, TA-41, TA-43, and TA-61 and includes a total of 115 SWMUs and AOCs. Sites include septic tanks and outfalls; sanitary waste lines and sewage treatment facilities; industrial waste lines, drains, and outfalls; storm drains and outfalls; soil contamination areas from Laboratory operations; landfills and surface disposal areas; transformer sites; and incinerators. Of the 115 sites in the Upper Los Alamos Canyon Aggregate Area, 47 sites underwent sampling in 2008–2009.

b. Remediation and Sampling Activities

The Upper Los Alamos Canyon Aggregate Area investigation work plan was submitted to NMED in 2006 and subsequently approved. The work plan, as modified and approved by NMED, proposed to collect soil, fill, tuff, and/or sediment samples from more than 300 locations at 47 sites and to implement a phased sampling approach at two additional sites. A total of 701 investigation samples were collected from 330 locations. Excavation was performed at one site during the 2008–2009 investigations, resulting in approximately 6 cubic yards (yd^3) of fill material being removed.

As a result of the characterization sampling conducted as part of the Upper Los Alamos Canyon Aggregate Area investigations and previous storm water monitoring at Los Alamos Site Monitoring Area 2 (LA-SMA-2), the excavation of polychlorinated biphenyl (PCB)-contaminated sediment and confirmatory sampling in the drainage below SWMU 01-001(f) was commenced in late 2009. The implementation of this activity as well as other actions was conducted to control the migration of PCB-contaminated sediment in storm water into and down Los Alamos Canyon. The actions were conducted in conjunction with the recommendations in the Upper Los Alamos Canyon Aggregate Area report (LANL 2009a) and NMED's approval with modifications of the LA-SMA-2 monitoring plan (NMED 2009a).

c. Conclusions and Recommendations

Sampling and other investigation/remediation activities were started in 2008 and completed in 2009. The results of the Upper Los Alamos Canyon Aggregate Area investigation were provided in an investigation report in 2009 (LANL 2009a), which was revised in early 2010 (LANL 2010a).

The Laboratory defined the nature and extent of contamination at 20 of the 47 sites evaluated during the 2008–2009 investigation. Eighteen sites do not pose a potential unacceptable risk or dose under a residential scenario. An additional 54 sites were previously approved for no further action. No further investigation or remediation activities are warranted for these 74 sites, and they are recommended for corrective actions complete without controls (LANL 2010a). AOC 43-001(b2) does not pose a potential unacceptable risk or dose under the recreational scenario, which is the current and reasonably foreseeable land use scenario. Therefore, AOC 43-001(b2) is recommended for corrective actions complete with controls (LANL 2010a).

The Laboratory has not defined the nature and extent of contamination at 27 of the 47 sites evaluated during the 2008–2009 investigation. These sites require additional characterization for certain chemicals of potential concern (COPCs). At nine of the 27 sites for which the extent of contamination is not defined, enough data have been collected to determine that removal actions are warranted. A Phase II investigation work plan will be developed to provide detailed plans for removing soil, fill, sediment, or tuff from six of the nine sites [three sites are addressed by a separate work plan for former TA-32 (LANL 2009b; NMED 2010a)] to reduce

concentrations of COPCs and the associated risks to the extent practicable. Confirmation and/or additional extent sampling will be conducted at all sites.

To mitigate contaminant migration from the SWMU 01-001(f) drainage, the Laboratory continued remediation, sampling, and other actions and completed these actions in 2010.

2. Upper Mortandad Canyon Aggregate Area

a. Site Description and History.

The Upper Mortandad Canyon Aggregate Area is located in TA-3, former TA-42, TA-48, TA-50, and TA-55 and consists of 119 sites, 56 of which have been previously investigated and/or remediated and have been approved for no further action. The remaining SWMUs and AOCs were evaluated by the investigation.

b. Remediation and Sampling Activities

The 2009 investigation activities included collecting 800 surface and shallow subsurface soil, sediment, and rock samples from 306 locations, from the surface to a maximum depth of 101.5 ft below ground surface. Data from the samples collected during the investigation were combined with data collected before 2009 that meet current Laboratory data-quality requirements.

Twenty sites are proposed for delayed characterization and investigation pending the decommissioning and demolition of certain buildings and structures within the Upper Mortandad Canyon Aggregate Area.

c. Conclusions and Recommendations

The investigation report describing the sampling, analyses, and evaluation of the data was submitted in 2009 (LANL 2009c). The objective of the investigation was to define the nature and extent of contamination and, if defined, to determine whether the sites pose a potential unacceptable risk to human health or the environment.

The sampling data indicated the extent of contamination has been defined for nine sites. These sites also have been determined to pose no potential unacceptable risk or dose to human health under the residential and/or industrial scenarios and the environment. No further investigation or remediation activities are warranted at the nine sites. The Laboratory recommended corrective action complete without controls for seven sites because they do not pose potential unacceptable risks or doses to human health under a residential scenario or to the environment. The Laboratory recommended corrective action complete with controls for two sites. The Laboratory intends to retain ownership of the property indefinitely and will continue to restrict the property to industrial use only. The controls required include continuation of the current land use (i.e., industrial) and maintenance of current site conditions.

The extent of contamination has not been defined at 31 sites. Additional sampling is needed to define the vertical and/or lateral extent of one or more COPCs at each of these sites. The Laboratory will provide a Phase II investigation work plan to address the additional sampling required to define the extent of contamination at the sites. The Phase II work plan will also identify specific sampling locations, sampling depths, and analytical suites required to confirm the effectiveness of characterization activities. Once additional data are available and the extent of contamination is defined, human health and ecological risk-screening assessments will be conducted to determine if the sites pose a potential unacceptable risk to human health or the environment.

3. North Ancho Canyon Aggregate Area

a. Site Description and History

The North Ancho Canyon Aggregate Area includes TA-39 and portions of TA-49. The TA-49 sites are addressed in separate work plans and investigation reports. The North Ancho Canyon Aggregate Area includes 44 individual SWMUs and AOCs. Four active sites are included for preliminary characterization only because these sites are impacted by continuing site operations. In addition, the results of the investigation of potential

contamination of canyon alluvial sediment outside and down gradient of the North Ancho Canyon Aggregate Area within the ephemeral stream channel (the extended drainages) are included. The investigation conducted in 2009 included surface and subsurface sampling of 11 SWMUs and AOCs and remediation and confirmatory sampling of three SWMUs.

The North Ancho Canyon Aggregate Area is primarily composed of firing sites for testing of high explosives (HE) and associated support facilities and waste disposal areas. Active facilities include firing sites, storage areas, administrative offices, workshops, sewage disposal facilities, and supporting infrastructure. Inactive facilities include firing sites, storage areas, waste disposal areas, and sewage and chemical disposal facilities.

b. Remediation and Sampling Activities

The investigation included the sampling of 14 SWMUs and AOCs. These sites were sampled to determine the nature and extent of contaminants and, if appropriate, the potential risks and doses to human health and the environment. To determine if contaminants are migrating from the individual SWMUs and AOCs down the canyon during periods of surface water flow, the Laboratory included the results of the investigation of potential contamination at three active firing sites and of canyon alluvial sediment outside and down gradient of the North Ancho Canyon Aggregate Area within the ephemeral drainage channel (the extended drainages).

Remedial actions were performed at three SWMUs resulting in the excavation of waste material and inactive subsurface structures (including waste lines, a septic tank, a seepage pit, and a sand filter).

c. Conclusions and Recommendations

The investigation report was completed and submitted in 2009 (LANL 2009d) and subsequently revised in 2010 (LANL 2010b).

The nature and extent of contamination are defined at six sites plus the extended drainages, but are not defined at five sites. The results of the preliminary characterization for the three active firing sites indicated that contaminants are not migrating off-site from these SWMUs.

The human health risk-screening assessments indicated no potential unacceptable risks or doses for the industrial and residential scenarios at five sites. Following remediation and sampling, the risks and doses were less than the NMED and DOE target levels for the residential scenario at three sites. The human health risk-screening assessments in the extended drainages indicated no potential unacceptable risks or doses for the recreational and residential scenarios. No potential ecological risks exist at the sites within the North Ancho Canyon Aggregate Area.

The Laboratory recommended five sites [SWMUs 39-001(b) and 39-005, and AOCs 39-002(c), 39-002(f), and 39-007(d)] for corrective action complete without controls (i.e., the sites meet cleanup goals for the residential scenario). The Laboratory recommended additional remediation and/or sampling for four sites. The complete characterization of five other sites (including the three active firing sites) will be delayed until operations cease.

A Phase II work plan to address the sampling needed to define extent of contamination and conduct remediation at the sites will be submitted to NMED. The NMED approved the revised report in early 2010 (NMED 2010b).

4. Middle Cañada del Buey Aggregate Area

a. Site Description and History

Middle Cañada del Buey Aggregate Area is located in the central portion of Cañada del Buey and Mesita del Buey and incorporates parts of TA-51 and TA-54. Middle Cañada del Buey Aggregate Area consists of 23 SWMUs and AOCs located on the mesa top. Of the 23 sites, only four AOCs required additional characterization activities and were addressed by the investigation.

b. Remediation and Sampling Activities

Eight samples were collected at AOCs 18-005(b) and 18-005(c) from four locations in/around the footprints of each former magazine for a total of 16 samples. Samples were collected from two depths at each location.

Samples at AOC 51-001 were collected from directly beneath the former inlet and outlet drain line connections to the septic tank from two depths. Samples were collected from three locations within the septic tank footprint from two depths at each location. Four samples were collected from two boreholes drilled adjacent to the seepage pit from two depths to a maximum of 60 ft below ground surface (bgs).

Activities at AOC 54-007(d) consisted of samples collected directly beneath the former inlet and outlet drain line connections to the septic tank from two depths. Samples were collected from three locations within the septic tank footprint from two depths at each location. A total of 24 samples were collected from 12 locations in trenches or with hand augers within the drain field from two depths.

c. Conclusions and Recommendations

Investigation sampling was conducted and completed in December 2008. The Laboratory presented the results in an investigation report submitted to NMED in early 2009 (LANL 2009e) and subsequently revised (LANL 2009f).

Based on information and data presented in the investigation report, remediation and characterization activities are complete at the four Middle Cañada del Buey Aggregate Area sites. The investigation defined the nature and extent of contamination at all sites and found that there are no unacceptable risks or doses to human and ecological receptors. The Laboratory recommended corrective action complete without controls for the four sites. Because these sites do not pose a potential unacceptable risk to human health under a residential scenario and no potential ecological risk, neither site controls nor future actions are necessary.

NMED approved the revised report (NMED 2009b).

5. Guaje/Barrancas/Rendija Canyons Aggregate Area

a. Site Description and History

The Guaje/Barrancas/Rendija Canyons Aggregate Area includes SWMU 00-011(a), a mortar impact area; SWMU 00-011(c), a possible mortar impact area; SWMU 00-011(d), a bazooka firing area; SWMU 00-011(e), an ammunition impact area; AOC C-00-020, a possible mortar impact area; AOC C-00-041, an asphalt batch plant and tar remnant site; and AOC 00-015, the Sportsmen's Club small-arms firing range.

b. Remediation and Sampling Activities

The Laboratory conducted field investigations in 2006 based on the approved work plan. The Laboratory completed investigation activities and submitted the investigation report and a revised report in 2007. Because of the potential for continued exposure of asphalt or tar in the vicinity of AOC C-00-041 by erosion during storms or other runoff events in the future, a work plan was developed to periodically monitor (every two years), by visual inspection, asphalt contamination at the surface of the site and to remove visible asphalt and tar, if exposed (LANL 2008a). The plan was approved by NMED (NMED 2008a).

c. Conclusions and Recommendations

AOC C-00-041 was inspected in October 2009 for remnants of tar and asphalt exposed at the surface by runoff or erosion. The inspection was performed by traversing the site on foot and visually inspecting the ground surface. The Laboratory submitted a report to NMED documenting the observations and actions resulting from the inspection (LANL 2009g).

Exposed asphalt fragments were found and removed during the site inspection. Asphalt was removed only if it was visible at the surface and involved no excavation or significant soil disturbance. Seven 55-gal. drums were filled with the removed asphalt and tar from the site during this monitoring effort. The asphalt was recycled at the Los Alamos County Eco-Station.

6. Bayo Canyon Aggregate Area

a. Site Description and History

The Bayo Canyon Aggregate Area consists of former TA-10 in the lower central portion of Bayo Canyon, between Kwage Mesa to the south and Otowi Mesa to the north, approximately 0.5 mi west of the Los Alamos County Sewage Treatment Plant. TA-10 was used as a firing test site from 1943 through 1961, and the area and related structures were constructed to test assemblies that contained conventional HE, including components made from depleted or natural uranium. TA-10 also included ancillary facilities associated with waste disposal, particularly for the radiochemistry laboratory. Associated facilities included sanitary and radioactive liquid waste sewage lines, manholes, septic tanks, seepage pits, and solid radioactive waste disposal pits. The area underwent extensive decontamination and decommissioning (D&D) from 1960 to 1963; all explosive testing ceased in 1961. After D&D, the site was released to Los Alamos County in 1967 but remains under DOE administrative control.

b. Remediation and Sampling Activities

The Laboratory conducted field investigations in 2007 based on the approved work plan. The Laboratory completed investigation activities and submitted the investigation report and revision 1 of the report in 2008 (LANL 2008b; LANL 2008c). Based on the characterization data from the investigation, the nature and extent of surface and subsurface contamination are defined for all sites within the aggregate area.

Two locations south of SWMU 10-002(b) are contaminated with strontium-90 and were recommended for removal (LANL 2008c). Excavation 1 was approximately 10 ft by 20 ft and was excavated to 3 ft bgs. Excavation 2 was west of Excavation 1, was approximately 5 ft by 5 ft, and was also excavated to 3 ft bgs. Confirmation sampling was conducted at the base of both excavations. Approximately 15 samples were collected from the base of Excavation 1, and five samples were collected from the base of Excavation 2. All shallow subsurface samples were collected from 0 to 1 ft bgs (zero is defined as the base of the excavation) and analyzed for strontium-90 only.

c. Conclusions and Recommendations

Remediation and confirmatory sampling were conducted in 2009. Because results indicated elevated strontium-90 concentrations remained, additional removal and sampling needs to be conducted.

7. TA-16-340 Complex [Consolidated Units 13-003(a)-99 and 16-003(n)-99 and SWMUs 16-003(o), 16-026(j2), and 16-029(f)]

a. Site Description and History

The TA-16-340 Complex is located near the eastern end of the TA-16 mesa, close to the head of Fishladder Canyon, and consists of Consolidated Unit 13-003(a)-99, the septic system associated with the western area of the P-Site Firing Site; Consolidated Unit 16-003(n)-99, the sump and drain line for former building 16-342; SWMU 16-003(o), the sumps and drain lines for former building 16-340; and SWMUs 16-029(f) and 16-026(j2), the sump and drain line for former building 16-345. The TA-16-340 Complex operated from 1952 to 1999 and processed and produced large quantities of plastic-bonded explosives. The plastic-bonded explosives were produced by slurrying HE and solvents together with inert binders. HE and solvent-contaminated washwater was routed to six sumps associated with building 16-340 and to the single sump and outfall associated with building 16-342. Historically, discharges from these sumps were routed to the building 16-340 and 16-342 outfalls, respectively.

b. Remediation and Sampling Activities

A Phase II investigation was conducted in 2008, which involved additional soil-removal actions and sampling to complete the investigation of the TA-16-340 Complex sites. Eighteen boreholes (17 shallow and one intermediate depth) were drilled, 106 samples collected, and 88 yd^3 of soil and tuff excavated during the Phase II investigation.



c. Conclusions and Recommendations

The Laboratory submitted the Phase II investigation report in 2008 (LANL 2008d) and revised it in early 2009 (LANL 2009h). The lateral and vertical extent of inorganic, organic, and radionuclide COPCs was defined using data from all investigations. Although volatile organic compounds (VOCs) were detected in the pore-gas samples in the intermediate borehole next to the former TA-16-340 drain line, the screening evaluation indicated that VOCs in subsurface pore gas are not a potential source of groundwater contamination (LANL 2009h). Several inorganic chemicals, radionuclides, and organic chemicals were detected in surface water and alluvial groundwater but were sporadically above standards or screening levels with no clear trends.

Following Phase II sampling and remediation activities, the human health risk screening assessments determined there are no potential unacceptable risks or doses under the industrial and construction worker scenarios. The ecological risk screening assessment indicated no potential risk to ecological receptors. Based on the results, the Laboratory recommended corrective action complete with controls for the TA-16-340 Complex sites. The controls required include continuation of the current land use (i.e., industrial) and maintenance of current site conditions.

In addition, surface water and alluvial groundwater will continue to be monitored at this site. Monitoring of the three alluvial wells down gradient from SWMU 16-003(o) is recommended as a site condition for characterizing chemical concentrations and variability in the alluvial groundwater.

The NMED approved the revised investigation report in 2009 (NMED 2009c).

8. Consolidated Unit 16-021(c)-99 (260 Outfall) Corrective Measures Implementation

a. Site Description and History

Building 16-260, located on the north side of TA-16, has been used for HE processing and machining since 1951. Wastewater from machining operations contained dissolved HE and may have contained entrained HE cuttings. At building 16-260, wastewater treatment consisted of routing the water to 13 settling sumps for recovery of any entrained HE cuttings. From 1951 through 1996, the water from these sumps was discharged to the 260 Outfall, which drained into Cañon de Valle.

As a result of the discharge, both the 260 Outfall and the drainage channel from the outfall were contaminated with HE and barium. The sumps and drain lines of this facility are designated as SWMU 16-003(k), and the 260 Outfall and drainage are designated as SWMU 16-021(c), and comprise Consolidated Unit 16-021(c)-99. SWMU 16-021(c) consists of three portions: an upper drainage channel fed directly by the 260 Outfall, a former settling pond, and a lower drainage channel leading to Cañon de Valle.

b. Remediation and Sampling Activities

A Corrective Measures Implementation (CMI) Plan for Consolidated Unit 16-021(c)-99 was submitted (LANL 2007) and approved by NMED (NMED 2007). The CMI plan presented the designs and plans for implementing remediation actions within the former 260 Outfall channel and in the alluvial systems of Cañon de Valle and Martin Spring Canyon. The objective of the 2009–2010 CMI was to remediate HE and other contaminants present in the concrete trough, former settling pond, outfall drainage channel, and in the alluvial groundwater system in Cañon de Valle and Martin Spring Canyon.

c. Conclusions and Recommendations

The Laboratory implemented the CMI plan in 2009 and completed most of the plan's remediation and investigation actions in early 2010. The CMI activities consisted of the following actions.

