2/30-95 JS(1)

Supplemental Site Inspection for Air Force Plant 59, Johnson City, New York

Volume 1: Investigation Report

**Energy Systems Division
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ANL/ESD/TM-90

Supplemental Site Inspection for Air Force Plant 59, Johnson City, New York

Volume 1: Investigation Report

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August 1995

Work sponsored by United States Department of Defense, U.S. Air Force, monitored by U.S. Army Corps of Engineers, Baltimore District

**Nashold is affiliated with the Environmental Research Division; Tomasko and Durham, with the Environmental Assessment Division; and Hau, with Hydro-Terra, Inc., Columbia, Md.*

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REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE August 1995	3. REPORT TYPE AND DATES COVERED Final - Aug. 91 to Aug. 95	
4. TITLE AND SUBTITLE Supplemental Site Inspection for Air Force Plant 59, Johnson City, New York			5. FUNDING NUMBERS MIPR Nos. E87-93-0156 E87-92-0056 E87-91-0047	
6. AUTHOR(S) B. Nashold, D. Rosenblatt, J. Hau, D. Tomasko, L. Durham, W. Harrison, L. Shepard, L. Reed, E. Schug, and T. Sydelko				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Argonne National Laboratory 9700 South Cass Avenue Argonne, IL 60439			8. PERFORMING ORGANIZATION REPORT NUMBER N/A	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Air Force Aeronautical Systems Center Wright - Patterson Air Force Base Ohio 45433-7203			10. SPONSORING/MONITORING AGENCY REPORT NUMBER N/A	
11. SUPPLEMENTARY NOTES N/A				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Distribution controlled by sponsoring organization			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) This report describes the findings of an Argonne National Laboratory (ANL) investigation of contaminants in the soil, surface water, and groundwater at Air Force Plant 59 (AFP 59), located in Johnson City, New York. Included in the report are (1) an expanded characterization of the geohydrological system underlying AFP 59; (2) a groundwater flow model of contaminant transport, particularly from AFP 59 to Johnson City Municipal Well No. 2; and (3) results of ANL's human-health risk assessment for contaminants of concern in the soil, surface water, and groundwater at the site.				
14. SUBJECT TERMS Groundwater, Modeling, Health Risk			15. NUMBER OF PAGES 1,054	
			16. PRICE CODE	
19. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT None	

Preface

The main objective of this report is to describe the findings of an Argonne National Laboratory (ANL) investigation of contaminants in the soil, surface water, and groundwater at Air Force Plant 59 (AFP 59), located in Johnson City, New York. In addition, the report presents ANL's work on (1) expanded characterization of the geohydrological system underlying AFP 59; (2) contaminant transport by groundwater flow, particularly from AFP 59 to Johnson City Municipal Well No. 2; and (3) results of ANL's human-health risk assessment for contaminants of concern discovered in the soil, surface water, and groundwater at the site.

Argonne's work at AFP 59 was conducted for two Department of Defense entities. The Hazardous, Toxic, and Radioactive Waste Branch of the Baltimore District, U.S. Army Corps of Engineers, functioned as the Contract Agency for the U.S. Air Force. Funding was provided to Argonne via Military Interdepartmental Purchase Requests numbers E87 910047 and E87 920056 to the U.S. Department of Energy, Argonne Area Office. Gary Poling functioned as the Baltimore District's Project Manager for contract oversight. Overall project responsibility was exercised by Andrew T. Jeffers, Remedial Project Manager of the Restoration Branch, Acquisition Environmental Management group, Aeronautical Systems Center, Wright-Patterson Air Force Base, Dayton, Ohio.

Argonne began work in August 1991 under the direction of Wyman Harrison, Senior Geologist and Project Manager in the Waste Management and Bioengineering Section of ANL's Energy Systems Division. Barney Nashold, Scientific Associate in ANL's Environmental Research Division, acted as Field Operations Supervisor, and Joe Hau, Senior Hydrologist at HydroTerra, Inc., Columbia, Maryland, acted as the on-site geohydrologist. David Rosenblatt, Chemist in ANL's Environmental Assessment and Information Sciences Division (now with Energy Systems Division), conducted the human-health risk assessment. Dallas Wait, Director of the Chemistry Division of Gradient Corporation, Cambridge, Massachusetts, functioned as Quality Assurance Officer for both field sampling and chemical analysis by Galson Laboratories, Syracuse, New York. Data validation services were provided by ECHEM, Inc., under the direction of Bruce Wallin. Drilling activities were performed by Marcor of New York, Inc., Rochester, New York, and surveying was accomplished by Purdey Engineering, Vestal, New York. Waste disposal was handled by Laidlaw Environmental Services, Inc., North Andover, Massachusetts.

The authors wish to thank the staff of General Electric for its support during the field sampling phase of the ANL study. Especially helpful were Melonie Sviatyla, Environmental Health and Safety Leader; Richard Vosefski, Plant Engineering; and Randy Cochran, Manager, Plant Security. Laura Giblin, ANL Special Term Appointee, is also thanked for her considerable help during the field phase of the study. Audrey Arns of Argonne is gratefully acknowledged for her help in records management and procurement.

Contents

Summary	1
1 Introduction.....	11
1.1 Air Force Installation Restoration Program.....	11
1.2 Installation Description	15
1.2.1 Environmental Setting	15
1.2.2 Regional Hydrogeological Setting.....	18
1.2.3 Local Hydrogeological Setting.....	23
1.2.4 Surface Water.....	35
1.2.5 Air	35
1.2.6 Biology.....	35
1.2.7 Demographics	35
1.2.8 Mission and Waste Disposal Activities of AFP 59	35
1.3 Site Inventory	38
1.3.1 Site A-1: Former Underground Waste Oil Storage Tanks Area	40
1.3.2 Site A-2: Plating Building.....	41
1.3.3 Site A-3: WWII Oil/Water Separator Site.....	41
1.3.4 Site A-4: Storage and Settling Tanks.....	41
1.3.5 Site A-5: JP-4 Fluid Storage and Piping Area.....	42
1.3.6 Site A-6: Former Gasoline Storage Tank Area.....	42
1.3.7 GE Deep Production Well	42
1.3.8 Historical Data.....	43
1.3.9 Outfalls.....	45
1.3.10 Choconut Creek	46
1.4 Remedial Actions.....	46
1.5 Site Documents	46
2 Project Activities	53
2.1 Project Objectives	53
2.2 Field Activities.....	54
2.2.1 Field Program	54
2.2.2 Chronology of Field Work	87
2.2.3 Field QA/QC.....	88
2.2.4 Analyses Using Field-Portable Equipment	95
2.3 Laboratory Analyses	97
2.3.1 Analytical Program.....	97
2.3.2 QA/QC Program.....	97
2.4 Data Evaluation	99
2.4.1 Identification of Valid Chemical Data.....	99
2.4.2 Hydrogeological Data Analysis and Synthesis	100
2.4.3 Methodology for Risk Estimation	100
2.4.4 Groundwater Flow Modeling.....	101

Contents (Cont.)

3	Remedial Investigation	124
3.1	General Information.....	125
3.1.1	Review of Site Data	125
3.1.2	Data Summary.....	126
3.1.3	Data Usability.....	126
3.1.4	Background Sampling.....	127
3.1.5	Overall State of Contamination at AFP 59.....	133
3.1.6	Trend Analysis	146
3.1.7	Migration Pathways.....	148
3.2	Site/Interpretive Unit Sampling and Analysis Results	151
3.2.1	Former Location of Waste Oil Tanks — Site A-1.....	151
3.2.2	Plating Building — Site A-2.....	153
3.2.3	WWII Oil/Water Separator Site — Site A-3.....	155
3.2.4	Settling Pond Area — Site A-4.....	156
3.2.5	JP-4 Fluid Storage and Piping Area — Site A-5.....	157
3.2.6	Former Location of a Gasoline Storage Tank — Site A-6	160
3.2.7	Perimeter Wells.....	161
3.2.8	Interior Wells	168
3.2.9	Outfalls.....	172
3.2.10	Creek	173
3.2.11	MEM/EDXRF Screening Locations.....	174
3.3	Baseline Risk Assessment for Human Health Effects under a Current-Use Scenario.....	178
3.3.1	Scope and Organization.....	179
3.3.2	Selection of Chemicals of Potential Concern	180
3.3.3	Exposure Assessment	202
3.3.4	Toxicity Assessment.....	217
3.3.5	Risk Characterization	230
3.3.6	Assessment of Uncertainties	235
3.3.7	Summary.....	243
3.3.8	References	245
4	Conclusions and Recommendations	250
4.1	Categorization of Sites	250
4.2	Future Studies	250
	Appendix A: Data Validation and Usability.....	A-1
	Appendix B: Well Data and Lithological Logs.....	B-1
	Appendix C: Raw Field Data.....	C-1
	Appendix D: Surveying Data Sampling Locations at AFP 59.....	D-1
	Appendix E: Chain-of-Custody Forms.....	E-1
	Appendix F: Analytical Data	F-1

Contents (Cont.)