260 Outfall Drainage Channel Remediation – The Laboratory began this work by excavating and removing the concrete trough and underlying soil. After the concrete trough was excavated, samples were collected from the base of the excavation, and the trench was backfilled, compacted, and re-graded. Three locations with elevated HE screening concentrations were excavated to depths of 7 to 10 ft bgs; a total of approximately 8 yd^3 of soil was removed. Three removal locations within the former settling pond were excavated. Removal activities were also conducted at five 260 Outfall drainage channel locations. A total of 9.3 yd^3 of soil and tuff was excavated,

but additional soil removal still needs to be done at one location. Confirmation sample results for each of these activities indicated contaminant concentrations were below cleanup levels.

Sanitary Wastewater Systems Consolidation (SWSC) Cut Soil Investigation – The Phase III Resource Conservation and Recovery Act (RCRA) facility investigation indicated that soil in the vicinity of the SWSC sewer pipeline near SWSC Cut contained elevated concentrations of silver and failed sediment toxicity testing of chironomids. Five samples from the SWSC Cut were collected, analyzed for metals, and found to contain elevated concentrations of barium and silver. The location will be resampled and submitted to an off-site laboratory for sediment toxicity testing of chironomids. If the sample is found to contain elevated concentrations of silver and fails the toxicity tests, further removal actions may be required.

Former Settling Pond Surge Bed Remediation – The remedial objective of surge bed injection grouting is to prevent groundwater from making contact with the contaminated upper surge bed within the settling pond area. More specifically, isolation of the contaminated horizon is needed to prevent contaminants from leaching into groundwater, migrating off-site, and threatening drinking water supplies or the environment. To avoid potential hydraulic fracturing of the subsurface formation in and around the surge bed, low pressure grouting was used (LANL 2009i). Low-pressure grouting, otherwise known as permeation or area grouting, is a technique where a low-viscosity grout is injected in a formation, filling pores and fissures and thereby decreasing formation permeability.

Maintain Existing Low-Permeability Cap on the Former Settling Pond– The low-permeability cap in the former settling pond was replaced in the excavated areas after attaining the appropriate soil concentrations in those locations. The purpose of the cap is to prevent surface water from infiltrating to groundwater. Soil/bentonite cover material was applied in 6 in lifts and compacted to 95% compaction. The cover is 1 to 2 ft thick and is designed to prevent surface and groundwater from coming into contact with potentially contaminated tuff.

Spring Carbon Filters at SWSC Cut and Burning Ground Spring and Modification of Existing Carbon Filter at Martin Spring– The spring carbon filters are designed to optimize hydraulic head difference across the filter and to preserve any existing wetlands associated with the spring, both during and after construction for cleanup of SWSC Cut and Burning Ground Spring in Cañon de Valle and Martin Spring in Martin Spring Canyon.

Permeable Reactive Barrier (PRB)– The primary remedial objective for the PRB is to reduce RDX and barium concentrations in alluvial groundwater to below their respective groundwater standards, which will in turn reduce the concentrations of contaminants infiltrating to intermediate and regional groundwater zones. Groundwater is funneled by diversion walls through a gate into a reactive cell in which the contaminants are treated by the reactive media: zero valent iron, zeolite, and gravel mixture. A total of 16 alluvial groundwater wells were drilled to monitor the PRB performance; five wells were installed upgradient, and 11 wells were installed down gradient. In addition, four 2-inch piezometers were installed to monitor water levels and water chemistry.

To confirm the effectiveness of the CMI characterization and remediation activities, the Laboratory will sample and monitor the springs and alluvial and intermediate-perched groundwater. The Laboratory will submit a monitoring plan to NMED in 2010.

9. MDA C

a. Site Description and History

MDA C, an inactive 11.8-acre landfill, is located within TA-50 at the head of Ten Site Canyon. MDA C consists of seven disposal pits and 108 shafts; the depths of the pits range from 12 to 25 ft and the shafts range from 10 to 25 ft below the original ground surface. Ten shafts in Shaft Group 3 (Shafts 98–107) are lined with 12-in.-thick concrete, while the rest of the pits and shafts are unlined. MDA C operated from May 1948 to April 1974 but received waste only intermittently from 1968 until it was decommissioned in 1974. Wastes disposed of at MDA C consisted of liquids, solids, and containerized gases generated from a broad range of nuclear energy research and development activities conducted at the Laboratory. These wastes included uncontaminated classified materials, metals, hazardous materials, and radioactively contaminated materials.

b. Remediation and Sampling Activities

Investigation activities at MDA C began in 2005 and have continued through 2009. The Laboratory submitted a Phase II investigation work plan in 2007, which was approved by NMED and implemented in 2008. The Laboratory designed the proposed activities so that they provide the additional data to define the extent of contamination by collecting subsurface tuff and pore-gas samples at greater depths and at additional locations. Surface soil samples were also collected and analyzed for inorganic chemicals to confirm the results of previous screening-level sample analyses. Specific activities included drilling five new boreholes outside the boundary of MDA C and extending nine existing boreholes to greater depths to define the lateral and vertical extent of contamination, collecting surface soil samples at multiple locations across MDA C to be analyzed for inorganic chemicals, installing vapor monitoring wells using the five new boreholes and nine extended boreholes, and collecting fracture-density and orientation data to evaluate the potential role of fractures in contaminant transport.

c. Conclusions and Recommendations

The results of the Phase II investigation of MDA C were presented in an investigation report (LANL 2009j; LANL 2009k). Based on the characterization data from all investigations conducted at the site, the nature and extent of surface (soil) and subsurface (tuff) contamination are defined. It was also concluded that the nature and extent of VOCs and tritium in pore gas were defined. The human health and ecological risk screening assessments indicated that MDA C does not pose an unacceptable present day risk and dose to human health under the industrial and residential scenarios and to ecological receptors.

It was recommended that the 14 Phase II boreholes currently configured as vapor-monitoring wells be used to monitor potential changes in subsurface pore-gas concentrations of VOCs and tritium. The vapor-monitoring wells will be sampled for VOCs and tritium on a quarterly basis.

Further investigation activities will be conducted to better define the lateral and vertical extent of subsurface VOC and tritium pore gas contamination at MDA C, install two down gradient regional groundwater monitoring wells, and characterize background concentrations of inorganic chemicals detected in dacite rocks. The data collected during the Phase III investigation will be used to support future corrective action decisions for MDA C.

The Laboratory developed a Phase III investigation work plan and submitted it to NMED in 2010 (LANL 2010c).

10. Los Alamos and Pueblo Canyons

a. Site Description and History

The portion of the canyon watershed investigated as the Los Alamos and Pueblo Canyons watershed includes Los Alamos, Pueblo, DP, and Acid Canyons (inclusive of the South Fork of Acid Canyon). The Los Alamos and Pueblo Canyons watershed heads on USFS land in the Sierra de los Valles west and northwest of the Laboratory. The entire watershed, inclusive of Los Alamos, Pueblo, Guaje, Rendija, Bayo, and Barrancas Canyons, as well as smaller tributary canyons (e.g., Acid and DP Canyons), has a combined drainage area of 153 km^2 (59 mi^2). The watershed extends eastward from the headwaters across the Pajarito Plateau for approximately 30.4 km (18.9 mi) to the confluence with the Rio Grande at an elevation of 1678 m (5504 ft) above sea level.

Contaminants have been released into the Los Alamos and Pueblo Canyons watershed from a variety of sources, including Laboratory operations in several TAs (primarily TA-0, TA-1, TA-45, TA-73, TA-21, TA-2, TA-41, and TA-53) and non-Laboratory sources in the Los Alamos town site, such as roads and other paved areas, application of pesticides in headwater areas in the Santa Fe National Forest and within the town site, and atmospheric fallout of radionuclides. Regardless of the source(s), the contaminants have been dispersed down canyon in sediment, surface water, and alluvial groundwater. Many constituents found naturally or derived from anthropogenic sources were concentrated in ash during the Cerro Grande fire in May 2000 and also were dispersed down canyon.

b. Remediation and Sampling Activities

As part of an overall watershed-scale approach, the Laboratory developed an interim measure work plan for Los Alamos and Pueblo Canyons to reduce the migration of contaminated storm water and sediment within the watershed (LANL 2008e; NMED 2008b). The Laboratory also developed a supplemental interim measure work plan, which provides details of additional mitigation actions that will be implemented in the watershed of Los Alamos and Pueblo Canyons to reduce the transport of contaminated sediment (LANL 2008f; NMED 2009d). These mitigation measures are intended to substantially reduce off-site transport of contaminated sediment and complement other actions implemented by the Laboratory and Los Alamos County.

c. Conclusions and Recommendations

The Laboratory implemented all interim actions proposed in the work plans in 2009. The effectiveness of the actions for reducing the transport of contaminants will be evaluated using stream discharge data and sampling and analysis of storm water collected up canyon and down canyon from the primary sediment deposition areas in Los Alamos and Pueblo Canyons. A monitoring plan was developed to evaluate the effect of mitigation measures installed in the Los Alamos and Pueblo Canyons watershed (LANL 2009l) and approved (NMED 2010c). Two types of monitoring will be conducted to meet the objective: (1) monitoring of geomorphic changes in the valley floor and (2) collection and analysis of storm water runoff samples at gage and monitoring stations located throughout the watershed.

Monitoring of geomorphic (surficial) changes associated with the mitigation measures will be conducted using three methods: repeat cross-section surveys, channel thalweg surveys, and general area surveys. Surveys will be conducted annually in late fall, winter, or early spring to document geomorphic changes that may have occurred during the previous summer season. The optimal time will be selected dependent on weather and the ability to work in the wetland after dense vegetation is laid down. The Laboratory may conduct additional surveys locally at other times of the year, if deemed necessary, to document geomorphic changes associated with unique runoff events.

Storm water monitoring will be conducted at locations situated to compartmentalize monitoring data for evaluation of performance of each of the mitigation features within the watershed. Data will also be available to document background or baseline conditions up canyon of the structures. The goals of the sampling strategy are to collect data that represent variations in contaminant concentrations and suspended sediment concentration within runoff events across a typical hydrograph for each location and to document short-term and long-term trends in storm water contaminant concentrations associated with the mitigation features.

The Laboratory will provide the survey data, plotted cross-section and channel thalweg profiles, and discussion in an annual report. An initial report documenting baseline geomorphic conditions will be submitted to NMED. The results of the storm water monitoring will also be reported annually and will include discharge data from each gage, analytical results, and discussion. The objective of the reports is to review the data in the context of each of the mitigation measures implemented. The Laboratory will review the data to evaluate overall watershed performance and to watch for impacts to ongoing activities within the watershed. Additionally, the Laboratory will evaluate geomorphic change with considerations of the need for adaptive management of any of the structures or activities implemented in the watershed.

11. Pajarito Canyon

a. Site Description and History

Pajarito Canyon is located in the central part of the Laboratory. The canyon heads in the Santa Fe National Forest west of the Laboratory boundary and empties into the Rio Grande in White Rock Canyon. The main channel is approximately 14.8 miles long, and the watershed area is approximately 8 mi^2. In addition, Twomile and Threemile Canyons are major tributaries that join Pajarito Canyon and have watershed areas of 3.1 mi^2 and 1.7 mi^2, respectively. Sites within the Pajarito Canyon watershed are located at TA-3, TA-8, TA-9, TA-12, TA-15, TA-18, TA-23, TA-27, TA-48, TA-54, TA-55, TA-59, TA-64, and TA-69.

b. Remediation and Sampling Activities

The Laboratory conducted phased investigations of sediment deposits in the Pajarito Canyon watershed from 2006 and into 2008 in accordance with the Pajarito Canyon summary reports. The Pajarito Canyon biota studies were implemented in 2007 and continued into 2008. The studies are based on assessment endpoints developed to protect the terrestrial and aquatic ecosystems within canyons in the watershed and complement previous studies conducted in the Los Alamos and Pueblo Canyons, Cañon de Valle, and Mortandad Canyon watersheds.

c. Conclusions and Recommendations

The Laboratory revised the Pajarito Canyon investigation report (LANL 2008g, LANL 2009m) and submitted the revised report to NMED in 2009. The objectives of the investigations included defining the nature and extent of COPCs in sediment, surface water, and groundwater and assessing the potential risks to human health and the environment from these COPCs. The investigations also addressed the sources, fate, and transport of COPCs in the canyon watershed. NMED approved the revised report (NMED 2009e).

Sediment COPCs in the Pajarito Canyon watershed are derived from a variety of sources, including Laboratory SWMUs and AOCs, runoff from developed areas, ash from the area burned in the May 2000 Cerro Grande fire, and natural sources such as uncontaminated soil, sediment, and bedrock. Monitoring COPC concentrations transported in sediment is ongoing, particularly in fine-grained sediment deposited after large flood events that have the highest potential for erosion and down-canyon transport. A sampling and analysis plan outlining an annual sediment monitoring program (LANL 2009n) was submitted and approved (NMED 2009f). Sampling at most of the locations will occur once each year after the summer monsoon season to evaluate the cumulative effects of summer floods on contaminant concentrations. To evaluate trends in sediment contamination over time the Laboratory will sample other geomorphic settings in the Pajarito Canyon watershed, contingent on floods that deposit new sediment of sufficient thickness (approximately 5 cm) for sampling at these locations. These contingency locations include wetlands and the depositional area behind the flood retention structure just below the Twomile Canyon confluence with Pajarito Canyon.

Surface water and groundwater are monitored to evaluate long-term trends in contaminant concentrations and for protection of supply wells PM-2, PM-4, and PM-5. In the meantime, protection of water supply wells PM-2, PM-4, and PM-5 is ensured by continued monitoring directly in those wells. In addition, recently installed wells PCI-2, R-37, R-38, R-39, R-40, R-41, and R-49 will be monitored as specified in annual updates to the Interim Facility-Wide Groundwater Monitoring Plan.

The results of the Pajarito Canyon investigation indicated that human health risks and doses based on a recreational exposure scenario are acceptable (LANL 2008g, LANL 2009m). In addition, no adverse ecological effects were observed within terrestrial and aquatic systems in the Pajarito Canyon watershed. Therefore, corrective actions are not needed to mitigate unacceptable risks or doses. However, the Laboratory will conduct additional monitoring of cavity-nesting birds and their food.

A nest box monitoring plan (LANL 2009o) was submitted in late 2009 and approved (NMED 2010d). Insects collected from occupied nest boxes in reaches AW-1, PAS-1E, PA-2W, and TWSE-1W will be analyzed for key chemicals of potential ecological concern (COPECs), as allowed by available sample mass and target detection limits. These samples will provide a comparison between reaches close to contaminant sources with relatively high COPEC concentrations (AW-1, PAS-1E, and TWSE-1W) and a down canyon reach with lower COPEC concentrations (PA-2W). In addition, insect samples will be collected from nest boxes on an adjacent mesa in TA-14, which serves as a local reference area. Insects from each reach will be composited to increase sample mass before they are submitted to analytical laboratories.



12. Sandia Canyon

a. Site Description and History

Sandia Canyon is located in the central part of the Laboratory, heads within TA-3, trends east-southeast across the Laboratory, Bandelier National Monument, and San Ildefonso Pueblo land, and empties into the Rio Grande in White Rock Canyon. The main channel is approximately 9.4 miles long, and the watershed area is approximately 5.5 mi^2. Sandia Canyon on Laboratory property extends for a distance of 5.6 mi and has a watershed area of 2.65 mi^2. Sites within the Sandia Canyon watershed are located at TA-3, TA-53, TA-60, TA-61, TA-72, and former TA-20.

b. Remediation and Sampling Activities

Investigations in Sandia Canyon were completed in 2008. The Laboratory conducted studies to investigate contamination in sediment, surface water, shallow perched alluvial groundwater, the vadose zone, perched-intermediate groundwater, and regional groundwater potentially impacted by SWMUs and AOCs located within the Sandia watershed. The Sandia Canyon investigation also included characterization activities for chromium contamination found in regional groundwater beneath Mortandad Canyon at concentrations exceeding the New Mexico groundwater standard of 50 µg/L.

The sediment investigations focused on characterizing the nature, extent, and inventory of contaminants in post-1942 sediment deposits for 12 reaches in Sandia Canyon. Data from these reaches were used to evaluate potential human health and ecological risks and to identify spatial trends in contamination at a watershed scale, including variations in contaminant concentrations and inventories at increasing distances from source areas and temporal trends in contamination.

The water investigations focused on watershed-scale characterization of surface-water base flow, springs, alluvial groundwater, vadose-zone pore water, perched-intermediate groundwater, and regional groundwater within and beneath Sandia Canyon. The report also considered groundwater information from beneath adjacent watersheds (primarily Mortandad and Los Alamos Canyons) because contaminants in the Sandia Canyon area have been transported laterally across watershed boundaries in the subsurface. These data were used to identify spatial trends in contamination at a watershed scale, including variations in contaminant concentrations at increasing distances from the source areas and as a function of time since contaminant releases were halted. This work involved sampling persistent surface water and springs, drilling and installing monitoring wells, sampling new and preexisting groundwater monitoring wells, and measuring water level variations in all groundwater sources.

c. Conclusions and Recommendations

The results of the sediment sampling and the biota investigation were reported in the Sandia Canyon investigation report (LANL 2009p).

Investigations of sediment, surface water, and groundwater in the Sandia watershed indicated inorganic, organic, and radionuclide COPCs are present at concentrations above screening levels and federal and/or state groundwater standards. The COPCs are derived from several sources, including Laboratory SWMUs and AOCs, runoff from developed areas, and natural sources such as uncontaminated soil, sediment, and bedrock. The nature and extent of these COPCs have been defined in sediment, surface water, the vadose zone, and regional groundwater.

The spatial distribution of contaminants in the Sandia watershed, supported by data from previous investigations, indicated that SWMUs and AOCs within TA-3 are the most important sources of contamination with respect to potential human health risk, ecological risk, and groundwater impacts. Important source areas for Laboratory-derived COPCs in TA-3 include the former outfall for the power plant cooling towers in upper Sandia Canyon, a former PCB transformer storage area along the south fork of Sandia Canyon, and the former asphalt batch plant along the north fork of Sandia Canyon. Contaminants in sediment originally released from TA-3 extend for approximately 10 to 12 km (6 to 7 mi) down canyon from the sources. Storm water runoff and surface-water flow from daily effluent releases generally infiltrate alluvium in the middle portion of Sandia Canyon, resulting

in deposition of contaminated sediment in that area. This finding is consistent with the lack of evidence of past transport of Laboratory-derived contaminants from Sandia Canyon into the Rio Grande. The most important sediment deposition area is in the upper canyon where a broad wetland exists (reach S-2). This area contains approximately 80% to 90% of the inventory of chromium and PCBs within Sandia Canyon sediment deposits.

Investigations of surface water and groundwater have identified the nature and extent of contaminants released into Sandia Canyon. The COPCs in surface water and alluvial groundwater relate closely to those identified for sediment but generally extend for a shorter distance down canyon from the source than do the sediment COPCs. A group of COPCs, including PCBs and several adsorbing and precipitating trace metals, are limited to surface water and alluvial groundwater within Sandia Canyon, as predicted by their geochemical behavior. Other more mobile COPCs are found in the underlying vadose zone, perched-intermediate groundwater, and regional groundwater. These mobile COPCs are present along a migration pathway that includes a spatially limited infiltration window in the middle portion of Sandia Canyon near TA-53. The COPCs along the pathway, particularly chromium and nitrate, are found in various phases. These phases include pore water collected from unsaturated core, perched horizons on top of and within the Cerros del Rio basalt, and, in the case of chromium, an adsorbed or reduced solid phase fixed on bedrock units extending from the base of alluvium to the base of the basalts.

Data from groundwater monitoring wells and the groundwater model provide information on the extent of chromium contamination at concentrations in the regional groundwater greater than the 50 µg/L New Mexico groundwater standard. However, transport modeling conducted for this report identified a possible uncertainty in extent to the south of regional well R-28, which will be addressed by the installation of a new regional monitoring well, R-50.

A mass balance for chromium is used to reconcile the estimated chromium mass released from the TA-3 power plant cooling tower outfall from 1956 to 1972, with the mass found in the principal environmental reservoirs of anthropogenic chromium, including surface sediment, vadose zone rocks, perched intermediate groundwater, and regional groundwater. The mass-balance estimate indicates that the majority of the chromium mass released from the original source is contained as trivalent chromium [Cr(III)] in the reach S-2 sediment and as adsorbed and reduced phases in the vadose zone. Geochemical studies indicate that the adsorbed and reduced chromium in the sediments and in the vadose zone are predominantly geochemically stable, indicating that the Cr(III) inventory is not likely to act as secondary sources for hexavalent chromium [Cr(VI)] under current hydrogeochemical conditions. A continued source of Cr(VI) to the regional aquifer might be present as perched-intermediate groundwater and in pore water within the vadose zone. However, measured chromium concentrations in perched-intermediate groundwater and vadose-zone pore water beneath Sandia Canyon are currently less than maximum observed concentrations in the regional aquifer. This finding indicates continuing recharge of the regional aquifer may result in decreasing chromium concentrations over time in the regional aquifer, although short-term variability, including slight increases, might be expected.

The human health risk assessment indicated that for the recreational scenario, no areas in Sandia Canyon have unacceptable risk for noncarcinogens or dose for radionuclides. However, potential carcinogenic risk is twice the target risk level in reach S-1N, primarily from polycyclic aromatic hydrocarbons (PAHs) in sediment. These PAHs may have originated from the former asphalt batch plant located near the reach and/or runoff from developed areas at the head of the watershed.

A baseline ecological risk assessment indicated exposures to COPECs may cause potential adverse effects to terrestrial and aquatic receptors in the upper part of Sandia Canyon, including the Sandia wetland. For the terrestrial environment, the main COPECs are PCBs for which there is the potential for adverse effects through the food ingestion pathway for shrews and other wildlife, particularly in reach S-2. For the aquatic environment, both the field macroinvertebrate surveys and the toxicity test results point toward potential ecological impacts that could be related to contaminants from Laboratory operations or other sources. However, other non-COPEC factors related to habitat quality also correlate to decreased growth or survival from the bioassay measures and may be the cause of the findings.

Groundwater is monitored as part of the annual Interim Facility-Wide Groundwater Monitoring Plan for potential changes in concentrations or distribution of contaminants for each of the zones, particularly with respect to chromium and nitrate in perched intermediate and regional groundwater. An assessment of remedial alternatives may be appropriate in the future and, if necessary, will address all pertinent issues in the watershed in an integrated manner.

The NMED approved the investigation report with modification in early 2010 (NMED 2010e).

13. Cañada del Buey

a. Site Description and History

Cañada del Buey, which is located in the central part of the Laboratory, is the largest tributary to Mortandad Canyon. The canyon heads within TA-52 and TA-36 and trends east-southeast across the Laboratory, San Ildefonso Pueblo land, and Los Alamos County ending at the confluence with Mortandad Canyon. The main channel is approximately 8.2 miles long and the watershed area is approximately 4.3 mi^2. On Laboratory property, Cañada del Buey extends for a distance of 5 mi, has a watershed area of 2.1 mi^2, has one main tributary (south fork of Cañada del Buey), and a smaller tributary referred to as the TA-46 tributary or the SWSC tributary. Sites within the Cañada del Buey watershed are located at TA-18, TA-46, TA-51, TA-52, TA-54, and former TA-4.

b. Remediation and Sampling Activities

Sampling of the canyon reaches in Cañada del Buey was performed as proposed in the work plan and addendum to the work plan and as modified by several subsequent documents, all approved by NMED. Sediment investigations included geomorphic mapping, associated geomorphic characterization, and sediment sampling in eight investigation reaches located down canyon from SWMUs or AOCs. Groundwater investigations included evaluation of analytical data from samples collected at two shallow monitoring wells within Cañada del Buey. No persistent surface water occurs in the Cañada del Buey investigation area; therefore, surface water investigations included evaluation of storm water at three stream gages along Cañada del Buey.

c. Conclusions and Recommendations

The Laboratory reported the results of the investigations in the Cañada del Buey investigation report. The report was submitted and revised (LANL 2009q; LANL 2009r) and subsequently approved (NMED 2009g).

Investigations of sediment and shallow groundwater in Cañada del Buey indicate that inorganic, organic, and radionuclide COPCs are present in these media, in some cases at concentrations above screening levels or standards. These COPCs are derived from several sources, including Laboratory SWMUs and AOCs; ash from the Cerro Grande burn area; and natural sources, such as uncontaminated soil, sediment, and bedrock. The conceptual model indicates that these conditions for sediment are likely to stay the same or improve because of decreases in contaminant concentrations after peak releases; therefore, no further monitoring of sediment in Cañada del Buey is necessary. However, storm water runoff from SWMUs and AOCs in the Cañada del Buey watershed will be monitored under the requirements of the "National Pollutant Discharge Elimination System Individual Permit for Stormwater Discharges from Certain SWMUs and AOCs at Los Alamos National Laboratory."

The spatial distribution of sediment COPCs in Cañada del Buey indicates that low levels of contaminants have been released and transported down canyon from several TAs in the watershed, including former TA-4, TA-46, and TA-54. Concentrations are highest in reaches close to the sources and decrease rapidly down canyon and do not pose an unacceptable risk in the canyon bottom. No Laboratory-derived COPCs have been identified in the farthest down canyon reach, CDB-4 above NM 4 and White Rock, indicating that Laboratory sites in this watershed are not a recognizable source of contaminants for White Rock or the Rio Grande.

The results of this investigation indicate that potential human health risks in Cañada del Buey are within acceptable limits for current and reasonably foreseeable future land uses. In addition, concentrations of COPECs

in Cañada del Buey derived from Laboratory SWMUs or AOCs are unlikely to produce adverse ecological impacts, and no additional biota investigations, mitigation, or monitoring is required.

14. North Canyons

a. Site Description and History

The Bayo, Barrancas, Rendija, and Guaje Canyon systems are referred to as the "north canyons systems." These canyons head in the northern part of the Pajarito Plateau, north of the Laboratory and are addressed by one work plan because of similarities common to all four canyons.

SWMUs and AOCs associated with TA-10 within the Bayo Canyon Aggregate Area and the SWMUs and AOCs associated with Rendija Canyon have been addressed in separate investigation work plans and reports.

b. Remediation and Sampling Activities

Sediment investigations included geomorphic mapping, associated geomorphic characterization, and sediment sampling in 10 investigation reaches located down canyon from SWMUs or AOCs. Sediment sampling also occurred in one additional reach down canyon from SWMUs and AOCs and in one reach located up canyon from SWMUs and AOCs.

Surface water investigations included samples collected at five locations along stream channels and one spring. Groundwater investigations included samples at one regional groundwater monitoring well within Bayo Canyon (R-24) and five municipal supply wells in Rendija and Guaje Canyons. Groundwater investigations also included core samples and evaluation of samples from one spring.

c. Conclusions and Recommendations

The results of the investigations were reported in the North Canyons investigation report. The report was submitted and revised (LANL 2009s; LANL 2009t) and subsequently approved (NMED 2009h).

Investigations of sediment, surface water, and groundwater in the north canyons indicate that inorganic, organic, and radionuclide COPCs are present. The COPCs are derived from several sources, including Laboratory SWMUs and AOCs; runoff from developed areas in the Los Alamos townsite; ash from the Cerro Grande burn area; and natural sources, such as uncontaminated soil, sediment, and bedrock. Storm water runoff from SWMUs and AOCs in the north canyons watershed will be monitored under the requirements of the "National Pollutant Discharge Elimination System Individual Permit for Stormwater Discharges from Certain SWMUs and AOCs at Los Alamos National Laboratory."

The spatial distribution of sediment COPCs in the north canyons indicates that contaminants have been or may have been released and transported down canyon from former TA-10 in Bayo Canyon and several SWMUs or AOCs in Rendija Canyon. Contaminants in sediment that were or may have been released from these sources are identifiable as COPCs for varying distances down canyon. Most are COPCs only in reaches close to the sources, but no COPCs have been detected farther down canyon in lower Los Alamos Canyon.

In groundwater, arsenic exceeds regulatory drinking water standards in a single detection from water supply well G-1A. This single result most likely reflects naturally occurring arsenic. In surface water, aluminum exceeds a surface water standard. Aluminum commonly exceeds the standard in surface water on the Pajarito Plateau, including background locations and, therefore, likely reflects naturally occurring aluminum. The lack of surface water and shallow alluvial groundwater at former TA-10, which is the principal area of subsurface contamination within the north canyons, leads to minimal or no subsurface contaminant transport. Regional well R-24, which is located down gradient of former TA-10, will continue to be monitored.

The results of this investigation indicate that potential human health risks in the north canyons are within acceptable limits for current and reasonably foreseeable future land uses. Although one surface water location had slightly elevated lead concentrations, the potential for adverse effects is unlikely, given the assumed frequency of exposure to surface water. In addition, concentrations of COPECs in the north canyons derived from Laboratory SWMUs or AOCs are unlikely to produce adverse ecological impacts, and no additional biota investigations, mitigation, or monitoring is required.

C. TA-54 CLOSURE PROJECT ACCOMPLISHMENTS

1. MDA G

a. Site Description and History

MDA G [Consolidated Unit 54-013(b)-99], which is located in the east-central portion of the Laboratory at TA-54, Area G, on Mesita del Buey, is a decommissioned (removed from service) subsurface site at TA-54 established for disposition of low-level waste, certain radioactively contaminated infectious waste, asbestos-contaminated material, and PCBs. The MDA was also used for the retrievable storage of transuranic waste and consists of inactive subsurface units that include 32 pits, 194 shafts, and four trenches. When operations ceased, the remaining capacity of the pits, shafts, and trenches was backfilled with clean, crushed, compacted tuff, and the pits, shafts, and trenches were closed. The disposal shafts were capped with a concrete plug. Portions of the disposal units at MDA G are covered with concrete to allow ongoing waste management activities to be conducted on the surface at Area G. Surface runoff from the site is controlled and discharges into drainages to the north (towards Cañada del Buey) and the south (towards Pajarito Canyon).

b. Remediation and Sampling Activities

The Laboratory continues to monitor VOCs and tritium in subsurface pore gas at MDA G. The Laboratory reports these monitoring results in periodic monitoring reports.

Groundwater-quality monitoring is being conducted currently in accordance with the annual Interim Facility-Wide Groundwater Monitoring Plan. This monitoring supports both the corrective measures process for solid waste management units at TA-54, the RCRA permit for operating units within TA-54, and DOE regulations. The groundwater monitoring network for TA-54 includes both perched-intermediate and regional wells. Several organic compounds have been detected infrequently and at low concentrations; however, none of the detections exceeds the New Mexico Water Quality Control Commission groundwater-quality standards.

c. Conclusions and Recommendations

The Laboratory finalized the report (LANL 2009u) initially submitted in 2008 (LANL 2008h) on the pilot test of SVE conducted at MDA G. The primary goal of the SVE pilot test was to evaluate the effectiveness of SVE and to determine whether SVE is a suitable alternative for remediating the MDA G vapor plumes. The results of the SVE pilot test indicated that SVE is an effective method for extracting vapor-phase VOC contamination from higher permeability geologic units in the vadose zone beneath MDA G (LANL 2008h; LANL 2009u). The SVE pilot test also provided sufficient data to validate the conceptual model for vapor transport at MDA G.

The Laboratory submitted a work plan for the implementation of a supplemental pilot study (LANL 2009v; LANL 2010d). To further document SVE effectiveness and aid in system design considerations, the Laboratory proposed collecting additional discrete permeability measurements from the MDA G extraction borehole(s) used during the 2008 pilot test, as well as from nearby open (uncased) borehole 54-24379. Discrete permeability data will be used to conduct supplemental numerical analysis to further evaluate the relationship between wellhead vacuums, extraction airflow rates, and radii of influence. The Laboratory also proposed collecting additional VOC field-screening data from the 2008 SVE pilot test pore-gas monitoring boreholes to evaluate potential long-term effects (e.g., rebound effects) of the 2008 SVE test on VOC vapor-plume concentrations. NMED approved the work plan in early 2010 (NMED 2010f).

The data to be collected under the work plan and the analysis of existing pore-gas data will be used to refine the conceptual site model by developing an estimate of vapor-phase VOC mass, determining mass distribution with respect to stratigraphic unit, and addressing the potential impact of SVE on the behavior of soil vapor beneath the disposal units at MDA G. The supplemental SVE pilot test report will discuss results in the context of the ability of SVE to achieve possible remediation goals, including the prevention of contaminant migration to groundwater. This discussion will also consider potential preliminary conceptual SVE system design scenarios for addressing these goals.

The Laboratory submitted the revised corrective measure evaluation (CME) report to NMED in 2009 (LANL 2009w). The CME screened 14 corrective measure alternatives based on their ability to meet regulatory thresholds and other qualitative screening criteria. Seven of the 14 alternatives met the screening criteria and were retained:

1. Monitoring and maintenance of the existing cover combined with an SVE system;
2. Construction of an engineered evapotranspiration (ET) cover combined with an SVE system for the removal of vapor-phase VOCs;
3. ET cover with partial waste excavation, monitoring and maintenance, and extraction of vapor-phase organic compounds using an SVE system;
4. ET cover with partial waste excavation, targeted stabilization, monitoring and maintenance, and SVE;
5. Complete excavation, waste treatment, off-site disposal of all MDA G waste, and SVE;
6. Complete waste excavation, on-site waste treatment, disposal of wastes in a RCRA Subtitle C landfill, and SVE; and
7. Complete waste excavation, on-site waste treatment, disposal of wastes in a RCRA corrective action management unit, and SVE.

The alternatives must meet the cleanup objectives of the Consent Order, RCRA closure standards for Pit 29 and Shaft 124, and DOE performance objectives for low-level waste disposal sites. The alternatives also assume that the subsurface RCRA units will be closed using alternative closure requirements developed through the CME and corrective measure implementation processes.

The CME report underwent a preliminary NMED review in 2009. NMED concluded that the Laboratory needs to implement a comprehensive groundwater monitoring network at TA-54 before NMED can more thoroughly evaluate the CME report.

2. MDA H

a. Site Description and History

MDA H is a 70-ft by 200-ft (0.3-acre) fenced area located within TA-54 on Mesita del Buey, a small mesa that lies between Pajarito Canyon and Cañada del Buey. The MDA consists of nine inactive vertical disposal shafts arranged in a line approximately 15 ft inside the southern fence. Each shaft is cylindrical with a diameter of 6 ft and a depth of 60 ft. When filled to within 6 ft of the surface, the space above the waste in Shafts 1 through 8 was filled with 3 ft of concrete, over which an additional 3 ft of crushed tuff was placed. The space above the waste in Shaft 9 was filled with 6 ft of concrete.

From May 1960 until August 1986, MDA H was the Laboratory's primary disposal area for classified, solid-form waste. Disposal of solid-form waste materials at MDA H was restricted to items or materials that were determined by authorized personnel to be both classified and no longer required for their intended use. This determination was recorded on disposal forms that accompanied the waste to MDA H. Liquids were prohibited from disposal.

b. Remediation and Sampling Activities

Since the third quarter of fiscal year (FY) 2006, subsurface pore-gas samples have been collected in boreholes next to MDA H using the FLUTe system for vapor monitoring. Prior to the third quarter of FY2006, a packer sampling system with Teflon tubing was used to collect pore-gas samples at MDA H. The Laboratory continues to monitor VOCs and tritium in subsurface pore gas at MDA H. The Laboratory reports these monitoring results in periodic monitoring reports.

c. Conclusions and Recommendations

The Laboratory conducted a study in 2008 to clarify whether the pore-gas sampling systems produced comparable pore-gas data. Subsurface vapor samples were collected from the boreholes at MDA H using the currently deployed FLUTe system and the previously used packer system. The Laboratory then compared the TCE concentrations collected from both systems. The comparison of the VOC results during the second and third quarter monitoring events in FY2008 found no substantial difference in pore-gas concentrations using the FLUTe or the packer sampling systems (LANL 2008i; LANL 2009x).

A work plan describing activities to install a new vapor-monitoring well and new vapor-sampling systems in two existing vapor-monitoring wells at MDA H was submitted in 2009 (LANL 2009y) and approved (NMED 2009i). The new vapor-monitoring well and reconfiguration of two of the three existing vapor-monitoring wells (54-01023 and 54-15462) are designed to collect additional data to evaluate the lateral and vertical extent of vapor-phase contamination at MDA H. An additional monitoring point is needed to the north of MDA H and deeper samples are needed in existing wells to measure pore-gas concentrations to determine vertical extent of contamination. Installation of the vapor-monitoring wells was completed in late 2009 and sampling was initiated. The results will be reported in the periodic monitoring reports.

D. TA-21 CLOSURE PROJECT ACCOMPLISHMENTS

1. MDA V

a. Site Description and History

Consolidated Unit 21-018(a)-99 is a 0.88-acre fenced area located on the south side of DP Road west of the TA-21 entrance. The consolidated unit is comprised of four SWMUs and one AOC and consists of three absorption beds that received radioactive liquid waste derived from the TA-21 laundry facility. The Laboratory constructed the absorption beds in 1945 and operated them until 1961.

b. Remediation and Sampling Activities

A work plan describing the activities needed to drill a borehole to investigate and determine the geohydrological characteristics of the unsaturated zone at MDA V was submitted and revised (LANL 2009z; LANL 2009aa) and subsequently approved (NMED 2009j). The vapor-monitoring well has been installed to investigate the nature and extent of subsurface tritium contamination. The vapor-monitoring well is installed within 10 ft of original borehole location 21-24524. (The new borehole will retain the designation of 21-24524.) The additional characterization sampling will contribute to a better understanding of the hydrology of the vadose zone below TA-21 and will assist in characterizing the vertical extent of subsurface tritium in pore-water vapor at MDA V. Sampling of the newly installed well began in the first quarter of calendar year 2010.