Appendix G: Correspondence with Agencies	G-1
Appendix H: Data from Previous IRP Investigations.....	H-1
Appendix I: Soil-Contaminant Screening at the AFP 59.....	I-1
Appendix J: Contaminant Distributions at AFP 59 and Volatile Organic Compound Summary	J-1
Appendix K: Quality Assurance/Quality Control for Production of Documents	K-1
Appendix L: Dimensionless Henry's Law Constants and Octanol/Water Partition Coefficients Used to Select 12-h Skin Absorption Efficiencies for Sediment Contaminants.....	L-1
Appendix M: Estimate of the Maximum Potential Effect of Contaminants in AFP 59 Well Cluster 9 on Water Drawn from the Johnson City Well Field.....	M-1
Appendix N: Toxicity Summaries for Contaminants Contributing to AFP 59 Site-Related Risks.....	N-1
Appendix O: Problems Noted during the Field Season.....	O-1
Appendix P: Quality Assurance Project Plan for AFP 59 IRP Supplemental SI and Laboratory Environmental Analysis QA/AC Manual.....	P-1
Appendix Q: Internal Documents.....	Q-1

Figures

1.1 Location and Vicinity Map of AFP 59.....	12
1.2 Site Map of AFP 59 Showing Locations of Potentially Contaminated Sites, Test Borings, Sampling Points, and Groundwater Monitoring Wells.....	13
1.3 Location of Johnson City Public Water Supply Well Numbers 1, 2, 3, and 5 in Relation to AFP 59	14
1.4 1967 Aerial View of the Area Surrounding AFP 59	16
1.5 1991 Aerial View of the Area Surrounding AFP 59	17
1.6 An Idealized Geological Cross Section beneath AFP 59 and Vicinity.....	19
1.7 Water Level Contours and Flow Lines in the Clinton Street-Ballpark Aquifer, October 1967	22

Figures (Cont.)

1.8	The Location of Geological Cross Sections beneath AFP 59	24
1.9	Idealized Geological Cross Section A-A' beneath AFP 59.....	25
1.10	Idealized Geological Cross Section B-B' beneath AFP 59.....	26
1.11	Idealized Geological Cross Section C-C' beneath AFP 59.....	27
1.12	Approximate Boundary of Aquifer Regimes at AFP 59.....	29
1.13	Map of the Potentiometric Surface of the Static Water Level of the Shallow Aquifer at AFP 59, prior to the Slug Test, January 11-12, 1992.....	31
1.14	Map of the Average Potentiometric Surface of the Shallow Aquifer at AFP 59, January 17-27, 1992	32
1.15	Map of the Potentiometric Surface of the Static Water Level of the Deep Aquifer at AFP 59, prior to the Slug Test, January 11-12, 1992.....	33
1.16	Map of the Average Potentiometric Surface of the Deep Aquifer at AFP 59, January 17-27, 1992	34
1.17	Little Choconut Creek in 1942 and at Present	37
2.1	Finite-Element Grid for the Numerical Model.....	104
2.2	Calculational Domain for AFP 59 Groundwater Modeling Relative to Regional Aquifer Boundaries.....	105
2.3	Localized Finite-Element Grid to Show Calibration and Scenario Results	106
2.4	Model-Predicted Water Elevations in the Upper Zone or Aquifer with City Well 2 Pumping.....	109
2.5	Model-Predicted Water Elevations in the Lower Zone or Aquifer with City Well 2 Pumping.....	110
2.6	Groundwater Flow Directions and Relative Velocities in Upper Zone with City Well 2 Pumping.....	111
2.7	Groundwater Flow Directions and Relative Velocities in Lower Zone with City Well 2 Pumping.....	112
2.8	Model-Predicted Water Elevations in the Upper Zone with City Wells 2 and 5 and the AFP 59 Production Well Pumping	114
2.9	Model-Predicted Water Elevations in the Lower Zone with City Wells 2 and 5 and the AFP 59 Production Well Pumping	115

Figures (Cont.)

2.10	Groundwater Flow Directions and Relative Velocities in Upper Zone with City Wells 2 and 5 and the AFP 59 Production Well Pumping.....	116
2.11	Groundwater Flow Directions and Relative Velocities in the Lower Aquifer with City Wells 2 and 5 and the AFP 59 Production Well Pumping	117
2.12	Location of Potential Sources for Groundwater Travel Time Calculations....	118
2.13	Flow Paths for Particles 1 through 5 with City Well 2 Pumping.....	119
2.14	Flow Paths for Particles 1 through 5 with City Wells 2 and 5 and the AFP Production Well Pumping.....	120

Tables

S.1	Summary of Monitoring Wells Constructed at AFP 59 and of the 17 New and Existing Wells Sampled for Laboratory Analysis	4
S.2	Summary of Samples Collected at AFP 59 for Laboratory Analysis.....	5
1.1	Substances of Concern in Subsurface Soils.....	39
1.2	Substances of Concern in Groundwater.....	40
1.3	Analytical Results for Samples Taken from beneath Settling Tank.....	43
1.4	History of AFP 59 Production Well Water Contamination to 1990	44
1.5	Environmental Management Documents Generated by General Electric at AFP 59	48
2.1	AFP 59 Sample Shipment Summary.....	66
2.2	Categorical Sample List	70
2.3	Total Number of Samples Collected at AFP 59 by Matrix and Type.....	74
2.4a	Field Control Parameter Data Collected while Purging Wells in Preparation for Groundwater Sampling	89
2.4b	Summary and Conclusions of Field Control Parameter Data Collected while Purging Wells in Preparation for Groundwater Sampling	94
2.5	Comparison of Time Elapsed between the End of Purging and the Beginning of Sample Collection during Sampling Rounds A and B	95

Tables (Cont.)

2.6	Comparison of Well Volumes Purged during Sampling Rounds A and B.....	96
2.7	Origin and Site Association of Hand-Augered Soil Samples	98
2.8	Calculated Travel Times.....	121
3.1	Concentrations of Volatile Organic Compounds in Background Wells.....	128
3.2	Concentrations of Inorganic Analytes in Background Wells	130
3.3	Semivolatile Organic Compounds and Pesticides in Background Soil	131
3.4	Concentrations of Inorganic Analytes in Background Soil	132
3.5	Detected Inorganic Analytes in Background Surface Water	133
3.6	Detected Organic Compounds in Local Background Sediment.....	133
3.7	Concentrations of Inorganic Analytes in Background Sediment.....	134
3.8	Concentrations of Volatile Organic Compounds Detected in Groundwater Samples	135
3.9	Inorganic Analytes Detected in Groundwater Samples.....	138
3.10	Volatile Organic Compounds Detected in Soil Samples.....	140
3.11a	Concentrations of Semivolatile Organic Compounds, Pesticides, and PCBs Detected in Named-Site Soil Samples	141
3.11b	Concentrations of Semivolatile Compounds and Pesticides Detected in Well Borehole Soil Samples.....	142
3.12	Concentrations of Inorganic Analytes Detected in Soil Samples	144
3.13	Inorganic Analytes Detected in Creek Water	146
3.14	Organic Compounds Detected in Outfalls	147
3.15	Inorganic Analytes Detected in Outfalls.....	147
3.16	Organic Compounds Detected in Creek Sediment Samples.....	147
3.17	Inorganic Analytes Detected in Sediment Samples	148
3.18	Comparison of Concentrations of Volatile Organic Compounds in Groundwater in 1986 and in 1991-1992	149
3.19	Comparison of Concentrations of Detected Inorganic Analytes in Groundwater in 1986 and in 1991-1992	150

Tables (Cont.)