Samples of tuff were collected at each interval for volumetric and gravimetric moisture content, dry density, chloride concentration of pore water, nitrates, tritium, and perchlorate. Undisturbed core samples for unsaturated hydraulic conductivity testing (Van Genuchten properties) were collected at approximately 303 ft in the Tsankawi Pumice Bed, 380 ft in the Otowi Formation, 670 ft in the Guaje Pumice Bed, and 715 ft in the Puye Formation. Where samples are fragile and an undisturbed sample cannot be collected, a disturbed sample was collected for the specified testing at the target interval. The data obtained will be used to understand the geohydrological setting of the vadose zone at TA-21 and to perform future modeling, as needed.

In addition, the open borehole location 21-02523 was abandoned by grouting from the depth of caving to the ground surface.

c. Conclusions and Recommendations

A minimum of four quarters of sampling will be conducted at the vapor wells starting in the first quarter of calendar year 2010. The Laboratory will include results from the quarterly monitoring in a status report that presents data sampling results from previous and current rounds of sampling as well as any discussion required to qualify the sampling results. This report may include recommendations for future monitoring based on data results and trends.

2. MDA T

a. Site Description and History

MDA T, Consolidated Unit 21-016(a)-99, is an area of approximately 2.2 acres located within TA-21 on DP Mesa. MDA T includes 25 SWMUs and AOCs associated with decommissioned radioactive liquid waste treatment facilities and various storage areas. The SWMUs and AOCs associated with MDA T were operational from 1945 to 1986. The Laboratory discharged approximately 18.3 million gallons of wastewater to the MDA T absorption beds between 1945 and 1967. The SWMUs and AOCs include inactive absorption beds, a retrievable waste storage area, asphalt-lined disposal shafts, sumps, acid holding tanks, acid sumps, effluent holding tanks, sodium hydroxide storage tank, an americium raffinate storage tank, acid valve pit manholes, underground steel tanks, a septic tank, grit chamber or settling tank, and airborne releases from incinerators used to burn waste oils and organics after testing. Also included are eight AOCs that are not part of Consolidated Unit 21-016(a)-99 but are within the footprint of the consolidated unit. The eight sites consist of four unintentional releases or one-time spills and four former storage and treatment tanks.

b. Remediation and Sampling Activities

A Phase III investigation work plan describing the additional activities at MDA T was submitted (LANL 2009bb) and subsequently approved (NMED 2009l). The work plan proposed to install and monitor three new vapor-monitoring wells in order to investigate the nature and extent of VOCs and tritium vapor. To continue the investigation of nature and extent of tritium and VOCs in the subsurface and to identify the source area of the contamination, the Laboratory drilled one well to the approximate depth of 695 ft bgs with nine sampling ports. A new permanent vapor-monitoring well, located along the North Perimeter Road, will be drilled to approximately 960 ft bgs with 11 sampling ports. These new wells will augment the three existing vapor-monitoring wells installed in 2006 to intermediate depths of approximately 380 ft bgs. A third vapor-monitoring well (near building 21-257) will be installed after the waste line removal as part of the DP Site Aggregate Area investigation activities (see Section D.4).

Core samples were collected at the targeted vapor-well intervals to characterize vadose zone chemistry, including moisture content, dry density, chlorides, nitrates, and unsaturated conductivity. The data obtained will be used to understand the vadose zone geohydrological setting at TA-21 and for future modeling efforts, as needed.

c. Conclusions and Recommendations

The Laboratory submitted the Phase III investigation report and then revised it (LANL 2009cc; LANL 2009dd). Specific objectives of the investigation were to (1) establish the nature and extent of VOC and tritium vapors beneath MDA T; (2) ascertain the source(s) for vapor-phase contamination; (3) project vapor-phase behavior beneath MDA T over time; and (4) confirm the nature and extent of specific inorganic, organic, and radioactive COPCs in the MDA T subsurface identified by previous investigations.

Evaluation of all 2009 solid media analytical results obtained from boreholes 21-25262 and 21-607955 core samples confirm that the nature and extent of contamination are defined.

Evaluation of the pore-gas analytical results from samples collected from vapor-monitoring wells 21-25262, 21-25264, 21-603058, and 21-603059 through November 2009 showed no significant deviation from results of previous investigations. Carbon tetrachloride, chloroform, methylene chloride, tetrachloroethene, and trichloroethene are the only VOCs consistently detected throughout the sampling period. At vapor-monitoring well 21-25262, concentrations of these five VOCs decreased with depth, indicating the vertical extent of VOCs is defined at this well. Tritium activity also showed a decrease in concentrations to the total depth of the well.

Pore-gas results obtained from samples collected during the initial round of sampling in early December 2009 at vapor-monitoring well 21-607955 (the new well located along the North Perimeter Road) reflect the VOC concentration trends observed in the other vapor-monitoring wells, with the exception of acetone. Acetone was detected at a total depth of ~960 ft bgs at a concentration of 30,000 $\mu g/m^3$. Tritium was also detected at a low activity at this depth after showing decreasing concentrations to nondetects below ~550 ft bgs. Additional

rounds of vapor sampling at vapor-monitoring well 21-607955 will help ascertain whether these concentrations of acetone and tritium at 960 ft are indicative of conditions beneath MDA T or whether the well had not reached equilibrium conditions when the first-quarter sampling was conducted.

Continued collection of vapor-monitoring samples from all current MDA T vapor-monitoring wells, including the new, deep vapor-monitoring well 21-607955 and the future vapor-monitoring well near building 21-257, will provide additional information concerning extent of contamination, corroborate potential contamination sources, and verify time-dependent trends to support the corrective measures evaluation. Evaluation of a groundwater monitoring network for MDA T will define locations, depths, and objectives for potential new groundwater and vadose-zone monitoring.

NMED approved the revised investigation report in early 2010 (NMED 2010g).

3. MDA B

a. Site Description and History

MDA B (SWMU 21-015) is an inactive subsurface disposal site that occupies approximately six acres and consists of multiple disposal trenches. The site runs along the fence line on DP Road and is located about 1,600 ft east of the intersection of DP Road and Trinity Drive. MDA B drains south into BV Canyon, a small tributary of Los Alamos Canyon. Historical records state that MDA B consisted of several disposal trenches approximately 300 ft long, 15 ft wide, and 12 ft deep, and included at least one smaller, shallower trench on the eastern end of the site. From 1944 until it closed in 1948, MDA B received process wastes from operations within TA-21 at DP East and DP West. The wastes disposed of at MDA B were highly heterogeneous, primarily radioactively contaminated laboratory wastes and debris, and limited liquid chemical waste; however, a formal waste inventory was not maintained.

b. Remediation and Sampling Activities

A sampling and analysis plan describing the locations and methods to be used to collect samples and analytical data using direct-push technology (DPT) at MDA B was prepared as an addendum to the investigation/remediation work plan (LANL 2006). The MDA B DPT sampling activities are designed to provide operational data for (1) safely performing waste retrieval and sorting activities by establishing correlations between field instrument readings and laboratory analysis before actual excavation begins; (2) revising the estimated quantity and distribution of radioactive material at risk; and (3) analyzing waste samples for hazardous materials before excavation to aid in initial waste-sorting activities. The systematic sampling data using DPT are intended to supplement, but not to replace, any sampling performed during waste excavation, as described in the approved work plan. The DPT work plan was approved by NMED (NMED 2009m).

Phase I sampling involved the systematic sampling of trenches 1–10 at locations determined on the site-wide grid. The site-wide grid used state plane coordinates to track all activities during the removal process, including DPT samples, waste removal, and verification sampling after waste is removed. Samples were submitted for analysis by gamma spectroscopy and for americium-241, isotopic plutonium, isotopic uranium, isotopic thorium, strontium-90, tritium, VOCs, semivolatile organic compounds, target analyte list metals, uranium, and dioxins/furans (for apparent burnt material).

DPT involves a portable sampling device, such as a Geoprobe, that uses a small-diameter, steel push-tube and core collection sleeve technique rather than a rotating bit to core and extract small volume samples. If refusal is encountered, the DPT will be moved in 2-ft increments about the initial location, and the DPT core will be driven into/through the waste until either (1) a core is obtained or (2) four attempts have been completed without retrieving a sample. If a core cannot be collected, the sampling location will be moved to an adjacent grid. Each sample will be field screened, and based on these results, all or part of the materials collected in the push tube will be submitted for laboratory analysis.

The results of Phase I sampling and analyses will determine how Phase II of the proposed approach will proceed. If both DPT and the field methods are deemed effective, Phase II will proceed by collecting core samples from additional site-wide locations, as necessary, to achieve the required statistical confidence in the data set to support radioactive material at risk control limits. DPT will then be used to collect samples on the broader site-wide grid as a means of establishing an inventory for preparing the excavation control plans.

c. Conclusions and Recommendations

The Laboratory submitted an investigation report presenting the data obtained during the direct-push core sampling investigation at MDA B (LANL 2009ee). Forty-five locations within MDA B were core-sampled to depths between 1 ft and 20 ft, using direct-push sampling. The resulting analytical data from DPT have been received, verified, and validated in parallel with preparation of the report; therefore, the report describes the sampling and presents the data. Progress was made toward the objectives of DPT, as follows.

- Analytical data have been obtained to be evaluated against field gamma assay data. This evaluation will occur before excavation.
- Analytical data have been obtained that will contribute to a reevaluation of estimated radioactive material at risk quantities and distribution in the landfill. Before excavation, these analytical data will be reviewed and a decision made about whether to reevaluate estimated radioactive material at risk or to continue with the current estimate.
- Analytical hazardous materials data are now available to aid in waste excavation planning and initial waste sorting activities. Analytical data on hazardous materials will be evaluated to determine areas that require additional precautions and controls during excavation, as well as areas in which little or no contamination was found and reduced controls are required.
- The depth at which the coring tube struck the underlying tuff rock has provided an indication of the configuration of the trenches and, in certain areas, provided an indication that no trench is present.

Direct-push core sampling has provided a strong indication at several areas that a waste trench is not present; however, these areas will be further examined to determine the contamination present and possibly identify areas of low or no contamination. See Section D.5.c for additional status.

4. DP Site Aggregate Area

a. Site Description and History

TA-21 is located on DP Mesa on the northern boundary of LANL and is immediately east-southeast of the Los Alamos townsite. From 1945 to 1978, TA-21 was used primarily for plutonium research, metal production, and related activities. Since 1978, various administrative and research activities have been conducted at TA-21. The DP Site Aggregate Area consists of SWMUs and AOCs located throughout TA-21. The SWMUs and AOCs include container storage areas, surface disposal areas, a PCB storage area, septic systems, sumps, drainlines, outfalls, a waste treatment laboratory, a sewage treatment plant, and seepage pits.

b. Remediation and Sampling Activities

Site characterization and remediation activities were conducted for this aggregate area in 2006 and 2007, based on the approved work plan. A Phase II investigation work plan was submitted and revised in 2008 (LANL 2008j; LANL 2008k). NMED approved the Phase II work plan in early 2009 (NMED 2009n). Lateral and vertical extent samples were collected at Consolidated Unit 21-003-99 and SWMU 21-024(c) for PCB analyses to define the area to be excavated. Environmental media containing total PCBs at concentrations greater than the 1 mg/kg cleanup level were excavated. Confirmatory samples were collected to verify that the cleanup goal was met.

The Phase II investigation activities included collecting 243 surface and subsurface soil and tuff samples from 175 locations to define extent of contamination. Data from the samples collected during the Phase II investigation were combined with data presented in the Phase I investigation report that met current Laboratory data-quality requirements. The investigation of AOC C-21-027 resulted in the collection of an additional 22 surface and subsurface samples. Two boreholes were completed to a depth of 200 ft bgs in the area of diesel tank 21-57 and

defined the extent of diesel contamination. At the PCB site, a total of 142 pre-excavation samples and 368 post-excavation samples were collected and analyzed for PCBs. Approximately 1,400 yd^3 of PCB-contaminated material was removed.

The investigations of Consolidated Unit 21-004(b)-99, SWMU 21-011(b), and Consolidated Unit 21-022(b)-99 were approved for delayed action until collocated active/occupied buildings, Laboratory processes, and/or utilities were removed and/or taken out of service. LANL revised the investigation work plan for the delayed sites describing the operational history, evaluation of existing data, and the removal of the sumps, waste lines and aboveground storage tanks, and sampling associated with accessible portions of Consolidated Unit 21-004(b)-99, SWMU 21-011(b), and Consolidated Unit 21-022(b)-99 (LANL 2009ff; LANL 2009gg).

c. Conclusions and Recommendations

In early 2010, the Laboratory submitted the Phase II investigation report to NMED, which discussed the Phase II sampling results with regards to extent of contamination. The report also included human health and ecological risk-screening assessments for several sites using all of the data that reflects current site conditions.

The NMED approved the work plan for delayed sites, which includes SWMUs and AOCs at TA-21 where investigations cannot occur until collocated active/occupied buildings, Laboratory processes, and/or utilities are removed and/or taken out of service, in early 2010 (NMED 2010h).

5. American Recovery and Reinvestment Act at TA-21

a. Site Description and History

TA-21 is located on DP Mesa on the northern boundary of LANL and is immediately east-southeast of the Los Alamos townsite. It is bounded by two adjacent canyons, DP Canyon to the north and Los Alamos Canyon to the south. In 1945, the operations for establishing the chemical and metallurgical properties of the nuclear material necessary to achieve and sustain the required nuclear fission reaction were transferred to the newly built facilities at TA-21. The facilities were located in the areas of DP West and DP East.

b. Remediation and Sampling Activities

The Laboratory received $212 million for environmental cleanup projects as part of the American Recovery and Reinvestment Act of 2009. The Laboratory's Recovery Act projects include the following:

- Decontamination and demolition of 21 buildings at TA-21;
- Removal and remediation of early laboratory waste from MDA B; and
- Installation of 16 groundwater monitoring wells.

c. Conclusions and Recommendations

The status of the Recovery Act projects as of January 2010 is as follows:

- TA-21 D&D – Six buildings (buildings 21-370, 21-167, 21-166, 21-210, 21-328 and 21-18) have been demolished. The footprint of TA-21 has been reduced by about 27,000 square feet. At the Tritium Systems and Test Assessment facility, the entire tritium inventory has been removed and utility isolation is complete. Hazardous and radioactive waste removal is more than 85% complete, and a contaminated exhaust system was removed from the roof of the building.
- MDA B – The metal structures that will be erected over MDA B during excavation were delivered and are ready to assemble when the site is graded. All three phases of geoprobe activity have been completed.
- Groundwater monitoring wells – Two of 16 groundwater monitoring wells have been completed ahead of schedule, and drilling is underway for three additional wells. Total depth of the new wells, which monitor groundwater in the regional aquifer, is 1,050 feet.
- Waste – To date, the Laboratory has shipped 143 tons of asbestos waste, 1,309 tons of low-level radioactive plus PCB waste, 6.7 tons of New Mexico Special Waste, and 88 tons of industrial waste off-site. In addition, 56 tons of metal have been shipped for recycling.

E. QUALITY ASSURANCE PROGRAM

1. Quality Assurance Program Development

The EP Directorate's quality assurance objectives are to perform work in a quality manner while minimizing potential hazards to the environment, public, and workers. All work is performed by using approved instructions, procedures, and other appropriate means that implement regulatory or contractual requirements for technical standards, administrative controls, and other hazard controls. The LANL Quality Management Plan establishes the principles, requirements, and practices necessary to implement an effective quality assurance program.

The use of a graded approach in accordance with DOE Order 414.1C determines the scope, depth, and rigor of implementing the quality assurance criteria for a specific activity. Activities are managed through systems that are commensurate with the quality requirements, risk, and hazards involved in the activity. Such a selective approach allows the Laboratory to apply extensive controls to certain elements of activities and limited controls to others. The control measures applied to any particular activity are covered in documents such as procedures, statements of work, project-specific work plans, and procurement contracts associated with the activity.

2. Field Sampling Quality Assurance

Overall quality of sample collection activities is maintained through the rigorous use of carefully documented procedures that govern all aspects of these activities.

Soil, water, vapor, and biota samples are (1) collected under common EPA chain-of-custody procedures using field notebooks and sample collection logs and (2) prepared and stored in certified pre-cleaned sampling containers in a secure and clean area for shipment. The Laboratory delivers samples to analytical laboratories under full chain-of-custody, including secure FedEx shipment to all external vendors, and tracks the samples at all stages of their collection and analysis.

3. Analytical Laboratory Quality Assessment

The Laboratory writes specific statements of work to govern the acquisition and delivery of analytical chemistry services after the Laboratory's Data Quality Objective process defines the project needs. These statements of work are sent to potentially qualified suppliers who are National Environmental Laboratory Accreditation Conference (NELAC)-certified for a pre-award assessment by experienced and trained quality systems and chemistry laboratory assessors. Statement of work specifications, professional judgment, and quality system performance at each laboratory (including recent past performance on nationally conducted performance-evaluation programs) are primarily used to award contracts for specific types of radiochemical, organic chemical, and inorganic chemical analyses.

Each analytical laboratory conducts its chain-of-custody and analytical processes under its own quality plans and analytical procedures. The analytical laboratory also submits a full set of hard copy records that serves as the legally binding copy of the data. Each set of samples contains all the internal quality assurance/quality control data the analytical laboratory generates during each phase of chemical analysis (including laboratory control standards, process blanks, matrix spikes, duplicates, and replicates, when applicable). The electronic data are uploaded into the database and verified and validated according to its corresponding variety of quality and consistency checks. All parts of the data-management process are tracked electronically, and periodic reports to management are prepared.

Most analytical laboratories are required to participate in independent national performance evaluation programs. These programs measure each analytical laboratory's performance when analyzing analytes in different media. The laboratories participate in the Mixed Analyte Performance Evaluation Program (MAPEP) and other pertinent programs as available for the analytical methods conducted under contract with LANL.

MAPEP studies and other performance evaluation studies were conducted on analytical performance on soil samples. Of the samples analyzed as part of these studies, the vast majority of the results passed. If the results for an analyte or group of analytes did not pass, the analytical laboratory director investigated the cause of the laboratory's performance, provided an explanation of the results, and established a corrective action plan, if appropriate. The investigation report and corrective action plan is on file at the laboratory and available for review during on-site assessments.

4. Analytical Laboratory Assessments

The EP Directorate has contracts with several external analytical laboratories. The laboratories are audited in order to retain their NELAC and DOE Contract Audit Program (DOECAP) certifications. During 2009, four external laboratory audits were performed under DOECAP: TestAmerica Inc., Paragon Analytics, Inc., General Engineering Laboratories, Inc., and American Radiation Services. Overall, the analytical laboratories were judged to have acceptable performance for almost all analytes and methods attempted in all matrices. Corrective action plans were submitted and approved by DOE and are available on the DOECAP website. Corrective action plans from NELAC audits conducted in 2008 were submitted and approved by the certification agency and certifications granted to the laboratories. In addition, each laboratory conducts internal audits of their procedures, instrumentation, and reporting practices on a regular basis. Issues found are documented and corrective actions performed and recorded. LANL submitted copies of the audit and corrective action reports with the quarterly progress reports, which are maintained on file for each laboratory.



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10. Environmental Stewardship



contributing author:
Jean Dewart, Chris EchoHawk, Philip Fresquez, Danny Katzman, Steven Reneau

To Read About **Turn to Page**

Introduction 347
Long-Term Environmental Data Stewardship 347
Monitoring of the Rio Grande 348
References 353

A. INTRODUCTION

In this report, we are beginning a new chapter called Environmental Stewardship to bring environmental information together within a framework of the long-term environmental stewardship of Los Alamos National Laboratory (LANL or the Laboratory). At certain sites, we anticipate that some contaminants may be left in place following the completion of the environmental restoration program because they will not pose a threat to human health or the environment (because of regulatory criteria defined in the Consent Order). These sites will be monitored over time to assure that this status does not change.

In addition, some environment subjects are of interest to stakeholders and do not fall into single environmental media categories (water, sediments, air, foodstuffs, etc.), following the current organization of this report. We will use the Environmental Stewardship chapter to present some of these cross-cutting environmental subjects. One of these subjects of concern is the Rio Grande. This chapter provides the reader with a comprehensive review of all LANL monitoring of the Rio Grande. LANL is not presenting new environmental monitoring projects or environmental assessments in this section, but rather summarizing environmental data presented in Chapters 5 through 8 of this report and summarizing recent risk assessments.

Our first subject of long-term environmental stewardship of the LANL site is long-term stewardship of environmental data. The Risk Analysis, Communication, Evaluation, and Reduction (RACER) database will be a primary tool for maintaining and making publicly accessible the long-term environmental monitoring data record for the Laboratory.

B. LONG-TERM ENVIRONMENTAL DATA STEWARDSHIP

The RACER database was created to enhance the Laboratory's ability to effectively communicate data to the public in a uniform way. RACER provides web-based access to environmental measurement data collected by LANL and the New Mexico Environment Department. Its purpose is to provide a "transparent" view to the public (http://racernm.com/). Nearly six million data records are available.

An integrated data analysis tool provides the user with a variety of features for analyzing, displaying, and mapping the measurement data. Data may be compared with applicable standards and screening values prescribed by regulators and agencies. Information may also be downloaded in spreadsheet format for additional analysis. RACER is administered by the New Mexico Community Foundation. Public input is vital to RACER effectiveness. The idea is to help neighboring communities understand environmental releases of chemicals and radionuclides as a result of Laboratory operations. Anyone may access RACER to perform their own analyses, using the same data used by LANL and its regulators. The New Mexico Community Foundation requests input for making RACER even more useful through an email address available at the RACER site.

The RACER database will be maintained to provide the long-term environmental monitoring record for the Laboratory. For example, as corrective measures are completed at LANL, monitoring data can be evaluated to determine if corrective measures have been successful in protecting the public from concentrations of contaminants above regulatory limits.

C. MONITORING OF THE RIO GRANDE

1. Monitoring Information

Water quality, sediments, and biota/foodstuffs have been monitored for many years in and along the Rio Grande to assess LANL impacts. Annually, these data are presented in Chapters 5 through 8 of this environmental surveillance report. Individual measurements are available in Supplemental tables and on the RACER database. Environmental samples may not be collected every year when contaminant values are not above standards and do not demonstrate an upward trend over time. Sample locations may change (e.g., sediments) to gain more information when trends are identified. Stations located along the Rio Grande above Otowi Bridge (e.g., Abiquiu Reservoir) are considered upstream or background locations.

2. Water Quality in the Rio Grande

Chapter 6 of this report, *Watershed Monitoring*, presents information on (1) contaminant concentrations in storm water that flows from canyons on LANL property into the Rio Grande and (2) contaminant concentrations in water moving down the Rio Grande, upstream, adjacent, and downstream of LANL property. No perennial flow of water from LANL property flows into the Rio Grande, with the exception of springs that discharge near the river.

Surface water samples were collected from three locations along the Rio Grande in 2009: upriver of Los Alamos Canyon and LANL at Otowi Bridge, at the planned surface water diversion site for Santa Fe at Buckman (at the mouth of Cañada Ancha, downriver from Los Alamos, Sandia, and Mortandad Canyons), and at the mouth of Frijoles Canyon in Bandelier National Monument (downriver from all canyons draining LANL) (see Figure 6-5).

a. Radionuclides

Nine radionuclides were detected in the Rio Grande water samples: radium-226, radium-228, thorium-228, thorium-230, thorium-232, tritium, uranium-234, uranium-235/236, and uranium-238. No screening levels were exceeded in these samples. The highest concentrations for radium-226, the thorium isotopes, and tritium were measured at Otowi Bridge, upriver from LANL, demonstrating naturally occurring and non-LANL sources. For the uranium isotopes, the maximum concentrations downriver from Otowi Bridge were within 1% to 13% of the maximum concentrations measured upriver, also indicating little or no LANL impacts.

b. Metals

Two water samples (one from an upstream location) collected on the same day showed elevated arsenic while samples collected on other days showed lower levels. This arsenic is probably naturally occurring.

c. Organics

For organic chemicals, a sample collected from the Rio Grande at Buckman on September 22 had detected results for benzo(a)pyrene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene above screening levels. The result for benzo(a)pyrene was above the New Mexico Water Quality Control Commission human health standard and the US Environmental Protection Agency (EPA) tap water screening level. The results for dibenz(a,h)anthracene and indeno(1,2,3-cd)pyrene were above the EPA tap water screening levels. No other organic chemicals were detected at concentrations above screening levels. These types of contaminants are associated and consistent with urban runoff.



3. Fish in the Rio Grande

Over the past 30 years, LANL has periodically collected and analyzed fish from the Rio Grande (most recently in 2008) to measure the levels of radionuclides, metals, and polychlorinated biphenyls (PCBs). The methods, locations, analytes, and detailed results are presented in Fresquez et al. (2009). The data have consistently shown no measureable impact from LANL and have indicated sources for mercury and PCBs are upstream from LANL. Long-term trends of radionuclides, metals, and PCBs in fish from Abiquiu Reservoir, the Rio Grande near Los Alamos, and Cochiti Reservoir were evaluated and plotted in Fresquez et al. (2009).

a. Radionuclides

The data from fish show that the concentrations are mostly non-detectable and that there are no statistical differences between upstream and downstream sites. Additionally, the data show that the relatively short-lived fallout radionuclides (strontium and cesium) are generally decreasing and the other fallout radionuclides, including plutonium and americium, are steady.

b. Metals

Metals concentrations in the fish are generally very low or not detectable, with the exception of mercury. Mercury has been measured in fish at levels near and occasionally above the Food and Drug Administration consumption levels, especially in predator fish from the upstream and downstream reservoirs. This is most likely because of biomagnification of mercury in the food chain. The main sources of mercury into the water systems in New Mexico are from natural sources and the burning of fossil fuels. After entering water systems, the inorganic mercury is converted to methylmercury by anaerobic sulfate reducing bacteria using carbon from flooded vegetation as an energy source. Virtually all of the mercury found in the edible portions of fish is methylmercury (EPA 2001), a highly toxic neurotoxin in humans, where it may bioaccumulate (the longer an organism lives, the more contaminant is accumulated in the body) and biomagnify (the contaminant moves up the food chain as organisms are eaten by predators). Currently, there are New Mexico advisories recommending limiting consumption of fish caught in Cochiti Lake due to mercury contamination (NMSWQB 2010).

c. PCBs

In general, PCBs in fish often exceeded the EPA risk-based consumption limits both upstream and downstream of LANL, especially in fish collected from the reservoirs. Total PCB concentrations (all congeners combined) in muscle fillet tissue of the bottom feeders are higher than in muscle fillet tissue of the predator fish. The higher concentrations of PCBs in muscle tissue of the bottom-feeding fish (omnivores) compared with predator fish (carnivores) may be a reflection of their feeding habits (location of food sources) and/or the higher amounts of lipid content (fat) in their tissues. Owing to their low solubility in water, PCBs are most prevalent in sediment at the bottom of lakes and rivers (Ashley and Baker 1999), and fish with higher lipid (fatty tissues) content usually contain higher PCB levels than fish with lower lipid content (Grafton et al. 2008). Currently, there are New Mexico advisories recommending limiting consumption of fish caught in Abiqui Lake, the Rio Grande between Embudo Creek and Cochiti Lake, and in Cochiti Lake due to PCB contamination (NMSWQB 2010).

4. Crayfish in the Rio Grande

For the first time, crayfish (crawfish, crawdads, or mudbugs) (*Orconectes* spp.) were sampled and analyzed as part of LANL's program to help identify any potential impacts to the Rio Grande. Crayfish samples were collected from the Rio Grande within two reaches relative to the location of LANL: upstream and downstream (see Figure 8-1). Upstream (or background) samples were collected starting from the Otowi Bridge north to the Black Mesa area (about a three-mile stretch) and downstream samples were collected from the Los Alamos Canyon confluence south (about a one-mile stretch).

a. Radionuclides

Radionuclides in crayfish were not elevated, were similar to levels found in fish, and were not significantly different in upstream versus downstream samples.

b. Metals

Some metals were statistically higher in crayfish collected downstream compared with crayfish collected upstream of LANL. The differences between crayfish collected downstream and upstream could be caused by LANL impacts to the Rio Grande or they may be explained by natural variability. The results were based on only three samples from each site and additional sampling in the future should help determine the nature and extent of the differences.

c. PCBs

The total concentrations of PCBs in crayfish from both reaches were low and a comparison of the mean PCB homolog distributions in crayfish collected from upstream and downstream reaches relative to LANL show that the profiles are nearly identical to one another with both profiles peaking at the hexachlorinated biphenyl level (see Figure 8-5). Based on the homolog distribution, the profiles from both upstream and downstream locations intersect the patterns of Aroclor 1254 and Aroclor 1260—more of the Aroclor 1260 than the Aroclor 1254. These data agree with the bottom-feeding fish results obtained in 2002 (Gonzales and Fresquez 2008) and 2008 (Fresquez et al. 2009) and with sediments in 2009 (Reneau et al. 2010) and indicate that there is no significant contribution of PCBs to the Rio Grande from the Los Alamos Canyon watershed.

5. Benthic Macroinvertebrates in the Rio Grande

Benthic macroinvertebrates (BMI) are defined as insects, oligochetes, leeches, molluska, and crustaceans that live on the river bottom and are retained by a Standard No. 35 sieve (0.50-mm opening). The numbers and types of organisms, quantified by metrics or indices, may provide an indication of water quality within a stream system (EPA 1998). Because they are continually exposed during their life cycles to extremes in the environment, BMIs can serve as effective indicators of environmental changes and stress (Hilsenhoff 1987).

In general, the total number of organisms was statistically higher ($p<0.05$) in the downstream reach than in the upstream reach. Both reaches were dominated by *Hydropsyche occidentalis*, a caddisfly, and the percent composition of the most pollution intolerant species within the orders of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) were high and very similar between the two reaches (upstream = 81% and downstream = 86%). Moreover, other metrics such as species richness (39 and 39), diversity (2.7 and 2.2), and the Hilsenhoff Biotic Index (5.0 and 4.9) showed similar results between upstream and downstream sites, respectively. These data indicate that potential Laboratory contributions, if any, via the Los Alamos Canyon system to the Rio Grande are not significantly impacting the aquatic BMI community.

6. Irrigation with Rio Grande Waters

In 2009, LANL sampled soil and alfalfa forage irrigated with Rio Grande water upstream and downstream of LANL. Radionuclides, metals, high explosives, PCBs, and semi-volatile organic compounds in soil from fields downstream of LANL were all similar to those from upstream sources. In addition, radionuclides and metals in alfalfa forage plants collected from downstream samples were similar to alfalfa plants collected from regional background locations upstream of LANL and confirm past results (Fresquez et al. 2001).

7. Sediments in the Rio Grande

Past analyses and studies have detected radionuclides and other contaminants that have been transported by flood events down Los Alamos Canyon to the Rio Grande near Otowi Bridge (Graf 1994, 1996; Reneau et al. 1998; LANL 2004). Using sensitive isotopic analytical methods, we have traced plutonium-239/240 from historic Acid Canyon discharges in sediment more than 55 km to lower Cochiti Reservoir (Gallaher and Efurd 2002).

Natural stream flow and sediment loading in the Rio Grande are quite large compared with Los Alamos area streams. These factors reduce the possibility of identifying significant impacts from the Laboratory in the Rio Grande. In both 2008 and 2009, the Laboratory collected sediment samples from banks, bars, and slackwater

areas along the Rio Grande between an area immediately upriver from Otowi Bridge (upriver of LANL) and Frijoles Canyon (downriver of LANL) (see Figure 6-7). In addition, bottom sediment samples were collected in 2008 and previous years at Abiquiu Reservoir (upriver) and Cochiti Reservoir (downriver). In particular, samples collected from four areas in 2009 from Otowi Bridge to Frijoles Canyon were analyzed for a full suite of potential contaminants and provide a larger data set to evaluate possible LANL impacts on the Rio Grande.

a. Metals

In sediment samples collected in 2009, 14 inorganic chemicals have higher concentrations along the Rio Grande, including sites upriver from LANL, than in background samples on the Pajarito Plateau. Concentrations are also higher in Abiquiu and Cochiti Reservoirs. Comparison of concentrations of metals and particle size shows strong positive correlations with silt and clay content. This indicates that variations in particle size between samples are a major cause of differences in inorganic element concentrations between samples collected along the river or in the reservoirs in comparison with samples from the plateau. Samples from the Pajarito Plateau are generally coarser-grained, resulting in lower average and maximum concentrations. The sediment data also indicate some differences related to differing geologic units in source areas. For example, for a given silt and clay content, barium is typically lower in Pajarito Plateau background samples than in river or reservoir samples, whereas copper is typically higher. In contrast, chromium shows no obvious differences related to source area. A comparison of results from samples with similar particle sizes also indicates no clear LANL impact on metals concentrations along the Rio Grande.

b. Radionuclides

In sediment samples collected in 2009, two radionuclides were detected at concentrations above LANL sediment background concentrations in single samples. One of these, tritium, was highest upriver from Otowi Bridge, indicating a naturally occurring or non-LANL source. The other, uranium-238, was highest in the finest-grained sample collected from the river, with 98% silt and clay. This relatively high result represents naturally occurring uranium associated with silt and clay particles.

c. PCBs

Sediment sampling results from 2008 and 2009 show that PCBs in the river are elevated both upstream and downstream of LANL, and the mixture of PCB congeners is similar upriver and downriver but different from that in LANL canyons. These data indicate that the vast majority of the PCBs in the Rio Grande are derived from upriver sources, and that there is no recognizable LANL impact.

We estimate that the average annual flux of PCBs in the Rio Grande upriver from Otowi Bridge and LANL is between 0.16 kg/yr and 0.35 kg/yr. A preliminary estimate of PCB flux in lower Los Alamos Canyon immediately above the river is 0.005 kg/yr, which is 1% to 3% of the total estimated long-term flux in the Rio Grande. These estimates support the conclusion based on PCB congener patterns that there is little LANL impact on PCBs in the river. Additional data are planned to be collected to refine these estimates.

8. Risk Assessments

Due to concern about potential LANL impacts to the Rio Grande, a number of risk assessments have been conducted over the past 10 years. Two areas of emphasis have been evaluated: LANL impacts to the Rio Grande following the May 2000 Cerro Grande fire and LANL impacts to the Rio Grande that may affect the Buckman Direct Diversion Project (BDDP).

a. Cerro Grande Fire

The Risk Assessment Corporation, at the request of the US Department of Energy (DOE), estimated the potential risk to the public from chemicals and radioactive materials released from the Cerro Grande fire in May 2000 (RAC 2002). They estimated the potential annual cancer risk to be less than 3 in 1 million for exposure to any LANL-derived chemical or radioactive material that may have been carried in the surface water and sediments to the Rio Grande and Cochiti Reservoir.

b. Buckman Direct Diversion Project

The City of Santa Fe and Santa Fe County are building the BDDP to access surface water from the San Juan-Chama Project and the Rio Grande. These waters will be treated and distributed to the City and the County through their drinking water distribution systems. The BDDP has evaluated the potential for LANL contaminants to impact this drinking water and has found that LANL contaminants are not present at the BDDP site but could reach the BDDP site in the event of high storm water runoff from Los Alamos Canyon (BDDP 2009). Because of this concern, LANL and the DOE agreed to install an early notification and storm water monitoring system in lower Los Alamos Canyon near the Rio Grande. The monitoring system will automatically notify the BDDP of storm water flows entering the Rio Grande through the use of remote telemetry. The BDDP can then temporarily discontinue water intake from the Rio Grande. The DOE and the BDDP Board have signed a Memorandum of Understanding for operating this system, including cost sharing, operation responsibilities, maintenance, sample testing, and a completion schedule for an early notification system.

In addition, DOE completed construction in 2009 and 2010 of two grade control structures in Pueblo and DP Canyons, both part of the Los Alamos Canyon watershed. These structures will reduce peak flows during storm water runoff events to reduce head-cutting, enhance riparian areas, and promote sediment deposition. The structures were completed in 2010. In addition, 10,000 willows were planted in Pueblo Canyon during 2005 to 2009 to help slow flood waters and aid sediment deposition.

The BDDP has hired ChemRisk, an independent peer reviewer, to prepare an independent risk assessment regarding LANL contaminants with potential exposure through the drinking water pathway, based on existing information, data, and studies. That exposure and risk will be compared to other pathways of exposure to LANL contamination and public exposure to radiation and radionuclides of other origins, including natural background. The risk assessment is scheduled for publication in early 2011.



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Appendix A

STANDARDS FOR ENVIRONMENTAL CONTAMINANTS

General Formation of a Standard

Standards are created to protect a target group from a variety of contaminants in a given exposure pathway for a specific time frame. A target group may refer to the general public, animals, or a sensitive population like adolescents, the elderly, or asthmatics. Contaminants of concern are addressed by a governing body, such as the EPA, which takes into consideration occurrence in the environment, human exposure and risks of adverse health effects, available methods of detection, cost of implementation, geographic location, and public health. After a contaminant of concern has been identified, all exposure pathways are considered to determine the most probable instances and the need for regulation. Pathways of exposure include air, water, soil, biota, and foodstuffs that can be ingested, absorbed, or inhaled. Time of exposure is also an important factor in the formation of standards because prolonged exposure to low levels of a contaminant can have similar health effects as a short exposure to a high level of a contaminant.