3.20	Organic Compounds Detected in Hand Soil Samples from Site A-1	152
3.21	Inorganic Analytes Detected in a Hand Soil Sample from Site A-1	153
3.22	Inorganic Analytes Detected in Preliminary Samples from Site A-2	154
3.23	Inorganic Analytes Detected in Hand-Auger 17 and Test Bore Samples at Site A-2	155
3.24	Organic Compounds Detected in Test Bore Sample JC2L1AS at Site A-2	156
3.25	Organic Compounds Detected in Hand Soil Samples JC3H1AS and JC3H1AS-DL from Site A-3	156
3.26	Inorganic Analytes Detected in Hand Soil Sample JC3H1AS at Site A-3	157
3.27	Inorganic Analytes Detected in Hand Soil Samples from Site A-4	158
3.28	Organic Compounds Detected in Well Borehole SW-7 and Possibly Related to Site A-5	158
3.29	Concentrations of Inorganic Analytes Detected in Hand Auger Soil Samples and Well Borehole SW-7, Possibly Related to Site A-5	159
3.30	Organic Compounds Detected in Hand Soil Sample JC6H1AS from Site A-6	160
3.31	Inorganic Analytes Detected in Hand Soil Sample JC6H1AS from Site A-6	160
3.32	Concentrations of Organic Compounds Detected in Perimeter Well Borehole Soil Samples	162
3.33	Concentrations of Inorganic Analytes Detected in Perimeter Well Borehole Samples	163
3.34	Concentrations of Volatile Organic Compounds Detected in Perimeter Well Water Samples	165
3.35	Concentrations of Inorganic Analytes Detected in Perimeter Well Water Samples	166
3.36	Organic Compounds Detected in Well Borehole Soil Samples from Cluster 4, an Interior Well Cluster	168
3.37	Inorganic Analytes Detected in Well Borehole Samples from Cluster 4, an Interior Well Cluster	169

Tables (Cont.)

3.38	Concentrations of Organic Compounds Detected in Interior Well Water.....	170
3.39	Concentrations of Inorganic Analytes Detected in Interior Well Water	171
3.40	Inorganic Analytes Detected in Hand Auger Sample HA-14, Related to Outfall No. 3.....	172
3.41	Concentrations of Inorganic Analytes Detected in Hand Auger Soil Samples under the AFP 59 Parking Lot.....	176
3.42	Contaminants That Were Not Detected in Any Medium at AFP 59.....	190
3.43	Characterization Results for Inorganic Analytes in Soil.....	191
3.44	Characterization Results for Organic Compounds in Soil.....	194
3.45	Inorganic Soil Analytes Remaining after Screening.....	195
3.46	Organic Soil Analytes Remaining after Screening	195
3.47	Characterization Results for Inorganic Analytes in Creek Sediment	196
3.48	Characterization Results for Organic Compounds in Creek Sediment.....	197
3.49	Inorganic Sediment Analytes Remaining after Screening.....	197
3.50	Characterization Results for Inorganic Analytes in Groundwater.....	198
3.51	Characterization Results for Organic Compounds in Groundwater.....	199
3.52	Groundwater Contaminants of Potential Concern Remaining after Screening and Their Permeability Coefficients	200
3.53	Characterization Results for Inorganic Analytes in Outfall Water and Creek Waters	201
3.54	Characterization Results for Organic Compounds in Outfall Waters.....	202
3.55	Characterization Results for Blanks.....	203
3.56	Summary of Contaminants of Potential Concern at AFP 59	204
3.57	Complete and Incomplete Exposure Pathways for Current Land Use	210
3.58	Groundwater Sampling Data of Potential Use for Exposure Calculations	213
3.59	Estimate of Percent Dermal Absorption of Contaminants from Sediment over 12 h at a Soil Loading of 1 mg/cm ²	218

Tables (Cont.)

3.60	Human Intake Factor Calculations for Percutaneous Absorption of Organic Contaminants from Sediment by Adolescents.....	219
3.61	Human Intake Factor Calculations for Ingestion of Groundwater Contaminants by Adults.....	219
3.62	Human Intake Factor Calculations for Percutaneous Absorption of Organic Contaminants through Bathing.....	220
3.63	Human Intake Factor Calculations for Inhalation Exposure to a Volatile Carcinogenic Contaminant of Groundwater during Showering.....	220
3.64	Summary of Human Intake Factor Values.....	221
3.65	Calculated Daily Intakes of Organic Compounds of Concern from Sediment through Dermal Absorption.....	222
3.66	Calculated Daily Intake of Groundwater Contaminants of Concern through Ingestion.....	223
3.67	Calculated Daily Intake of Groundwater Contaminants of Concern through Bathing.....	224
3.68	Chronic Oral Reference Doses and Critical Effects of Contaminants of Concern at AFP 59.....	225
3.69	Slope Factors and Carcinogenic Characteristics for Contaminants of Concern at AFP 59.....	226
3.70	Calculated Dermal Reference Doses for Noncarcinogenic Effects of Contaminants of Concern at AFP 59.....	227
3.71	Calculated Dermal Slope Factors for Carcinogenic Effects of Contaminants of Concern at AFP 59.....	229
3.72	Hazard Quotients and Hazard Index for Dermal Exposure to Sediment Contaminants of Concern at AFP 59.....	232
3.73	Hazard Quotients and Hazard Index for Groundwater Exposures via Ingestion near AFP 59.....	233
3.74	Hazard Quotients and Hazard Index for Groundwater Exposures via Bathing near AFP 59.....	233
3.75	Cancer Risk from Dermal Exposure to Sediment at AFP 59.....	234
3.76	Cancer Risk from Trichloroethene via Groundwater.....	234

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Summary

This summary describes a Supplemental Site Inspection (SSI) conducted by Argonne National Laboratory (ANL) at Air Force Plant 59 (AFP 59) in Johnson City, New York. All required data pertaining to this project were entered by ANL into the Air Force-wide Installation Restoration Program Information System (IRPIMS) computer format and submitted to an appropriate authority. The work was sponsored by the United States Air Force as part of its Installation Restoration Program (IRP). Previous studies had revealed the presence of contaminants at the site and identified several potential contaminant sources. Argonne's study was conducted to answer questions raised by earlier investigations.

S1 Previous Findings

Previous investigations at the facility, as detailed in Section 1.3.8, showed the presence of organic compounds in water from the deep aquifer beneath the site, but at relatively lower levels in the shallow aquifer. These facts suggested that some deeper groundwater contaminants emanated from off-site sources. Levels of metals found in AFP 59's production well were consistent with levels found in the shallow monitoring wells. Except for lead, metals present in soils were not found in notable concentrations in groundwater.

S2 Main Objective

A primary concern at AFP 59 was whether and to what degree plant activities have contributed or might contribute to groundwater contamination. The goals listed below were set in order to address that concern. The approach used to achieve each goal is noted. A specific auxiliary concern, informally appended late in the planning phase, was whether AFP 59 was a source of trichloroethane (TCA), which had been detected in a nearby municipal well field.

S3 Goals and Approaches

S3.1 Contaminant Assessments

A multimedia assessment of contamination at selected sites and locations, by means of a combination of on-site and laboratory analyses, was planned to achieve the goals listed below. Level 2 data obtained by using portable analytical instruments were meant to approximate contaminant conditions in soil at specified locations for screening purposes. Level 4 data obtained at U.S. Environmental Protection Agency Certified Laboratory Program (CLP) quality levels were meant to provide contaminant information of sufficient quality to support (1) a rigorous human-health risk assessment and (2) future remediation decisions. Contaminant-determination goals were as follows:

- Determine the quality of groundwater entering, transiting, and exiting the site through the placement of monitoring wells at locations along the site perimeter and within the site interior.
- Determine the contamination state of soils in the vicinity of Site A-1, a former waste oil storage tank location; Site A-2, a plating building; Site A-3, a WWII oil/water separator site; Site A-4, a settling/storage pond area; Site A-5, a JP-4 fluid storage and piping area; and Site A-6, a former gasoline storage tank area.
- Determine the contamination state of a nearby stream and of plant outfalls emptying into that stream.

S3.2 Hydrogeological Assessments

The goals of the hydrogeological assessments are listed below.

- Determine the extent and interconnectivity of upper and lower aquifers and better characterize the overall site geology through direct geological examination.
- Determine the direction of groundwater flow at the site through water-level monitoring.
- Determine the potential for infiltration of water from Little Choconut Creek into the groundwater beneath AFP 59.

- Determine transmissivity and permeability values for significant strata beneath the site through hydraulic testing and through sampling for geotechnical analysis.
- Construct a groundwater flow model that incorporates new and archival hydrogeological data and estimate contaminant migration routes from AFP 59 under various well-pumping scenarios.

S3.3 Risk Assessment

- Conduct a qualitative human-health risk assessment, whereby potential exposure pathways are identified and evaluated under a current-use scenario and the potential impacts of the AFP 59 site on human health are evaluated.

S4 Field Program Summary

Field activities began October 28, 1991, and ended February 5, 1992. The main accomplishments are noted below.

S4.1 Well Construction and Sampling

Fourteen new groundwater-monitoring wells were constructed on AFP 59 property. Boreholes were logged and soil samples were collected for geotechnical tests. Groundwater from thirteen new and two existing monitoring wells, and from one on-site production well, was sampled on two different occasions. An off-site municipal production well was also sampled. Well construction and sampling are summarized in Table S.1. Soil from boreholes for a well in each cluster area was sampled. Rig borings were made and sampled in Sites A-1, A-3, A-4, and A-6, and a sample from Site A-2 was collected with hand tools. Soil, groundwater, surface water, outfall water, and stream sediment samples were collected; these data are listed in Table S.2. Including replicates and excluding rinsates and trip blanks, 75 samples were submitted for laboratory analysis. All analytical sampling locations and all wells were plotted on a site map. The complete surveyor's plotting is provided to the sponsor (only) on mylar; a simplified base map is shown in the text (Figure 1.2).

TABLE S.1 Summary of Monitoring Wells Constructed at AFP 59 and of the 17 New and Existing Wells Sampled for Laboratory Analysis

Well Type	Total
Monitoring Wells Constructed	
Deep	7
Shallow	6
Intermediate	<u>1</u> (not sampled)
	14
Monitoring Wells Sampled for Groundwater	
Newly constructed	13 (sampled twice)
Existing	<u>2</u> (sampled twice)
	15
Production Wells Sampled	
GE production well	1 (sampled twice)
Johnson City Well	<u>1</u> (sampled twice)
	2

S4.2 Field Analysis

A screening study using a portable gas chromatograph/mass spectrometer (GC/MS) and an energy-dispersive X-ray fluorescence spectrometer was conducted in December 1991. Eighteen samples were collected by hand-augering and analyzed for organic compounds and trace metals.

S4.3 Hydrogeological Studies

During the course of well construction, three Shelby-tube samples were recovered for laboratory falling-head permeability testing. Aquifer slug tests were performed in January 1992 on 15 wells representing both the deep and shallow aquifers and on 1 well installed in the confining layer between aquifers. For 12 days during the same month, water levels in 5 well clusters were recorded at 3-min intervals by electronic data-loggers. A 72-h pump test was conducted during that time by using the GE deep production well for draw-down.

TABLE S.2 Summary of Samples Collected at AFP 59 for Laboratory Analysis (NYS DEC ASPm, except as noted)

Sample Type	Number of Samples Collected
Soil/Sediment	
Well boreholes	15
Test bores	5
(VOC only)	(1) ^b
Hand sample	1
MS/MSD replicates	2
Blind replicates	2
Soil background	1
Creek sediment	2
Creek sediment background	<u>1</u>
	Full suite ^c 29
	VOC only 1
Water	
Groundwater (G.W.)	32
G.W. MS/MSD replicate	2
G.W. blind replicate	2
G.W. background	1
Surface water, creek	2
Surface water, background	1
Surface water, outfall	2
Surface water, MS/MSD replicate	1
Rinsate, equipment	3
Rinsate, equipment	1 ^b
Special water	1 ^b
Trip blank ^d	<u>18</u>
	Full suite ^c 46
	VOC only 2
	Method 524.2 VOC 18
Total full-suite ^c samples	75

^a NYS DEC ASP, except as noted.

^b VOC (volatile organic compounds) only.

^c Full suite: samples were submitted for analyses for (1) PCBs and pesticides, (2) inorganic compounds, and (3) volatile and semivolatile organic compounds.

^d Method 524.2 VOC.

S5 Risk Assessment

During the risk assessment, 41 contaminants of potential concern were identified. Contaminants found only in soil or only in outfall water were deleted from the list on the grounds that potential pathways between these media and human receptors are unlikely. Additional deletions were made for other reasons, leaving a final total of 24 contaminants of potential concern. An assessment of the human-health risks posed by these contaminants was made.

S6 Main Findings

S6.1 General

- On the basis of a document review, General Electric's operating procedures at the time of this study appeared to be sufficient (1) to ensure that routine contamination would not occur and (2) to minimize or make known accidental contaminations. Site contaminants are the result of past rather than ongoing activities.
- Soil and groundwater contamination stemming from past activities was detected, but generally in concentrations too low to function as significant sources of contaminants for nearby municipal water-supply wells. Areas that do contain relatively high concentrations of contaminants are isolated or semi-isolated from the main (deep) aquifer and/or contain compounds that tend to become trapped in the soil.
- Lead, historically a site groundwater contaminant, is no longer detected in groundwater samples.
- Manganese, pending possible revisions of acceptable concentrations, may come to be viewed as a problem groundwater contaminant.
- Of the sites specifically named as potential sources of contaminants, Sites A-4 and A-5 were essentially contaminant-free.

S6.2 Named Sites

- Although a wide variety of contaminants were present in soils from named sites, concentrations were low, and none of the sites as defined is considered to

be a potential source of contaminants or in need of further study or remedial action.

- Except in the case of rare, unexpected occurrences, such as cyanide at Site A-1, contaminants that were found were consistent with the information available about past activities.

S6.3 Potential Problem Areas

- SVOC contamination was found in samples from Site A-1, Site A-2, and well cluster 8. These findings suggest that soil throughout the southeastern corner of the rear parking lot may be contaminated. Furthermore, the points sampled may or may not represent maximum contaminant levels for the area. Although the area could be better defined by further study, the baseline risk assessment concluded that the known contamination levels do not pose a risk to human health.
- TCE is present in the shallow aquifer at well clusters 4 and 9. The presence of TCE in these clusters suggests possible generalized or pocketed shallow aquifer TCE contamination in the western two-thirds of the area south of the manufacturing building, which may account for most of the TCE detected in the deep-aquifer production well. Although further study would be required to verify this hypothesis, the baseline risk assessment concluded that the known contamination state, in reference to TCE, does not pose a risk to human health.
- Level 2 screening data indicate the possible presence of inorganic contaminants in the soil beneath the central part of the rear parking lot area. This contamination predates paving of the lot.
- Laboratory analyses indicate that organic contaminants are present in the soil beneath the west-central parking lot area, and these contaminants were present before the parking lot was paved.

S6.4 Hydrogeology

- The shallow aquifer beneath AFP 59 receives substantial recharge volumes from Little Choconut Creek. The deep aquifer is somewhat confined from the creek, and therefore the influence of the creek upon it is subdued. Deep aquifer recharge from the creek increases when the deep production well is in use.

- Vertical flow components are upward in the vicinity of monitoring well clusters 3, 6, and 9, with hydraulic heads in the deep wells higher in elevation than in their corresponding shallow wells during static conditions. The opposite is true on the rest of the site. Vertical migration of contaminants from the shallow to the deep aquifer may not occur along the western boundary of the site when the deep production well is not in use.

S6.5 Groundwater Flow Modeling

The effect of plant and city production wells upon groundwater flow and contaminant migration was considered by using various pumping scenarios, as summarized in Section 2.4.4.9. It was concluded that, under historical pumping conditions, contaminants introduced into the shallow aquifer could migrate to City Well 2 from any of the on-site locations investigated. In all cases, the travel times would be two years or less.

S6.6 Groundwater Contamination

- The risk assessment concluded that, with the possible exception of manganese, groundwater contaminants beneath AFP 59 do not pose a risk to human health.
- Semivolatile compounds, pesticides, and PCBs were absent from all AFP 59 groundwater samples.
- Trace amounts of dibromochloromethane, bromoform, xylene, and toluene appear in deep aquifer water but not in shallow aquifer water (except for one trace occurrence). These compounds probably entered from outside the site and are unrelated to site activities.
- Overall contamination by VOCs is low at AFP 59. In the GE deep production well, TCA was found at the same level and TCE was found at higher levels than in a distant upgradient municipal well. TCA was present in most well samples, generally at values below that of the municipal well, and was undetectable in several instances.
- Low levels of TCA and barely detectable levels of TCE were found in an upgradient and distant municipal well. Although both compounds were present in AFP 59 groundwater, many wells contained levels that were lower than those in the municipal well or showed no detectable concentrations.
- 1,1-Dichloroethane, 1,1,1-trichloroethane, and trichloroethene were frequently encountered at trace levels in AFP 59 wells, but in some instances, these

contaminants exceeded New York State groundwater standards. They occur primarily in shallow wells, although traces of TCA occur as deep-aquifer contaminants. These three compounds (plus trans-1,2-dichloroethene) are historical contaminants in the on-site deep production well. All three VOCs, and only these three VOCs, occur in the deep production well at greater than 1 ppb. Of all VOCs, only these three occurred somewhere at AFP 59 (shallow wells SW-3, SW-4, and SW-9) in levels at or above 5 ppb during both rounds of sampling. All three compounds were present in these same three wells. The distribution of DCA, TCA, and TCE appear related and may indicate either a common mixed source or several discrete sources somewhere in the southern one-third of AFP 59. Independently, traces of TCA probably enter the deep aquifer from off-site.