Throughout this report, we compare concentrations of radioactive and chemical constituents in air and water samples with pertinent standards and guidelines in regulations of federal and state agencies. Los Alamos National Laboratory (LANL or the Laboratory) operations are conducted in accordance with directives for compliance with environmental standards. These directives are contained in Department of Energy (DOE) Orders 450.1, "Environmental Protection Program;" 5400.5, "Radiation Protection of the Public and the Environment;" and 231.1A, "Environmental Safety and Health Reporting."

Radiation Standards

DOE regulates radiation exposure to the public and the worker by limiting the radiation dose that can be received during routine Laboratory operations. Because some radionuclides remain in the body and result in exposure long after intake, DOE requires consideration of the dose commitment caused by inhalation, ingestion, or absorption of such radionuclides. This evaluation involves integrating the dose received from radionuclides over a standard period of time. For this report, 50-yr dose commitments were calculated using the EPA dose factors from Federal Guidance Report No. 13 (EPA 1999). The dose factors EPA adopted are based on the recommendations of Publication 30 of the International Commission on Radiological Protection (ICRP 1988).

In 1990, DOE issued Order 5400.5, which finalized the interim radiation protection standard for the public (NCRP 1987). Table A-1 lists currently applicable radiation protection standards, now referred to as public dose limits, for operations at the Laboratory. DOE's comprehensive public dose limit for radiation exposure limits the effective dose equivalent (EDE) that a member of the public can receive from DOE operations to 100 mrem per year. For one specific activity or pathway, DOE guidance specifies a "dose constraint" of 25 mrem per year (DOE 1999.) The public dose limits and the DOE occupational dose limits are based on recommendations in ICRP (1988) and the National Council on Radiation Protection and Measurements (NCRP 1987).

The EDE is the hypothetical whole-body dose that would result in the same risk of radiation-induced cancer or genetic disorder as a given exposure to an individual organ. It is the sum of the individual organ doses, weighted to account for the sensitivity of each organ to radiation-induced damage. The weighting factors are taken from the recommendations of the ICRP. The EDE includes doses from both internal and external exposure. External dose factors were obtained from Federal Guidance Report No. 12 (EPA 1993).

Radionuclide concentrations in water are compared with DOE's Derived Concentration Guides (DCGs) to evaluate potential impacts to members of the public. The DCGs for water are those concentrations in water that if consumed at a maximum rate of 730 liters per year, would give a dose of 100 mrem per year. Table A-2 shows the DCGs. For comparison with drinking-water systems, the DCGs are multiplied by 0.04 to correspond with the EPA limit of 4 mrem per year.

In addition to DOE standards, in 1985 and 1989, the EPA established the National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities, 40 CFR 61, Subpart H. This regulation states that emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr. DOE has adopted this dose limit (Table A-1). This dose is calculated at the location of a residence, school, business, or office. In addition, the regulation requires monitoring of all release points that can produce a dose of 0.1 mrem to a member of the public.

Table A-1
DOE Dose Limits for External and Internal Exposures

Exposure pathway	Dose Equivalent[a] at Point of Maximum Probable Exposure
Exposure of Any Member of the Public[b]	
All Pathways	100 mrem/yr[c]
One Specific Pathway (dose constraint)	25 mrem/yr[d]
Air Pathway Only[e]	10 mrem/yr
Drinking Water	4 mrem/yr
Occupational Exposure[b]	
Stochastic Effects	5 rem/yr (TEDE)[f]
Nonstochastic Effects	
Lens of eye	15 rem/yr
Extremity	50 rem/yr
Skin of the whole body	50 rem/yr
Skin of the whole body	50 rem/yr
Embryo/Fetus of Declared Pregnant Worker	0.5 rem/gestation period

[a] Refer to Glossary for definition.

[b] In keeping with DOE policy, exposures must be limited to as small a fraction of the respective annual dose limits as practicable. DOE's public dose limit applies to exposures from routine Laboratory operation, excluding contributions from cosmic, terrestrial, and global fallout; self-irradiation; and medical diagnostic sources of radiation. Routine operation means normal, planned operation and does not include actual or potential accidental or unplanned releases. Exposure limits for any member of the general public are taken from DOE Order 5400.5 (DOE 1990). Limits for occupational exposure are taken from 10 CFR 835, Occupational Radiation Protection.

[c] Under special circumstances and subject to approval by DOE, this limit on the EDE may be temporarily increased to 500 mrem/yr, provided the dose averaged over a lifetime does not exceed the principal limit of 100 mrem per year.

[d] Guidance (DOE 1999.)

[e] This level is from EPA's regulations issued under the Clean Air Act (40 CFR 61, Subpart H) (EPA 1989a).

[f] Refer to Glossary for definition.

Table A-2
DOE's Derived Concentration Guides for Water[a]

Nuclide	DCGs for Water Ingestion in Uncontrolled Areas (pCi/L)	DCGs for Drinking Water Systems (pCi/L)[b]
^{3}H	2,000,000	80,000
^{7}Be	1,000,000	40,000
^{89}Sr	20,000	800
^{90}Sr	1,000	40
^{137}Cs	3,000	120
^{234}U	500	20
^{235}U	600	24
^{238}U	600	24
^{238}Pu	40	1.6
^{239}Pu	30	1.2
^{240}Pu	30	1.2
^{241}Am	30	1.2

[a] Guides for uncontrolled areas are based on DOE's public dose limit for the general public (DOE 1990). Guides apply to concentrations in excess of those occurring naturally or that are due to worldwide fallout.

[b] Drinking water DCGs are 4% of the DCGs for non-drinking water.

Nonradioactive Air Quality Standards

Table A-3 shows federal and state ambient air quality standards for nonradioactive pollutants.

National Pollutant Discharge Elimination System

The types of monitoring required under National Pollutant Discharge Elimination System (NPDES) and the limits established for sanitary and industrial outfalls can be found at http://www.lanl.gov/environment/h2o/cw_npdes.shtml.

Drinking Water Standards

For chemical constituents in drinking water, regulations and standards are issued by the Environmental Protection Agency (EPA) and adopted by the New Mexico Environment Department (NMED) as part of the New Mexico Drinking Water Regulations (NMEIB 1995). To view the New Mexico Drinking Regulations go to http://www.nmenv.state.nm.us/Common/regs_idx.html. EPA's secondary drinking water standards, which are not included in the New Mexico Drinking Water Regulations and are not enforceable, relate to contaminants in drinking water that primarily affect aesthetic qualities associated with public acceptance of drinking water (EPA 1989b). There may be health effects associated with considerably higher concentrations of these contaminants.

Radioactivity in drinking water is regulated by EPA regulations contained in 40 CFR 141 (EPA 1989b) and New Mexico Drinking Water Regulations, Sections 206 and 207 (NMEIB 1995). These regulations provide that combined radium-226 and radium-228 may not exceed 5 pCi per liter. Gross alpha activity (including radium-226, but excluding radon and uranium) may not exceed 15 pCi per liter.

A screening level of 5 pCi per liter for gross alpha is established to determine when analysis specifically for radium isotopes is necessary. In this report, plutonium concentrations are compared with both the EPA gross alpha standard for drinking water and the DOE guides calculated for the DCGs applicable to drinking water (Table A-2).

Table A-3
National (40 CFR 50) and New Mexico (20.2.3 NMAC) Ambient Air Quality Standards

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards	
				Primary	Secondary
Sulfur dioxide	Annual	ppm	0.02	0.030	
	24 hours	ppm	0.10	0.14	
	3 hours	ppm			0.5
Hydrogen sulfide	1 hour	ppm	0.010		
Total reduced sulfur	1/2 hour	ppm	0.003		
Total Suspended Particulates	Annual	$\mu g/m^3$	60		
	30 days	$\mu g/m^3$	90		
	7 days	$\mu g/m^3$	110		
	24 hours	$\mu g/m^3$	150		
PM-10[a]	Annual	$\mu g/m^3$		50	50
	24 hours	$\mu g/m^3$		150	150
PM-2.5[b]	Annual	$\mu g/m^3$		15	15
	24 hours	$\mu g/m^3$		65	65
Carbon monoxide	8 hours	ppm	8.7	9	
	1 hour	ppm	13.1	35	
Ozone	1 hour	ppm		0.12	0.12
	8 hours	ppm		0.08	0.08
Nitrogen dioxide	Annual	ppm	0.05	0.053	0.053
	24 hours	ppm	0.10		
Lead and lead compounds	Calendar quarter	$\mu g/m^3$		1.5	1.5

[a] Particles ≤10 μm in diameter.
[b] Particles ≤2.5 μm in diameter.

For man-made beta- and photon-emitting radionuclides, EPA drinking water standards are limited to concentrations that would result in doses not exceeding 4 mrem per year, calculated according to a specified procedure. In addition, DOE Order 5400.5 requires that persons consuming water from DOE-operated public water supplies do not receive an EDE greater than 4 mrem per year. DCGs for drinking water systems based on this requirement are in Table A-2.

Surface Water Standards

Concentrations of radionuclides in surface water samples may be compared with either the DOE DCGs (Table A-2) or the New Mexico Water Quality Control Commission (NMWQCC) stream standard, which references the state's radiation protection regulations. However, New Mexico radiation levels are in general two orders of magnitude greater than DOE's DCGs for public dose, so only the DCGs will be discussed here. The concentrations of nonradioactive constituents may be compared with the NMWQCC Livestock Watering and Wildlife Habitat stream standards (NMWQCC 1995) (http://www.nmenv.state.nm.us/swqb/standards/20.6.4NMAC.pdf). The NMWQCC groundwater standards can also be applied in cases where discharges may affect groundwater.

Soils

If contaminant concentrations in soil exceed regional statistical reference levels, the concentrations are first compared to screening levels. The screening level for soils is the concentration that would produce (a) a dose of 15 mrem or greater to an individual, (b) a carcinogen risk of 10-5, or (c) a hazard quotient greater than 1. Screening levels for radionuclides are found in LANL 2005; screening levels for non-radionuclides are found in NMED 2006. If radionuclide concentrations in soil exceed the screening levels, then a dose to a person is calculated using RESRAD and all of the measured radionuclide concentrations available for a given year (these data are presented in Table S7-1). This calculated dose is compared to the 25-mrem/yr DOE single pathway dose standard (DOE 1999). Doses, risk, or hazard quotients are calculated using a conservative residential scenario given the measured contaminant soil concentration.

Foodstuffs

Federal standards exist for radionuclides and selected non-radionuclides (e.g. mercury and Polychlorinated Biphenyls (PCBs) in foodstuffs. Federal screening levels exist for selected non-radionuclides; LANL has selected screening levels for radionuclides. If contaminant concentrations in foodstuffs exceed regional statistical reference levels, the concentrations are compared to screening levels. LANL has established a screening level of 1 mrem/year for concentrations of individual radionuclides in individual foodstuffs (e.g. fish, crops, etc), assuming a residential scenario. EPA has established screening levels for mercury (EPA 2001) and PCBs (EPA 2007) in fish.

If contaminant concentrations in foodstuffs exceed screening levels, contaminant concentrations are compared against Food and Drug Administration (FDA) standards (FDA 2000). In the case of radionuclides, a dose to a person would be calculated from all the radionuclides measured and compared with the 25 mrem/yr DOE single-pathway dose constraint (DOE 1999).

Biota. If contaminant concentrations in biota exceed regional statistical reference levels, the concentrations are compared to screening levels. For radionuclides in biota, SLs were set at 10% of the standard by LANL to identify the potential contaminants of concern (McNaughton 2006). For chemicals, there are no SLs based on biota tissue concentrations. Instead, if a chemical in biota tissue exceeds the RSRL, then the chemical concentrations in the soil at the place of collection are compared with ecological screening levels (ESLs) (LANL 2008).

Based on the concentrations of radionuclides in biota, we calculate a dose and compare it with the 1-rad/day DOE dose standard for terrestrial plants and aquatic biota and 0.1-rad/day for terrestrial animals (DOE 2002).

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DOE 2002: US Department of Energy, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota," US Department of Energy Standard DOE-STD-1153-2002 (July 2002).

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Appendix B

UNITS OF MEASUREMENT

Throughout this report the US Customary (English) system of measurement has generally been used because those are the units in which most data and measurements are collected or measured. For units of radiation activity, exposure, and dose, US Customary Units (that is, curie [Ci], roentgen [R], rad, and rem) are retained as the primary measurement because current standards are written in terms of these units. The equivalent SI units are the becquerel (Bq), coulomb per kilogram (C/kg), gray (Gy), and sievert (Sv), respectively. Table B-1 presents conversion factors for converting US Customary Units into SI units.

Table B-1
Approximate Conversion Factors for Selected US Customary Units

Multiply US Customary Units	by	to Obtain SI (Metric) Unit
Fahrenheit (°F)	5/9 - 32	Celsius (°C)
inches (in.)	2.54	centimeters (cm)
cubic feet (ft^3)	0.028	cubic meters (m^3)
acres	.4047	hectares (ha)
ounces (oz)	28.3	grams (g)
pounds (lb)	0.453	kilograms (kg)
miles (mi)	1.61	kilometers (km)
gallons (gal.)	3.785	liters (L)
feet (ft)	0.305	meters (m)
parts per million (ppm)	1	micrograms per gram (μg/g)
parts per million (ppm)	1	milligrams per liter (mg/L)
square miles (mi^2)	2.59	square kilometers (km^2)
picocurie (pCi)	37	millibecquerel (mBq)
rad	0.01	gray (Gy)
millirem (mrem)	0.01	millisievert (mSv)

Table B-2 presents prefixes used in this report to define fractions or multiples of the base units of measurements. Scientific notation is used in this report to express very large or very small numbers. Translating from scientific notation to a more traditional number requires moving the decimal point either left or right from the number. If the value given is 2.0×10^3, the decimal point should be moved three numbers (insert zeros if no numbers are given) to the right of its present location. The number would then read 2,000. If the value given is 2.0×10^{-5}, the decimal point should be moved five numbers to the left of its present location. The result would be 0.00002.

Table B-2
Prefixes Used with SI (Metric) Units

Prefix	Factor	Symbol
mega	1 000 000 or 10^{6}	M
kilo	1 000 or 10^{3}	k
centi	0.01 or 10^{-2}	c
milli	0.001 or 10^{-3}	m
micro	0.000001 or 10^{-6}	µ
nano	0.000000001 or 10^{-9}	n
pico	0.000000000001 or 10^{-12}	p
femto	0.000000000000001 or 10^{-15}	f
atto	0.000000000000000001 or 10^{-18}	a

Table B-3 presents abbreviations for common measurements.

Table B-3
Common Measurement Abbreviations and Measurement Symbols

Symbol	Abbreviation	Symbol	Abbreviation
aCi	attocurie	mrem	millirem
Bq	becquerel	mSv	millisievert
Btu	British thermal unit	nCi	nanocurie
Ci	curie	nCi/dry g	nanocurie per dry gram
cm^3/s	cubic centimeters per second	nCi/L	nanocurie per liter
cpm/L	counts per minute per liter	ng/m^3	nanogram per cubic meter
fCi/g	femtocurie per gram	pCi/dry g	picocurie per dry gram
ft	foot or feet	pCi/g	picocurie per gram
ft^3/min	cubic feet per minute	pCi/L	picocurie per liter
ft^3/s	cubic feet per second	pCi/m^3	picocurie per cubic meter
kg	kilogram	pCi/mL	picocurie per milliliter
kg/h	kilogram per hour	pg/g	picogram per gram
m^3/s	cubic meter per second	pg/m^3	picogram per cubic meter
µCi/L	microcurie per liter	PM_{10}	small particulate matter (less than 10 µm diameter)
µCi/mL	microcurie per milliliter	$PM_{2.5}$	small particulate matter (less than 2.5 µm diameter)
µg/g	microgram per gram	R	roentgen
$\mu g/m^3$	microgram per cubic meter	*s*, SD, or σ	standard deviation
mL	milliliter	sq ft (ft^2)	square feet
mm	millimeter	>	greater than
µm	micrometer	<	less than
µmho/cm	micro mho per centimeter	≥	greater than or equal to
mCi	millicurie	≤	less than or equal to
mg	milligram	±	plus or minus
mR	milliroentgen	~	approximately
mrad	millirad		

DATA HANDLING OF RADIOCHEMICAL SAMPLES

Measurements of radiochemical samples require that analytical or instrumental backgrounds be subtracted to obtain net values. Thus, net values are sometimes obtained that are lower than the minimum detection limit of the analytical technique. Consequently, individual measurements can result in values of positive or negative numbers. Although a negative value does not represent a physical reality, a valid long-term average of many measurements can be obtained only if the very small and negative values are included in the population calculations (Gilbert 1975).

For individual measurements, uncertainties are reported as one standard deviation. The standard deviation is estimated from the propagated sources of analytical error.

Standard deviations for the AIRNET station and group (off-site regional, off-site perimeter, and on-site) means are calculated using the standard equation:

$$s = (\Sigma (c_i - \bar{c})^2 / (N - 1))^{1/2}$$

where

c_i = sample i,

$\bar{c}$ = mean of samples from a given station or group, and

N = number of samples in the station or group.

This value is reported as one standard deviation (1*s*) for the station and group means.

REFERENCE

Gilbert 1975: R. O. Gilbert, "Recommendations Concerning the Computation and Reporting of Counting Statistics for the Nevada Applied Ecology Group," Battelle Pacific Northwest Laboratories report BNWL-B-368 (September 1975).

Appendix C

DESCRIPTION OF TECHNICAL AREAS AND THEIR ASSOCIATED PROGRAMS

Locations of the technical areas (TAs) operated by the Laboratory in Los Alamos County are shown in Figure 1-3. The main programs conducted at each of the areas are listed in this Appendix.