S6.7 Risk

Because of consistently conservative assumptions made during the risk assessment, the actual risks associated with the site are likely to be considerably less than the estimated risks.

- An overall noncarcinogenic dermal exposure hazard quotient of less than 1 was determined for creek sediment and for groundwater.
- The ingestion pathway for groundwater had a calculated hazard index of 6.7, primarily because of the presence of manganese.
- The total carcinogenic risk associated with potential exposures to groundwater and with potential dermal exposures to creek sediments was slightly above the EPA target risk level. Groundwater risk was due almost entirely to trichloroethene.

S7 Main Conclusions

- The qualitative risk assessment concluded that contaminants at AFP 59 do not pose a risk to human health.
- Under historical pumping conditions, contaminants introduced into the shallow aquifer could migrate to city well 2 from any of the on-site locations investigated. Travel times would be on the order of two years or less.
- It is believed that the concentrations of contaminants leaving the site are not high enough to significantly affect the Camden Street well field.
- Current contaminant levels do not warrant remediation.

1 Introduction

This report describes an Installation Restoration Program (IRP) Supplemental Site Inspection conducted by Argonne National Laboratory (ANL) at Air Force Plant 59 (AFP 59) in Johnson City, Broome County, New York (Figure 1.1). The plant is located about 3 mi west-northwest of Binghamton, New York. Figure 1.2 is a site map that shows details of the facility and all activity areas to be discussed in this report. The field work was conducted in 1991-1992, and the data were interpreted in 1992-1993. This inspection supplemented two previous IRP studies employing soil and groundwater testing that were designed to determine whether AFP 59 is significantly contaminated and whether it is a source of aquifer contamination.

Concern about a specific contaminant, 1,1,1 trichloroethane (TCA), was expressed by Johnson City officials and New York State Department of Environmental Conservation (NYSDEC) personnel during the early stages of this project. In late 1990, a concentration of 1 part per billion (ppb) TCA was detected during routine monitoring of water from the Camden Street Well Field, a Johnson City municipal pumping field located about 1,000 ft southwest of AFP 59 (Figure 1.3). Subsequent sampling showed a slightly higher value. By the following summer, well field samples exceeded the regulatory limit of 5 ppb. On July 23, 1991, one well was shut down because of TCA contamination. Sampling on August 1, 1991, showed that the TCA concentration in a second well was above the Principal Organic Contaminant Standard (POC) of 5 ppb.

Because of its location and history of TCA use, and because previous analyses detected TCA in its groundwater, AFP 59 was a suspected source of the municipal well contaminant. Subsequent to the Johnson City findings, and concurrent with the initial stages of the IRP investigation, NYSDEC pursued a sampling program aimed at determining the TCA source. Argonne amended its well placement strategy to accommodate NYSDEC information needs and made preliminary results pertinent to their efforts available to them.

1.1 Air Force Installation Restoration Program

The U.S. Air Force (USAF) developed and implemented the IRP to ensure that discharges and releases from past disposal practices and spills were regulated to the same degree and extent as required by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980.

The Air Force environmental policy evolved in a series of steps. The Defense Environmental Quality Program Policy Memorandum (DEQPPM) 80-6 was issued by the Department of Defense (DoD) in June 1980 and implemented by the USAF in December 1980. DEQPPM 80-6 mandated that hazardous waste disposal sites on DoD facilities be identified. IRP directives were revised and expanded through DEQPPM 81-5, which was initiated by DoD in 1981 and implemented by the Air Force in January 1982. The Superfund Amendments and

FIGURE 1.1 Location and Vicinity Map of AFP 59

FIGURE 1.2 Site Map of AFP 59 Showing Locations of Potentially Contaminated Sites, Test Borings, Sampling Points, and Groundwater Monitoring Wells (see Plate 1 for details)

FIGURE 1.3 Location of Johnson City Public Water Supply Well Numbers 1, 2, 3, and 5 in Relation to AFP 59

Reauthorization Act of 1986 (SARA) became law (PL 98-499) on October 17, 1986; SARA required that all federal agencies responding to releases of hazardous substances follow U.S. Environmental Protection Agency (USEPA) rules and regulations, criteria, and guidelines, as described in 42 U.S. Code 9620. On November 10, 1986, USAFHQ directed that all IRP actions convert to the USEPA Remedial Investigation/Feasibility Study (RI/FS) methodology and other guidelines. This approach enabled the Air Force to develop and evaluate required remedial actions in conjunction with its investigative efforts, thereby expediting the determination of the environmental effects of releases and the selection of the remedial actions.

The objectives of the Air Force IRP are to assess the magnitude and extent of contamination at past hazardous waste disposal and spill sites on Air Force installations and to develop remedial actions consistent with the National Contingency Plan (NCP) for those sites that pose a threat to human health and welfare or the environment. The IRP is designed to ensure performance in accordance with CERCLA, as amended in 1986 by SARA, and with the National Contingency Plan.

1.2 Installation Description

The physical setting of AFP 59 is shown in Figures 1.4 and 1.5, which are aerial views of Johnson City ca. 1967 and 1991, respectively. Together, these photographs illustrate the rapid growth that occurred in the 1970s and 1980s — growth that dramatically increased demand on the city's water supply.

The quality of water in Little Choconut Creek may affect the quality of groundwater at both AFP 59 and at the Camden Street well field. It is therefore appropriate to call attention to several features evident in the photographs. What appears to have been the main (northerly) branch of Little Choconut Creek was apparently obliterated, or dramatically altered, by improvements in the area north of interchange 70 on Route 17. Landfill areas visible near this branch in 1967 have been developed as shopping malls. Downgradient water quality could be (or could have been) affected by such features and past activities.

1.2.1 Environmental Setting

Air Force Plant 59 is located about 1,000 ft from and on the floodplain of the Susquehanna River. It lies within the Appalachian Plateau physiographic province, which is characterized by relatively undisturbed, nearly horizontal sedimentary rocks bisected by streams. Site elevation ranges from 830 to 840 ft above mean sea level (MSL). Most of the ground surface is covered by construction in the form of buildings or paving. Surface runoff from the plant drains to Little Choconut Creek, which borders the plant to the south and discharges to the Susquehanna River.

FIGURE 1.4 1967 Aerial View of the Area Surrounding AFP 59

FIGURE 1.5 1991 Aerial View of the Area Surrounding AFP 59

The local climate is humid and maritime, with mild summers and long, cold winters. The prevailing wind direction is west-southwest. The weather is usually warm and humid when the air flow is from the south or southwest, and cold and less humid when the air flow is from the north or northwest.

The average annual temperature for nearby Binghamton is 46°F. Monthly mean temperatures vary from 20°F in January to 69°F in July. The average daily minimum temperature in January is 13°F, and the lowest recorded temperature is -20°F. The average daily maximum temperature in July is 78°F, and the highest temperature recorded at Binghamton is 96°F in the month of September. Freezing temperatures occur at Binghamton on the average of 147 d/yr.

Mean annual precipitation recorded near AFP 59 is about 37 in./yr. The greatest precipitation occurs in June and the least in February. For the most part, precipitation is evenly distributed throughout the year. Snowfall accounts for a large proportion of the total precipitation during the winter months, with an annual average of about 85 in. at the Broome County airport. Snowfall greater than 1 in. occurs approximately 24 d/yr. Mean annual lake evaporation, commonly used to estimate the mean annual evapotranspiration rate, is estimated to be 28 in./yr. Evapotranspiration over land areas may be greater or less than lake evaporation, depending upon the amount and type of vegetation and the availability of moisture.

1.2.2 Regional Hydrogeological Setting

The following discussion is based primarily on the published reports of Randall (1977, 1978, 1986) and McNish et al. (1983). An idealized geological cross section beneath AFP 59 and vicinity is shown in Figure 1.6.

1.2.2.1 Regional Geology

Southwestern Broome County is underlain by stratified and unconsolidated sand, gravel, silt, and clay glacial deposits of Pleistocene age. The most recent geological formations in the area were deposited as alluvial fans and stream channel deposits from postglacial-era streams. Below the recent alluvium, the youngest glacial outwash formations were deposited from streams derived from the northward-retreating glacier headwalls. Older glacial formations, known as ice-contact deposits, were deposited from meltwaters as stranded ice decayed and ablated within the depressions and valleys of the area. The oldest formation above bedrock is glacial till, which was deposited directly from the glacial ice without significant sorting by running water. Bedrock in the area consists of interbedded shales and siltstones.

FIGURE 1.6 An Idealized Geological Cross Section beneath AFP 59 and Vicinity

The geology in the vicinity of the Susquehanna River Valley is characterized by recent alluvium or man-made fill, underlain by broad terraces of outwash. These outwash deposits have been commonly called the Bright Gravel. The glacial outwash deposits are underlain by extensive fine- to coarse-grained ice-contact deposits, commonly known as the Drab Gravel. Other ice-contact deposits from glacial lakes that were trapped by stagnant ice and earlier deposited sediments formed lenses of stratified, fine-grained sand and silt materials with varying amounts of interspersed clay and clay layers. These lake-bed materials are commonly located between the ice-contact deposits and the younger glacial outwash, but they often occur throughout the ice-contact deposits. A thin layer of compact till usually underlies the ice-contact deposits, immediately above the bedrock surface.

The fill and alluvium layers consist of various fine- to coarse-grained earth and/or man-made materials. The fill in the area is generally derived from sand, gravel, and other natural materials, but the fill can also contain a significant amount of ashes, trash, and rubble material. The alluvial deposits in the vicinity of the Little Choconut Creek consist of fine-grained sediments and organic silts, which grade or interfinger away from the stream into sand and gravel deposits with moderate amounts of silt. These alluvial layers are commonly from 10 to 20 ft thick.

The glacial outwash deposits consist of sandy-pebble gravel and pebbly coarse to fine sand. The formation is present over most of the valley floors and forms broad terraces that are sometimes downwarped beneath postglacial lake beds. The thickness of the formation ranges from 10 to 100 ft, but it typically averages about 40 ft.

The ice-contact deposits consist of sandy-pebble to cobble gravel and pebbly sand with slight to abundant silt. Locally, the formation can exhibit silt layers of up to 10 ft or more in thickness. These formations are commonly referred to as the Drab Gravel; however, the name implies a texture that is not always present. Therefore, this report will refer to the Drab Gravel either as coarse-grained ice-contact (CGIC) deposits or as fine-grained ice-contact (FGIC) deposits. The formation commonly underlies the younger units in the central portions of the Susquehanna River Valley, but it can be exposed at the valley side walls. The formation generally ranges in thickness from 0 to 100 ft.

The lake-bed deposits consist of silt and silty-fine sand with varying amounts of clay and fine-grained sediment layering. The formation generally occurs throughout the valleys as lenses of limited areal extent, but it does form extensive deposits west of Johnson City.

The till deposits comprise a tough and compact mixture of unsorted silt, clay, sand, and gravel. It immediately overlies the bedrock and is typically only one to two feet thick. Thicker mantles and mounds have been identified below some hillsides and valley walls.

1.2.2.2 Regional Hydrogeology

A highly productive regional aquifer has been delineated in the vicinity of Johnson City; it extends from near the eastern terminus of Clinton Street in the northwest portion of Binghamton to a former baseball park in Johnson City. This aquifer is named the Clinton Street-Ballpark Aquifer after these two informal boundaries and was designated as a sole-source aquifer for the area by the USEPA in 1985.

The Clinton Street-Ballpark Aquifer is characterized by highly permeable glacial outwash deposits overlying fine-grained and coarse-grained ice-contact deposits. Interspersed in the ice-contact deposits are isolated fingers or lenses of lake-bed deposits. In some areas of the valley, the glacial outwash deposits directly overlie the CGIC deposits, whereas in other areas, a layer of FGIC deposits acts as a semiconfining layer between the two layers. Where a layer of FGIC deposits is present, vertical migration of groundwater from the glacial outwash deposits to the CGIC deposits is severely impeded.

The transmissivity of the Clinton Street-Ballpark Aquifer ranges from 10,000 ft²/d to 50,000 ft²/d and may be higher in localized areas. The hydraulic conductivity of the aquifer, inferred from a description of the subsurface materials, is 1,000 ft/d. Production wells in the aquifer have been reported to yield from 100 to 3,700 gpm, with an average yield of 400 gpm.

The pumping of high-yield municipal and industrial wells is the primary source of discharge from the Clinton Street-Ballpark Aquifer. Johnson City owns seven wells, identified by consecutive numbering. In the vicinity of AFP 59 (Figure 1.3), municipal extraction from the aquifer occurs through city well numbers 1, 2, and 3, which are located at the Camden Street Station west of AFP 59, and through city well number 5 [cap. 1.0 million gallons per day (mgd)], which is north of AFP 59. Occasionally, well number 7 is pumped as a backup to well number 2. The Camden Street Well Field has a capacity of 4 mgd and is typically pumped at high volumes from well number 2, with well number 3 serving as backup. This water is mostly derived from the deep aquifer. Well number 1 was inoperative at the time of this investigation. The seasonally used Plant 59 production well, capable of drawing 350 gal/min, is the only private production well in the area. A 1981 USGS regional water-table map of the Clinton Street-Ballpark aquifer reflects the influence of pumping at two locations and indicates a west to northwest groundwater flow across the site (Figure 1.7).

Pumping of the Johnson City well field has lowered the potentiometric surface at AFP 59 and the surrounding area. A comparison of water levels in September 1958 with those in October 1967 indicates that groundwater elevations decreased by about 10 ft in Binghamton and as much as 23 ft in Johnson City (Hart 1988). The total demand of the Johnson City water system has reached as high as about 4.5 mgd (URS 1992). Because of a recent general decline in industrial activity, demand has lessened. A representative of the Johnson City water department stated in March 1993 that average total demand had been reduced to 3 mgd.

FIGURE 1.7 Water Level Contours and Flow Lines in the Clinton Street-Ballpark Aquifer, October 1967. (These contours and flow lines reflect the influence of several municipal wells.)

Lesser amounts of discharge occur from the aquifer to the streams in the area. Recharge to the aquifer via precipitation occurs within the direct surficial expression of the aquifer. Infiltration from small streams in the Susquehanna River basin has been found to average about 1 ft³/s per 1,000 ft of channel. Of the 36 in. of average annual rainfall at Binghamton, approximately 12 to 15 in./yr returns to the atmosphere by evapotranspiration. The remainder, approximately 24 in./yr, reaches the water table as recharge. Runoff is assumed to be negligible. Pumping wells also induce recharge from local streams by lowering the potentiometric surface of the aquifer to a level below the streams and Susquehanna River. Infiltration then occurs in the portions of the streams that are hydraulically connected to the coarse-grained sediments of the aquifer. A lesser amount of recharge occurs as a result of runoff from the valley walls when interflow reaches the coarser-grained valley floors.

1.2.3 Local Hydrogeological Setting

The following discussion is based primarily on data generated by this site investigation.

1.2.3.1 Local Geology

The eastern portion of the AFP 59 site is capped by a thin layer of fine-grained alluvium from Little Choconut Creek. The northwestern portion of the site is capped by ashy fill grading to coarse-grained alluvium. The southern half of the site has been excavated and contains only a thin layer of alluvium overlying the glacial outwash. The lithology observed below the surficial fill and alluvium indicates that the southern portion of the site mainly comprises three stratigraphic layers. (See cross section locations Figure 1.8 for the locations of cross sections and Figure 1.9 for Cross Section A-A'.) This stratigraphic sequence comprises 15–35 ft of glacial outwash, underlain by 21–54 ft of FGIC deposits, which, in turn, are underlain by 20–54 ft of CGIC deposits. A thin mantle of glacial till lies directly on the bedrock. A layer of stratified lake-bed deposits is interfingered with the FGIC deposits on the western portion of the site. The lower CGIC deposits pinch out in the middle of the western portion of the site (Cross Section B-B'; Figure 1.10).

In the northeastern portion of the site, the FGIC deposits are absent, and the glacial outwash lies in direct hydraulic contact with the underlying CGIC deposits (Cross Section C-C'; Figure 1.11). The boring for DW1 was terminated at 62 ft because of refusal; however, New York Department of Transportation (DOT) borings directly adjacent to the location indicate that no fine-grained sediments were encountered to a depth of 98 ft, with till described from 98 to 110 ft. Apparently, bedrock is deeper and slopes downward to the northeast of the property.