Technical Area	Activities
TA-0 (Off-site Facilities)	This TA designation is assigned to structures leased by DOE that are located outside LANL's boundaries in the Los Alamos townsite and White Rock.
TA-2 (Omega Site or Omega West Reactor)	Omega West Reactor, an 8-MW nuclear research reactor, was located here. It was placed into a safe shutdown condition in 1993 and was removed from the nuclear facilities list. The reactor was decontaminated and decommissioned in 2002.
TA-3 (Core Area or South Mesa Site)	This TA is LANL's core scientific and administrative area, with approximately half of LANL's employees and total floor space. It is the location of a number of the LANL's Key Facilities, including the Chemistry and Metallurgy Research Building, the Sigma Complex, the Machine Shops, the Material Sciences Laboratory, and the Nicholas C. Metropolis Center for Modeling and Simulation.
TA-5 (Beta Site)	This TA is largely undeveloped. Located between East Jemez Road and the San Ildefonso Pueblo, it contains physical support facilities, an electrical substation, and test wells.
TA-6 (Two-Mile Mesa Site)	This TA, located in the northwestern part of LANL, is mostly undeveloped. It contains a meteorological tower, gas-cylinder-staging buildings, and aging vacant buildings that are awaiting demolition.
TA-8 (GT-Site [Anchor Site West])	This TA, located along West Jemez Road, is a testing site where nondestructive dynamic testing techniques are used for the purpose of ensuring the quality of materials in items ranging from test weapons components to high-pressure dies and molds. Techniques used include radiography, radioisotope techniques, ultrasonic and penetrant testing, and electromagnetic test methods.
TA-9 (Anchor Site East)	This TA is located on the western edge of LANL. Fabrication feasibility and the physical properties of explosives are explored at this TA, and new organic compounds are investigated for possible use as explosives.
TA-11 (K-Site)	This TA is used for testing explosives components and systems, including vibration analysis and drop-testing materials and components under a variety of extreme physical environments. Facilities are arranged so that testing may be controlled and observed remotely, allowing devices that contain explosives, radioactive materials, and nonhazardous materials to be safely tested and observed.
TA-14 (Q-Site)	This TA, located in the northwestern part of LANL, is one of 14 firing areas. Most operations are remotely controlled and involve detonations, certain types of high explosives machining, and permitted burning.
TA-15 (R-Site)	This TA, located in the central portion of LANL, is used for high explosives research, development, and testing, mainly through hydrodynamic testing and dynamic experimentation. TA-15 is the location of two firing sites, the Dual Axis Radiographic Hydrodynamic Test Facility, which has an intense high-resolution, dual-machine radiographic capability, and Building 306, a multipurpose facility where primary diagnostics are performed.
TA-16 (S-Site)	TA-16, in the western part of LANL, is the location of the Weapons Engineering Tritium Facility, a state-of-the-art tritium processing facility. The TA is also the location of high explosives research, development, and testing, and the High Explosives Wastewater Treatment Facility.

Technical Area	Activities
TA-18 (Pajarito Site)	This TA, located in Pajarito Canyon, is the location of the Los Alamos Critical Experiment Facility, a general-purpose nuclear experiments facility. It is the location of the Solution High-Energy Burst Assembly and is also used for teaching and training related to criticality safety and applications of radiation detection and instrumentation. All Security Category I and II materials and activities have been relocated to the Nevada Test Site.
TA-21 (DP-Site)	TA-21 is on the northern border of LANL, next to the Los Alamos townsite. In the western part of the TA is the former radioactive materials (including plutonium) processing facility that has been partially decontaminated and decommissioned. In the eastern part of the TA are the Tritium Systems Test Assembly and the Tritium Science and Fabrication Facility. Operations from both facilities have been transferred elsewhere as of the end of 2006.
TA-22 (TD-Site)	This TA, located in the northwestern portion of LANL, houses the Los Alamos Detonator Facility. Construction of a new Detonator Production Facility began in 2003. Research, development, and fabrication of high-energy detonators and related devices are conducted at this facility.
TA-28 (Magazine Area A)	TA-28, located near the southern edge of LANL, was an explosives storage area. The TA contains five empty storage magazines that are being decontaminated and decommissioned.
TA-33 (HP-Site)	TA-33 is a remotely-located TA at the southeastern boundary of LANL. The TA is used for experiments that require isolation, but do not require daily oversight. The National Radioastronomy Observatory's Very Long Baseline Array telescope is located at this TA.
TA-35 (Ten Site)	This TA, located in the north central portion of LANL, is used for nuclear safeguards research and development, primarily in the areas of lasers, physics, fusion, materials development, and biochemistry and physical chemistry research and development. The Target Fabrication Facility, located at this TA, conducts precision machining and target fabrication, polymer synthesis, and chemical and physical vapor deposition. Additional activities at TA-35 include research in reactor safety, optical science, and pulsed-power systems, as well as metallurgy, ceramic technology, and chemical plating. Additionally, there are some Biosafety Level 1 and 2 laboratories at TA-35.
TA-36 (Kappa-Site)	TA-36, a remotely-located area in the eastern portion of LANL, has four active firing sites that support explosives testing. The sites are used for a wide variety of nonnuclear ordnance tests.
TA-37 (Magazine Area C)	This TA is used as an explosives storage area. It is located at the eastern perimeter of TA-16.
TA-39 (Ancho Canyon Site)	TA-39 is located at the bottom of Ancho Canyon. This TA is used to study the behavior of nonnuclear weapons (primarily by photographic techniques) and various phenomenological aspects of explosives.
TA-40 (DF-Site)	TA-40, centrally located within LANL, is used for general testing of explosives or other materials and development of special detonators for initiating high explosives systems.
TA-41 (W-Site)	TA-41, located in Los Alamos Canyon, is no longer actively used. Many buildings have been decontaminated and decommissioned; the remaining structures include historic properties.
TA-43 (the Bioscience Facilities, formerly called the Health Research Laboratory)	TA-43 is adjacent to the Los Alamos Medical Center at the northern border of LANL. Two facilities are located within this TA: the Bioscience Facilities (formerly called the Health Research Laboratory) and NNSA's local Site Office. The Bioscience Facilities have Biosafety Level 1 and 2 laboratories and are the focal point of bioscience and biotechnology at LANL. Research performed at the Bioscience Facilities includes structural, molecular, and cellular radiobiology; biophysics; radiobiology; biochemistry; and genetics.

Technical Area	Activities
TA-46 (WA-Site)	TA-46, located between Pajarito Road and the San Ildefonso Pueblo, is one of LANL's basic research sites. Activities have focused on applied photochemistry operations and have included development of technologies for laser isotope separation and laser enhancement of chemical processes. The Sanitary Wastewater Systems Plant is also located within this TA.
TA-48 (Radiochemistry Site)	TA-48, located in the north central portion of LANL, supports research and development in nuclear and radiochemistry, geochemistry, production of medical radioisotopes, and chemical synthesis. Hot cells are used to produce medical radioisotopes.
TA-49 (Frijoles Mesa Site)	TA-49, located near Bandelier National Monument, is used as a training area and for outdoor tests on materials and equipment components that involve generating and receiving short bursts of high-energy, broad-spectrum microwaves. A fire support building and helipad located near the entrance to the TA are operated by the US Forest Service.
TA-50 (Waste Management Site)	TA-50, located near the center of LANL, is the location of waste management facilities including the Radioactive Liquid Waste Treatment Facility and the Waste Characterization, Reduction, and Repackaging Facility. The Actinide Research and Technology Instruction Center is also located in this TA.
TA-51 (Environmental Research Site)	TA-51, located on Pajarito Road in the eastern portion of LANL, is used for research and experimental studies on the long-term impacts of radioactive materials on the environment. Various types of waste storage and coverings are studied at this TA.
TA-52 (Reactor Development Site)	TA-52 is located in the north central portion of LANL. A wide variety of theoretical and computational research and development activities related to nuclear reactor performance and safety, as well as to several environmental, safety, and health activities, are carried out at this TA.
TA-53 (Los Alamos Neutron Science Center)	TA-53, located in the northern portion of LANL, includes the LANSCE. LANSCE houses one of the largest research linear accelerators in the world and supports both basic and applied research programs. Basic research includes studies of subatomic and particle physics, atomic physics, neutrinos, and the chemistry of subatomic interactions. Applied research includes materials science studies that use neutron spallation and contributes to defense programs. LANSCE has also produced medical isotopes for the past 20 years.
TA-54 (Waste Disposal Site)	TA-54, located on the eastern border of LANL, is one of the largest TAs at LANL. Its primary function is management of solid radioactive and hazardous chemical wastes, including storage, treatment, decontamination, and disposal operations.
TA-55 (Plutonium Facility Complex Site)	TA-55, located in the center of LANL, is the location of the Plutonium Facility Complex and is the chosen location for the Chemistry and Metallurgy Research Building Replacement. The Plutonium Facility provides chemical and metallurgical processes for recovering, purifying, and converting plutonium and other actinides into many compounds and forms. The Chemistry and Metallurgy Research Building Replacement, currently under construction, will provide chemistry and metallurgy research, actinide chemistry, and materials characterization capabilities.
TA-57 (Fenton Hill Site)	TA-57 is located about 20 miles (32 kilometers) west of LANL on land administered by the US Forest Service. The primary purpose of the TA is observation of astronomical events. TA-57 houses the Milagro Gamma Ray Observatory and a suite of optical telescopes. Drilling technology research is also performed in this TA.
TA-58 (Twomile North Site)	TA-58, located near LANL's northwest border on Twomile Mesa North, is a forested area reserved for future use because of its proximity to TA-3. The TA houses a few LANL-owned storage trailers and a temporary storage area.

Technical Area	Activities
TA-59 (Occupational Health Site)	This TA is located on the south side of Pajarito Road adjacent to TA-3. This is the location of staff who provide support services in health physics, risk management, industrial hygiene and safety, policy and program analysis, air quality, water quality and hydrology, hazardous and solid waste analysis, and radiation protection. The Medical Facility at TA-59 includes a clinical laboratory and provides bioassay sample analytical support.
TA-60 (Sigma Mesa)	TA-60 is located southeast of TA-3. The TA is primarily used for physical support and infrastructure activities. The Nevada Test Site Test Fabrication Facility and a test tower are also located here. Due to the moratorium on testing, these buildings have been placed in indefinite safe shutdown mode.
TA-61 (East Jemez Site)	TA-61, located in the northern portion of LANL, contains physical support and infrastructure facilities, including a sanitary landfill operated by Los Alamos County and sewer pump stations.
TA-62 (Northwest Site)	TA-62, located next to TA-3 and West Jemez Road in the northwest corner of LANL, serves as a forested buffer zone. This TA is reserved for future use.
TA-63 (Pajarito Service Area)	TA-63, located in the north central portion of LANL, contains physical support and infrastructure facilities. The facilities at this TA serve as localized storage and office space.
TA-64 (Central Guard Site)	This TA is located in the north central portion of LANL and provides offices and storage space.
TA-66 (Central Technical Support Site)	TA-66 is located on the southeast side of Pajarito Road in the center of LANL. The Advanced Technology Assessment Center, the only facility at this TA, provides office and technical space for technology transfer and other industrial partnership activities.
TA-67 (Pajarito Mesa Site)	TA-67 is a forested buffer zone located in the north central portion of LANL. No operations or facilities are currently located at the TA.
TA-68 (Water Canyon Site)	TA-68, located in the southern portion of LANL, is a testing area for dynamic experiments that also contains environmental study areas.
TA-69 (Anchor North Site)	TA-69, located in the northwestern corner of LANL, serves as a forested buffer area. The new Emergency Operations Center, completed in 2003, is located here.
TA-70 (Rio Grande Site)	TA-70 is located on the southeastern boundary of LANL and borders the Santa Fe National Forest. It is a forested TA that serves as a buffer zone.
TA-71 (Southeast Site)	TA-71 is located on the southeastern boundary of LANL and is adjacent to White Rock to the northeast. It is an undeveloped TA that serves as a buffer zone for the High Explosives Test Area.
TA-72 (East Entry Site)	TA-72, located along East Jemez Road on the northeastern boundary of LANL, is used by protective force personnel for required firearms training and practice purposes.
TA-73 (Airport Site)	TA-73 is located along the northern boundary of LANL, adjacent to Highway 502. The County of Los Alamos manages, operates, and maintains the community airport under a leasing arrangement with DOE. Use of the airport by private individuals is permitted with special restrictions.
TA-74 (Otowi Tract)	TA-74 is a forested area in the northeastern corner of LANL. A large portion of this TA has been conveyed to Los Alamos County or transferred to the Department of the Interior in trust for the Pueblo of San Ildefonso and is no longer part of LANL.

Appendix D

RELATED WEBSITES

For more information on environmental topics at Los Alamos National Laboratory, access the following websites:

Environmental Surveillance reports and supplemental data tables	http://www.lanl.gov/environment/all/esr.shtml
Los Alamos National Laboratory website	http://www.lanl.gov
DOE/NNSA Los Alamos Site Office website	http://www.doeal.gov/laso/default.aspx
Department of Energy website	http://www.energy.gov
LANL's air quality pages	http://www.lanl.gov/environment/air/index.shtml
LANL's water quality pages	http://www.lanl.gov/environment/h2o/index.shtml
LANL's waste pages	http://www.lanl.gov/environment/waste/index.shtml
LANL's biological resources pages	http://www.lanl.gov/environment/bio/index.shtml
LANL's risk reduction pages	http://www.lanl.gov/environment/risk/index.shtml
LANL's clean-up pages	http://www.lanl.gov/environment/cleanup/index.shtml
LANL's environmental database	http://www.lanl.gov/environment/all/racer.shtml
Comments and suggestions on this document	http://www.lanl.gov/environment/all/esr.shtml

Glossary

activation products	Radioactive products generated as a result of neutrons and other subatomic particles interacting with materials such as air, construction materials, or impurities in cooling water. These activation products are usually distinguished, for reporting purposes, from fission products.
alpha particle	A positively charged particle (identical to the helium nucleus) composed of two protons and two neutrons that are emitted during decay of certain radioactive atoms. Alpha particles are stopped by several centimeters of air or a sheet of paper.
ambient air	The surrounding atmosphere as it exists around people, plants, and structures. It is not considered to include the air immediately adjacent to emission sources.
AOC	Area of concern.
aquifer	A saturated layer of rock or soil below the ground surface that can supply usable quantities of groundwater to wells and springs. Aquifers can be a source of water for domestic, agricultural, and industrial uses.
artesian well	A well in which the water rises above the top of the water-bearing bed.
background radiation	Ionizing radiation from sources other than the Laboratory. This radiation may include cosmic radiation; external radiation from naturally occurring radioactivity in the earth (terrestrial radiation), air, and water; internal radiation from naturally occurring radioactive elements in the human body; worldwide fallout; and radiation from medical diagnostic procedures.
beta particle	A negatively charged particle (identical to the electron) that is emitted during decay of certain radioactive atoms. Most beta particles are stopped by 0.6 cm of aluminum.
biota	The types of animal and plant life found in an area.
blank sample	A control sample that is identical, in principle, to the sample of interest, except that the substance being analyzed is absent. The measured value or signals in blanks for the analyte is believed to be caused by artifacts and should be subtracted from the measured value. This process yields a net amount of the substance in the sample.
blind sample	A control sample of known concentration in which the expected values of the constituent are unknown to the analyst.

CAA	Clean Air Act. The federal law that authorizes the Environmental Protection Agency (EPA) to set air quality standards and to assist state and local governments to develop and execute air pollution prevention and control programs.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Also known as Superfund, this law authorizes the federal government to respond directly to releases of hazardous substances that may endanger health or the environment. The EPA is responsible for managing Superfund.
CFR	Code of Federal Regulations. A codification of all regulations developed and finalized by federal agencies in the *Federal Register*.
contamination	(1) Substances introduced into the environment as a result of people's activities, regardless of whether the concentration is a threat to health (see pollution). (2) The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.
controlled area	Any Laboratory area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.
Ci	Curie. Unit of radioactivity. One Ci equals 3.70×10^{10} nuclear transformations per second.
cosmic radiation	High-energy particulate and electromagnetic radiations that originate outside the earth's atmosphere. Cosmic radiation is part of natural background radiation.
CWA	Clean Water Act. The federal law that authorizes the EPA to set standards designed to restore and maintain the chemical, physical, and biological integrity of the nation's waters.
DCG	Derived Concentration Guides. The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in an effective dose equivalent of 100 mrem. DCGs do not consider decay products when the parent radionuclide is the cause of the exposure (DCG values are presented in DOE Order 5400.5).
DOE	US Department of Energy. The federal agency that sponsors energy research and regulates nuclear materials used for weapons production. Los Alamos National Laboratory is managed by the NNSA, an agency within the DOE.

dose	A term denoting the quantity of radiation energy absorbed.
absorbed dose	The energy absorbed by matter from ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray).
dose equivalent	The product of absorbed dose in rad (or gray) in tissue, a quality factor, and other modifying factors. Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 sievert).
TEDE	Total effective dose equivalent. The hypothetical whole-body dose that would give the same risk of cancer mortality and serious genetic disorder as a given exposure but that may be limited to a few organs. The effective dose equivalent is equal to the sum of individual organ doses, each weighted by degree of risk that the organ dose carries. For example, a 100-mrem dose to the lung, which has a weighting factor of 0.12, gives an effective dose that is equivalent to 100 × 0.12 = 12 mrem.
Maximum individual dose	The greatest dose commitment, considering all potential routes of exposure from a facility's operation, to an individual at or outside the Laboratory boundary where the highest dose rate occurs. It takes into account shielding and occupancy factors that would apply to a real individual.
population dose	The sum of the radiation doses to individuals of a population. It is expressed in units of person-rem. (For example, if 1,000 people each received a radiation dose of 1 rem, their population dose would be 1,000 person-rem.)
whole body dose	A radiation dose commitment that involves exposure of the entire body (as opposed to an organ dose that involves exposure to a single organ or set of organs).
effluent	A liquid waste discharged to the environment.
EIS	Environmental Impact Statement. A detailed report, required by federal law, on the significant environmental impacts that a proposed major federal action would have on the environment. An EIS must be prepared by a government agency when a major federal action that will have significant environmental impacts is planned.
emission	A gaseous waste discharged to the environment.
environmental compliance	The documentation that the Laboratory complies with the multiple federal and state environmental statutes, regulations, and permits that are designed to ensure environmental protection. This documentation is based on the results of the Laboratory's environmental monitoring and surveillance programs.

environmental monitoring	The sampling of contaminants in liquid effluents and gaseous emissions from Laboratory facilities, either by directly measuring or by collecting and analyzing samples in a laboratory.
environmental surveillance	The sampling of contaminants in air, water, sediments, soils, foodstuffs, and plants and animals, either by directly measuring or by collecting and analyzing samples in a laboratory.
EPA	Environmental Protection Agency. The federal agency responsible for enforcing environmental laws. Although state regulatory agencies may be authorized to administer some of this responsibility, EPA retains oversight authority to ensure protection of human health and the environment.
exposure	A measure of the ionization produced in air by x-ray or gamma ray radiation. (The unit of exposure is the roentgen.)
external radiation	Radiation originating from a source outside the body.
gallery	An underground collection basin for spring discharges.
gamma radiation	Short-wavelength electromagnetic radiation of nuclear origin that has no mass or charge. Because of its short wavelength (high energy), gamma radiation can cause ionization. Other electromagnetic radiation (such as microwaves, visible light, and radiowaves) has longer wavelengths (lower energy) and cannot cause ionization.
gross alpha	The total amount of measured alpha activity without identification of specific radionuclides.
gross beta	The total amount of measured beta activity without identification of specific radionuclides.
groundwater	Water found beneath the surface of the ground. Groundwater usually refers to a zone of complete water saturation containing no air.
half-life, radioactive	The time required for the activity of a radioactive substance to decrease to half its value by inherent radioactive decay. After two half-lives, one-fourth of the original activity remains (½ × ½), after three half-lives, one-eighth (½ × ½ × ½), and so on.
hazardous waste	Wastes exhibiting any of the following characteristics: ignitability, corrosivity, reactivity, or yielding toxic constituents in a leaching test. In addition, EPA has listed as hazardous other wastes that do not necessarily exhibit these characteristics. Although the legal definition of hazardous waste is complex, the term generally refers to any waste that EPA believes could pose a threat to human health and the environment if managed improperly. Resource Conservation and Recovery Act (RCRA) regulations set strict controls on the management of hazardous wastes.

hazardous waste constituent	The specific substance in a hazardous waste that makes it hazardous and therefore subject to regulation under Subtitle C of RCRA.
HSWA	Hazardous and Solid Waste Amendments of 1984 to RCRA. These amendments to RCRA greatly expanded the scope of hazardous waste regulation. In HSWA, Congress directed EPA to take measures to further reduce the risks to human health and the environment caused by hazardous wastes.
hydrology	The science dealing with the properties, distribution, and circulation of natural water systems.
internal radiation	Radiation from a source within the body as a result of deposition of radionuclides in body tissues by processes such as ingestion, inhalation, or implantation. Potassium-40, a naturally occurring radionuclide, is a major source of internal radiation in living organisms. Also called self-irradiation.
ionizing radiation	Radiation possessing enough energy to remove electrons from the substances through which it passes. The primary contributors to ionizing radiation are radon, cosmic and terrestrial sources, and medical sources such as x-rays and other diagnostic exposures.
isotopes	Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons. Isotopes of an element have similar chemical behaviors but can have different nuclear behaviors.
long-lived isotope	A radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period (half-life is greater than three years).
short-lived isotope	A radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is two days or less).
LANS	Los Alamos National Security. The limited liability corporation that took over management of LANL in June 2006.
LASO	Los Alamos Site Office. The Los Alamos office of the DOE's NNSA.
MCL	Maximum contaminant level. Maximum permissible level of a contaminant in water that is delivered to the free-flowing outlet of the ultimate user of a public water system (see Appendix A and Table A-6). The MCLs are specified by the EPA.
MDA	Material disposal area.