FIGURE 1.8 The Location of Geological Cross Sections beneath AFP 59

FIGURE 1.9 Idealized Geological Cross Section A-A' beneath AFP 59

FIGURE 1.10 Idealized Geological Cross Section B-B' beneath AFP 59

FIGURE 1.11 Idealized Geological Cross Section C-C' beneath AFP 59

1.2.3.2 Local Hydrogeology

General Features

AFP 59 is located on the western edge of the Clinton Street-Ballpark Aquifer. On the basis of the observed lithology, the site can be roughly divided into the two hydrogeological regimes shown on the plan view map in Figure 1.12. The northeastern portion of the site is a one-layer aquifer that comprises the uppermost glacial outwash in direct hydraulic connection with the lower CGIC deposits. There are no confining layers of either FGIC or lake-bed deposits present. The southern and western portion of the site is predominantly a three-layer aquifer system. The aquifer system in the southern portion of the site consists of an uppermost glacial outwash aquifer, separated from a lower CGIC aquifer by a semiconfining layer of FGIC deposits. The western portion of the site is similar in nature, except that a layer of lake-bed deposits is interfingering with the FGIC deposits. The lower aquifer is absent from the center of the western portion of the site.

Static and average groundwater elevations for the month of January are illustrated on potentiometric surface maps shown in Figures 1.13–16. Groundwater elevations in the shallow aquifer during static conditions ranged from 813.41 ft above MSL in SW6 to 816.82 ft above MSL in SW8. Groundwater depths ranged from 13.38 ft below ground surface (BGS) in SW8 to 22.72 ft BGS in SW5. Groundwater elevations in the deep aquifer during static conditions ranged from 813.67 ft above MSL in DW6 to 814.33 ft above MSL in DW8. Groundwater depths ranged from 15.05 ft BGS in DW8 to 22.83 ft BGS in SW5.

Because groundwater is relatively close to the ground surface (less than 14 ft in the vicinity of SW8), shallow sources of contaminants may readily migrate to the upper aquifer. Because there is a confining layer of FGIC deposits between the upper and lower aquifers in the southern and northwestern quadrants of the site, these potential contaminants could be impeded from reaching the lower aquifer on the southern and western portions of the site. However, the AFP 59 site is not underlain by the confining layer in the northeastern quadrant of the site, and it is possible that the layer may be absent or intermittent to the south and west of the site. Contaminants, especially dense, nonaqueous-phase liquids (DNAPLs), could follow the slope of the confining layer and enter the lower aquifer at the confining layer boundaries or its discontinuities.

Hydraulic Parameters

Falling-head permeability analyses in Shelby-tube samples were 1.6×10^{-5} cm/s and 2.3×10^{-4} cm/s in the FGIC deposits. A permeability of 8.1×10^{-4} cm/s was calculated for a Shelby-tube sample collected from the lake-bed deposits in IW9 (see Appendix C-4).

FIGURE 1.12 Approximate Boundary of Aquifer Regimes at AFP 59

The hydraulic conductivity of the aquifer inferred from a description of the subsurface materials is 1,000 ft/d. The results of a pump test performed at the site between December 3 and December 27, 1991, indicate that the hydraulic conductivity of the aquifer beneath the site ranges from about 200 to 2,000 ft/d (URS 1992) for both the shallow and deep regions.

Groundwater Flow Patterns

Static and average potentiometric surface maps of the upper and lower aquifers were constructed in January 1992. The static potentiometric surface maps (Figures 1.13 and 1.15) represent the aquifer status during nonpumping conditions. The average potentiometric surface maps (Figures 1.14 and 1.16) represent the aquifer's status during nonpumping conditions by Johnson City wells and its status during partial pumping conditions by the AFP 59 site's production well. The static potentiometric surface maps illustrate that under nonstressed conditions, groundwater flow in both the shallow and deep aquifers is to the northwest. The average potentiometric surface maps illustrate that average flow patterns remain northwesterly during partial pumping conditions on the AFP 59 site. However, deep aquifer flow is more affected by pumping of the production well, which bends the flow pattern to the north on the western portion of the site and to the west on the northern portion of the site.

The groundwater potentiometric surface maps also show that groundwater flow directions in the study area are being strongly influenced by Little Choconut Creek. The water level in Little Choconut Creek is at a higher elevation than the potentiometric surface of the shallow aquifer, and infiltration is occurring from the stream, recharging the shallow aquifer. Groundwater flow in the vicinity of the creek is influenced by the hydraulic head in the stream, creating the northwesterly flow patterns observed in the shallow aquifer maps. The deep aquifer is semiconfined from Little Choconut Creek by the confining FGIC deposits, and the deep-aquifer static potentiometric surface map illustrates a more subdued reflection of its hydraulic influence. However, similar recharges from the nearby Susquehanna River are likely to be creating the observed flow patterns to the northwest in the deep aquifer.

During static conditions, the vertical components of flow are downward throughout the northern and eastern portions of the site. In these areas, the hydraulic heads in all of the shallow wells are higher in elevation than the hydraulic heads in the deep wells. However, vertical flow components are upward in the vicinity of monitoring well clusters 3, 6, and 9, which are located in the southwestern portion of the site. In these areas, the hydraulic heads in the deep wells are higher in elevation than in their corresponding shallow wells. The reason for this observed change may be that during static conditions, discharge from the shallow aquifer to the Susquehanna River south of the AFP 59 site creates a slight upward gradient in the deep aquifer in the southwest portion of the site.

FIGURE 1.13 Map of the Potentiometric Surface of the Static Water Level of the Shallow Aquifer at AFP 59, prior to the Slug Test, January 11-12, 1992

FIGURE 1.14 Map of the Average Potentiometric Surface of the Shallow Aquifer at AFP 59, January 17-27, 1992

FIGURE 1.15 Map of the Potentiometric Surface of the Static Water Level of the Deep Aquifer at AFP 59, prior to the Slug Test, January 11-12, 1992

FIGURE 1.16 Map of the Average Potentiometric Surface of the Deep Aquifer at AFP 59, January 17-27, 1992

1.2.4 Surface Water

The storm sewer system at AFP 59 empties directly into Little Choconut Creek, a tributary of the Susquehanna River. Both of these streams help recharge the Clinton Street-Ballpark Aquifer.

1.2.5 Air

Estimates of fugitive emissions of volatiles are provided annually by General Electric (GE) under SARA Title III. The assessment of migration of contaminants by air at AFP 59 is not a part of this investigation.

1.2.6 Biology

No biological study was conducted as part of this investigation. AFP 59 is located in an urban area on the former floodplain of the Susquehanna River. No natural plant or animal communities are present on the site. Small stands of second-growth hardwood forest are located adjacent to AFP 59 along Little Choconut Creek and the Susquehanna River.

1.2.7 Demographics

Groundwater is the contaminant migration route of greatest concern at AFP 59. In 1985, the Clinton Street-Ballpark Aquifer was designated as a sole-source aquifer by the USEPA under the Safe Drinking Water Act (FR 2026, 14 J 85). This classification was made because the aquifer is the principal source of drinking water for the residents of Broome and Tioga counties, who then numbered 128,000 (see Risk Assessment; Section 3.3).

1.2.8 Mission and Waste Disposal Activities of AFP 59

1.2.8.1 Physical Plant

Air Force Plant 59 is located in Broome County, New York, in the Village of Johnson City, about three miles west-northwest of the center of the city of Binghamton, and about four miles east of the center of the village of Endicott. Towns within five miles of the plant include Endicott, Maine, Chenango, Dickinson, Union, Binghamton, and Vestal. The location and vicinity of AFP 59 are shown in Figure 1.1. Air Force Plant 59 was designed and built in 1942

by PLANCOR, a former U.S. defense plant corporation. The original 621,500-ft² building remains at about its original size.

Several long-time GE employees said that Little Choconut Creek used to pass through what are now the boundaries of AFP 59. If true, this fact could affect the interpretations of subsurface conditions and contaminant migration potential. The 1942 USGS Binghamton West quadrangle map indicates, however, that while the streambed just prior to plant construction was located at about its present position east of the plant, it was located south of its present position south of the plant (Figure 1.17). The last-mentioned stream segment was positioned within what are presently NYSEG Gaudy Station boundaries. An aerial photograph taken in the late 1930s or early 1940s (Broome County Historical Society Map Book 2 #20) shows the same stream configuration. That photograph also shows what appear to have been small agricultural plots, structures, and lanes occupying the subject area from route 17-C (Main Street) to the old creek's edge. General cut and fill requirements of future improvements may be approximated by comparing the contours shown in Figure 1.17 with the Figure 1.1 site map. The stream south of the plant was altered prior to 1956, as shown on a facility map that was based upon a survey taken that year (Factory Mutual System 1969). The stream was probably straightened in the 1940s prior to the construction of a site-access railroad trestle. The rear fence of the facility in 1956 followed the property line near the creek, largely beneath the flood-control levee mentioned below.