MEI	Maximally exposed individual. The average exposure to the population in general will always be less than to one person or subset of persons because of where they live, what they do, and their individual habits. To try to estimate the dose to the MEI, one tries to find that population subgroup (and more specifically, the one individual) that potentially has the highest exposure, intake, etc. This becomes the MEI.
mixed waste	Waste that contains a hazardous waste component regulated under Subtitle C of the RCRA and a radioactive component consisting of source, special nuclear, or byproduct material regulated under the federal Atomic Energy Act (AEA).
mrem	Millirem. See definition of rem. The dose equivalent that is one-thousandth of a rem.
NEPA	National Environmental Policy Act. This federal legislation, passed in 1969, requires federal agencies to evaluate the impacts of their proposed actions on the environment before decision making. One provision of NEPA requires the preparation of an EIS by federal agencies when major actions significantly affecting the quality of the human environment are proposed.
NESHAP	National Emission Standards for Hazardous Air Pollutants. These standards are found in the CAA; they set limits for such pollutants as beryllium and radionuclides.
NNSA	National Nuclear Security Agency. An agency within the DOE that is responsible for national security through the military application of nuclear energy.
nonhazardous waste	Chemical waste regulated under the Solid Waste Act, Toxic Substances Control Act, and other regulations, including asbestos, PCB, infectious wastes, and other materials that are controlled for reasons of health, safety, and security.
NPDES	National Pollutant Discharge Elimination System. This federal program, under the Clean Water Act, requires permits for discharges into surface waterways.
nuclide	A species of atom characterized by the constitution of its nucleus. The nuclear constitution is specified by the number of protons, number of neutrons, and energy content—or alternately, by the atomic number, mass number, and atomic mass. To be a distinct nuclide, the atom must be capable of existing for a measurable length of time.
outfall	The location where wastewater is released from a point source into a receiving body of water.

PCB	Polychlorinated biphenyls. A family of organic compounds used since 1926 in electric transformers, lubricants, carbonless copy paper, adhesives, and caulking compounds. PCBs are extremely persistent in the environment because they do not break down into new and less harmful chemicals. PCBs are stored in the fatty tissues of humans and animals through the bioaccumulation process. EPA banned the use of PCBs, with limited exceptions, in 1976.
PDL	Public Dose Limit. The new term for Radiation Protection Standards, a standard for external and internal exposure to radioactivity as defined in DOE Order 5400.5 (see Appendix A and Table A-1).
PE Curie	One PE curie is the quantity of transuranic material that has the same radiation inhalation hazard as one curie of Pu-239. The PE curie is described in Appendix B of http://www.wipp.energy.gov/library/wac/WAC.pdf
perched groundwater	A groundwater body above a slow-permeability rock or soil layer that is separated from an underlying main body of groundwater by a vadose zone.
person-rem	A quantity used to describe the radiological dose to a population. Population doses are calculated according to sectors, and all people in a sector are assumed to get the same dose. The number of person-rem is calculated by summing the modeled dose to all receptors in all sectors. Therefore, person-rem is the sum of the number of people times the dose they receive.
pH	A measure of the hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH less than 7, basic solutions have a pH greater than 7, and neutral solutions have a pH of 7.
pollution	Levels of contamination that may be objectionable (perhaps because of a threat to health [see contamination]).
point source	An identifiable and confined discharge point for one or more water pollutants, such as a pipe, channel, vessel, or ditch.
ppb	Parts per billion. A unit measure of concentration equivalent to the weight/volume ratio expressed as µg/L or ng/mL. Also used to express the weight/weight ratio as ng/g or µg/kg.
ppm	Parts per million. A unit measure of concentration equivalent to the weight/volume ratio expressed as mg/L. Also used to express the weight/weight ratio as µg/g or mg/kg.

QA	Quality assurance. Any action in environmental monitoring to ensure the reliability of monitoring and measurement data. Aspects of quality assurance include procedures, interlaboratory comparison studies, evaluations, and documentation.
QC	Quality control. The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes. QC procedures include calibration of instruments, control charts, and analysis of replicate and duplicate samples.
rad	Radiation absorbed dose. The rad is a unit for measuring energy absorbed in any material. Absorbed dose results from energy being deposited by the radiation. It is defined for any material. It applies to all types of radiation and does not take into account the potential effect that different types of radiation have on the body. 1 rad = 1,000 millirad (mrad)
radionuclide	An unstable nuclide capable of spontaneous transformation into other nuclides through changes in its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.
RCRA	Resource Conservation and Recovery Act of 1976. RCRA is an amendment to the first federal solid waste legislation, the Solid Waste Disposal Act of 1965. In RCRA, Congress established initial directives and guidelines for EPA to regulate hazardous wastes.
release	Any discharge to the environment. Environment is broadly defined as water, land, or ambient air.
rem	Roentgen equivalent man. The rem is a unit for measuring dose equivalence. It is the most commonly used unit and pertains only to people. The rem takes into account the energy absorbed (dose) and the biological effect on the body (quality factor) from the different types of radiation. rem = rad × quality factor 1 rem = 1,000 millirem (mrem)
SARA	Superfund Amendments and Reauthorization Act of 1986. This Act modifies and reauthorizes CERCLA. Title III of this Act is known as the Emergency Planning and Community Right-to-Know Act of 1986
saturated zone	Rock or soil where the pores are completely filled with water, and no air is present.

SWMU	Solid waste management unit. Any discernible site at which solid wastes have been placed at any time, regardless of whether the unit was intended for the management of solid or hazardous waste. Such units include any area at or around a facility at which solid wastes have been routinely and systematically released, such as waste tanks, septic tanks, firing sites, burn pits, sumps, landfills (material disposal areas), outfall areas, canyons around LANL, and contaminated areas resulting from leaking product storage tanks (including petroleum).
terrestrial radiation	Radiation emitted by naturally occurring radionuclides such as internal radiation source; the natural decay chains of uranium-235, uranium-238, or thorium-232; or cosmic-ray-induced radionuclides in the soil.
TLD	Thermoluminescent dosimeter. A material (the Laboratory uses lithium fluoride) that emits a light signal when heated to approximately 300°C. This light is proportional to the amount of radiation (dose) to which the dosimeter was exposed.
TRU	Transuranic waste. Waste contaminated with long-lived transuranic elements in concentrations within a specified range established by DOE, EPA, and Nuclear Regulatory Agency. These are elements shown above uranium on the chemistry periodic table, such as plutonium, americium, and neptunium, that have activities greater than 100 nanocuries per gram.
TSCA	Toxic Substances Control Act. TSCA is intended to provide protection from substances manufactured, processed, distributed, or used in the United States. A mechanism is required by the Act for screening new substances before they enter the marketplace and for testing existing substances that are suspected of creating health hazards. Specific regulations may also be promulgated under this Act for controlling substances found to be detrimental to human health or to the environment.
tuff	Rock formed from compacted volcanic ash fragments.
uncontrolled area	An area beyond the boundaries of a controlled area (see controlled area in this glossary).
unsaturated zone	See vadose zone in this glossary.
UST	Underground storage tank. A stationary device, constructed primarily of nonearthen material, designed to contain petroleum products or hazardous materials. In a UST, 10% or more of the volume of the tank system is below the surface of the ground.
vadose zone	The partially saturated or unsaturated region above the water table that does not yield water for wells. Water in the vadose zone is held to rock or soil particles by capillary forces and much of the pore space is filled with air.

water table	The water level surface below the ground at which the unsaturated zone ends and the saturated zone begins. It is the level to which a well that is screened in the unconfined aquifer would fill with water.
watershed	The region draining into a river, a river system, or a body of water.
wetland	A lowland area, such as a marsh or swamp, that is inundated or saturated by surface water or groundwater sufficient to support hydrophytic vegetation typically adapted for life in saturated soils.
wind rose	A diagram that shows the frequency and intensity of wind from different directions at a particular place.
worldwide fallout	Radioactive debris from atmospheric weapons tests that has been deposited on the earth's surface after being airborne and cycling around the earth.

Acronyms and Abbreviations

AIRNET	Ambient Air Monitoring Network
AOC	area of concern
AQA	Analytical Quality Associates
BCG	Biota Concentration Guides
BSRL	baseline statistical reference level
CFR	Code of Federal Regulations
CGP	Construction General Permit
CMR	Chemistry and Metallurgy Research (LANL building)
CWA	Clean Water Act
DAC	derived air concentration (DOE)
DARHT	Dual Axis Radiographic Hydrotest facility
DCG	Derived Concentration Guide (DOE)
DOE	Department of Energy
DOECAP	Department of Energy Contract Analytical Program
DRO	diesel-range organic compound
DPRNET	Direct penetrating radiation monitoring network
DU	depleted uranium
EDE	Effective Dose Equivalent
EIS	Environmental Impact Statement
EMS	Environmental Management System
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ES&H	environment, safety, & health
EU	enriched uranium
FFCA	Federal Facility Compliance Agreement
FY	fiscal year
GEL	General Engineering Laboratory
GMAP	gaseous mixed air activation products
HE	high-explosive
HMX	cyclotetramethylenetetranitramine
HSWA	Hazardous and Solid Waste Amendments
HT	elemental tritium
HTO	tritium oxide
ISM	Integrated Safety Management (LANL)
LANL	Los Alamos National Laboratory (or the Laboratory)
LANSCE	Los Alamos Neutron Science Center (TA-53)
LASO	Los Alamos Site Office (DOE)
LC/MS/MS	liquid chromatography/mass spectrometry/mass spectrometry

MAPEP	Mixed-Analyte Performance Evaluation Program
MCL	maximum contaminant level
MDA	material disposal area
MDL	method detection limit
MEI	maximally exposed individual
MSGP	Multi-Sector General Permit
NCRP	National Council on Radiation Protection
NESHAP	National Emission Standards for Hazardous Air Pollutants
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NMWQCC	New Mexico Water Quality Control Commission
ODS	Ozone depleting substances
P2	Pollution Prevention Program
PCB	polychlorinated biphenyls
PM	particulate matter
ppb	parts per billion
P/VAP	particulate/vapor activation products
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RDX	research department explosive (cyclonite)
RLWTF	Radioactive Liquid Waste Treatment Facility (LANL)
RSRL	regional statistical reference level
SAL	screening action level
SL	screening level
SOW	statement of work
SPCC	Spill Prevention Control and Countermeasures
SR	State Road
SWEIS	Site-Wide Environmental Impact Statement
SWPPP	Storm Water Pollution Prevention Plan
SWMU	solid waste management unit
TA	Technical Area
TCE	trichloroethylene
TLD	thermoluminescent dosimeter
TNT	trinitrotoluene
TSCA	Toxic Substances Control Act

Elemental & Chemical Nomenclature

Actinium	Ac	Helium	He	Praseodymium	Pr
Aluminum	Al	Holmium	Ho	Promethium	Pm
Americium	Am	Hydrogen	H	Protactinium	Pa
Argon	Ar	Hydrogen oxide	H_2O	Radium	Ra
Antimony	Sb	Indium	In	Radon	Rn
Arsenic	As	Iodine	I	Rhenium	Re
Astatine	At	Iridium	Ir	Rhodium	Rh
Barium	Ba	Iron	Fe	Rubidium	Rb
Berkelium	Bk	Krypton	Kr	Ruthenium	Ru
Beryllium	Be	Lanthanum	La	Samarium	Sm
Bicarbonate	HCO_3	Lawrencium	Lr (Lw)	Scandium	Sc
Bismuth	Bi	Lead	Pb	Selenium	Se
Boron	B	Lithium	Li	Silicon	Si
Bromine	Br	Lithium fluoride	LiF	Silver	Ag
Cadmium	Cd	Lutetium	Lu	Sodium	Na
Calcium	Ca	Magnesium	Mg	Strontium	Sr
Californium	Cf	Manganese	Mn	Sulfate	SO_4
Carbon	C	Mendelevium	Md	Sulfite	SO_3
Cerium	Ce	Mercury	Hg	Sulfur	S
Cesium	Cs	Molybdenum	Mo	Tantalum	Ta
Chlorine	Cl	Neodymium	Nd	Technetium	Tc
Chromium	Cr	Neon	Ne	Tellurium	Te
Cobalt	Co	Neptunium	Np	Terbium	Tb
Copper	Cu	Nickel	Ni	Thallium	Tl
Curium	Cm	Niobium	Nb	Thorium	Th
Cyanide	CN	Nitrate (as Nitrogen)	NO_3-N	Thulium	Tm
Carbonate	CO_3	Nitrite (as Nitrogen)	NO_2-N	Tin	Sn
Dysprosium	Dy	Nitrogen	N	Titanium	Ti
Einsteinium	Es	Nitrogen dioxide	NO_2	Tritiated water	HTO
Erbium	Er	Nobelium	No	Tritium	^3H
Europium	Eu	Osmium	Os	Tungsten	W
Fermium	Fm	Oxygen	O	Uranium	U
Fluorine	F	Palladium	Pd	Vanadium	V
Francium	Fr	Phosphorus	P	Xenon	Xe
Gadolinium	Gd	Phosphate (as Phosphorus)	PO_4-P	Ytterbium	Yb
Gallium	Ga	Platinum	Pt	Yttrium	Y
Germanium	Ge	Plutonium	Pu	Zinc	Zn
Gold	Au	Polonium	Po	Zirconium	Zr
Hafnium	Hf	Potassium	K		

The following Los Alamos National Laboratory organizations perform environmental surveillance, ensure environmental compliance, and provide environmental data for this report:

- *Waste and Environment Support Services Division (Terry Morgan, Coordinator)*
- *Water Quality and RCRA Group (Luciana Vigil-Holterman and Robert Beers, Coordinators)*
- *Air Quality and Ecology Group (Sonja Salzman, Coordinator)*

The beginning of each chapter credits the primary authors.

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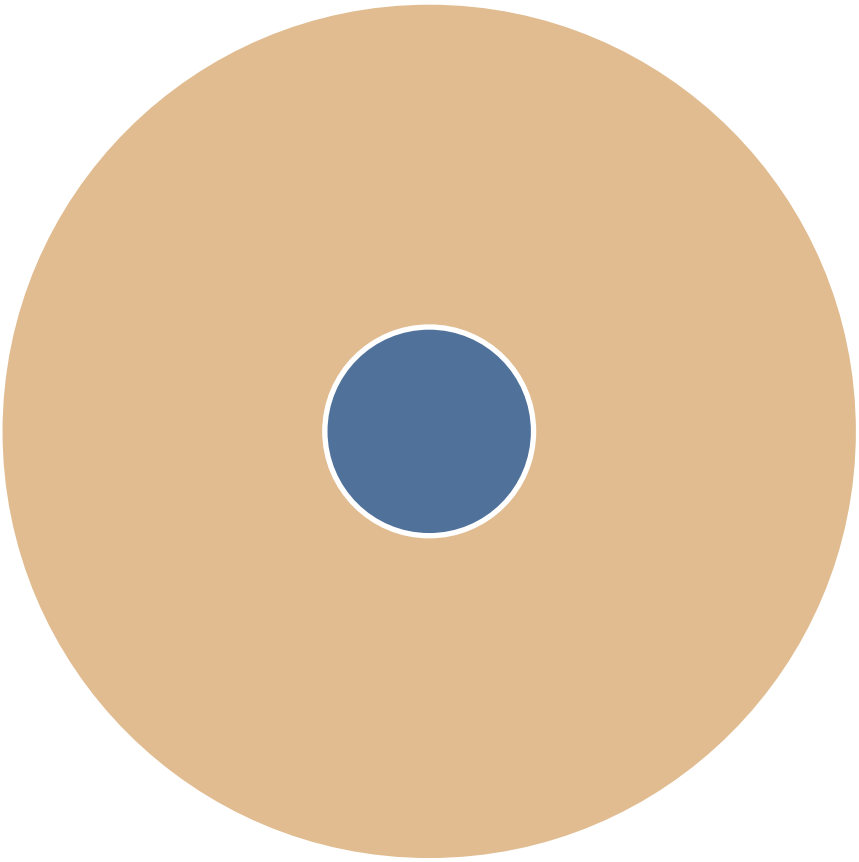
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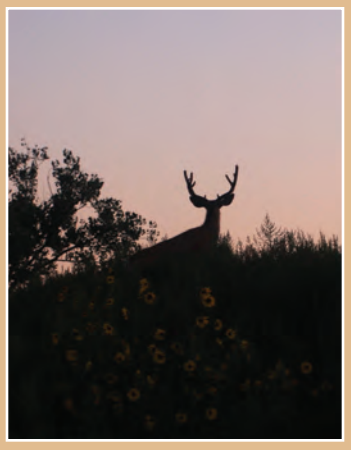
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