Several improvements have been made to the outdoor facilities at AFP 59 over the years. In 1959, the gravel and dirt parking lots surrounding the manufacturing building were paved. In the mid-1960s, the state of New York built an earthen containment dike along the banks of Little Choconut Creek, behind the facility, as part of a flood control project. In 1974, a water supply well was drilled immediately south of the manufacturing building to reduce the plant's demand on municipal water supplies. A water recharge well for noncontact cooling water was also drilled at this time, but the well was abandoned shortly after installation because of the failure of geological strata (CH2M Hill 1984). The use of railroad spurs into the facility was discontinued by GE in the early 1950s.

The total land area of AFP 59 is 29.6 acres. The main plant entrance is at 600 Main Street (New York State Route 17C). Main Street marks the northern boundary of the installation proper, though a 0.6-acre parking lot is maintained north of Main Street. The plant is located on a bend of Little Choconut Creek, which flows on the east and south sides of the installation. The creek joins the Susquehanna River about 1,000 ft west of the southwest corner of the plant.

1.2.8.2 Manufacturing

Remington Rand, Inc., the first manufacturer to occupy AFP 59, made aluminum aircraft propellers from 1942 to 1945. The plant was then closed for four years. It was reopened by GE in 1949 as an aircraft controls manufacturing facility; GE has operated the facility since that time.

FIGURE 1.17 Little Choconut Creek in 1942 and at Present

1.2.8.3 Waste Generation

The operations at AFP 59 have generated a variety of waste products, including cutting oils, lubricants, refrigerating fluids, degreasing agents, plating acids, caustics, chromium and cyanide solutions, and paint residues. The quantity of wastes generated in the past varied proportionally to the manufacturing activity at the plant. The following summarizes past and present waste disposal practices at AFP 59:

- Concentrated plating bath fluids were stored in an aboveground holding tank and removed as hazardous waste by a contractor from 1952 to 1990. Because of a subsequent reduction in the number of plating baths, 55-gal drums were used for disposal. Plating operations were discontinued in 1991. The plating equipment has since been removed, and the plating room has been decontaminated.

- Plating rinse water was treated in a settling tank to precipitate metals prior to discharge to Outfall No. 001 (1952–1969); plating rinse water was treated in a settling tank for chromium reduction and metal precipitation prior to discharge to Outfall 001 (1969–1984). From 1984 to 1988, plating rinse water was treated by using an anion and cation exchange column and reused. In February 1988, the treatment system became contaminated, and the system was abandoned. From 1988 to 1991, plating rinse water was discharged into the sanitary sewer.
- Waste oils were primarily recovered, with some waste oils being discharged to an oil/water separator upstream of Outfall No. 002 (1942–1953); waste oils were discharged to two interconnected underground waste oil storage tanks and removed by a contractor for disposal (1953–1985); waste oils are discharged to one aboveground storage tank, and oils are removed monthly by a private contractor (1985–present).
- Kerosene-based degreasing solvents were disposed of with the waste oils from 1942 to 1969. Spent organic solvents were drummed and removed by a contractor until 1990. Since that time, halogenated solvents have been recycled on-site by using a distillation unit. Other organic solvent and solvent-contact wastes (including still bottoms, waste flux, paint shop waste, contaminated Q-tips, etc.) are removed by a contractor. (Postscript: the use of the distillation unit ceased sometime before May 1994.)

1.3 Site Inventory

A records search of AFP 59 was completed in October 1984 by CH2M Hill, Inc., Gainesville, Florida. The contractor identified and prioritized sites posing a potential threat to public health or the environment through contaminant migration and recommended that field sampling and laboratory analysis be performed to confirm or deny the presence of environmental contamination at AFP 59.

A second study of AFP 59 was completed in March 1988 by Fred C. Hart Associates, Inc., New York, New York. That study defined and quantified, through preliminary sampling and analysis, the presence of contamination at AFP 59 and recommended that additional studies be performed to further define the presence, evaluate potential sources, and determine the magnitude and extent of contamination at AFP 59.

Sixteen soil boring and five groundwater samples were collected from three shallow wells along the site periphery and three boreholes near the plating building during the Phase II, Stage 1 investigation of AFP 59. Tables 1.1 and 1.2 provide a summary of the analytical results for subsurface soils and groundwater, respectively. The soil beneath the settling and storage tanks was sampled and analyzed in 1991.

TABLE 1.1 Substances of Concern in Subsurface Soils

Constituent	Maximum Allowable Concentration of Contaminants for EP Toxicity ^a (mg/L)	Borehole Program Concentration Range (mg/L)	No. of Samples above Method Detection Limit/ Total No. of Samples	Monitoring Well Program Concentration Range (mg/L)	No. of Samples above Method Detection Limit/ Total No. of Samples
Arsenic ^b	5.0	<0.01–0.02	5 / 8	<0.01–0.03	6 / 8
Barium ^b	100.0	<0.05–0.51	3 / 8	0.10–0.52	8 / 8
Cadmium ^b	1.0	<0.01–0.02	1 / 8	0.01–0.06	8 / 8
Chromium ^b	5.0	<0.02–0.02	1 / 8	<0.02	0 / 8
Lead ^b	5.0	<0.02–0.78	7 / 8	0.03–0.71	8 / 8
Selenium ^b	1.0	<0.01–0.01	1 / 8	<0.01–0.01	2 / 8
Silver ^b	5.0	<0.01–0.01	1 / 8	<0.01–0.01	3 / 8
Total chromium (mg/kg)	c	5.43–67.4	8 / 8	NA ^d	NA
Petroleum hydro- carbons (mg/kg)	c	NA	NA	<10.0–11.4	1 / 8

^a Concentrations contained in Appendix II, 40 CFR 261, Subpart D.

^b Results based on Extraction Procedure Toxicity (EP TOX) methodology.

^c Maximum concentration for soils not established for this parameter.

^d NA = sample not analyzed for this parameter or not applicable.

Source: Hart (1988).

TABLE 1.2 Substances of Concern in Groundwater

Constituent	Concentration Range (mg/L)	No. of Sample Constituent Detected/Total No. of Samples
Inorganics		
Arsenic	<0.005-0.02	4 / 5
Barium	<0.01-0.21	3 / 5
Cadmium	<0.005-0.01	2 / 5
Lead	0.03-0.30	5 / 5
Petroleum hydrocarbons	<0.5-0.6	1 / 5
Organics		
1,1-Dichloroethane	<1-16	1 / 5
trans-1,2-Dichloroethene	<1-66	1 / 5
1,1,1-Trichloroethane	<2-9	1 / 5
Trichloroethene	<2-11	2 / 5

Source: Hart (1988).

As a result of, in part, these earlier investigations, six potential contaminant sources (Sites A-1 through A-6) and several additional locations of interest were identified for further study, as described below (see also Section 1.2.8.3).

1.3.1 Site A-1: Former Underground Waste Oil Storage Tanks Area

Site A-1, located immediately south of the Special Programs Facility (Room 904), was formerly used for the temporary storage of waste cutting oils. Two interconnected, 1,000-gal underground storage tanks were installed in 1953 and used until their removal in 1985. The area surrounding the tanks was back-filled with gravel. Though the area was inspected daily to prevent overtopping, spills occurred during the monthly removal of oils from the tanks.

In the course of removing the tanks, the gravel surrounding both tanks was found to be heavily stained. The stained gravel and soil around the tanks was excavated to a depth of 12 ft, about 6 ft below the bottom of each tank, and was removed from the site. Soil beyond the removal zone was sampled by O'Brien and Gere Engineers, Inc., and declared nonhazardous (Schneider 1985). The tanks were replaced by a single, double-walled, aboveground tank.

Information was available on the waste types associated with Site A-1, but no samples were collected that could attribute specific contaminants to the underground storage tank area. The tanks were used to store waste oils collected from a number of different areas of the plant. Prior to 1969, nonchlorinated, kerosene-based degreasers were stored in the underground tanks along with

waste oils. It was not known whether groundwater had been affected by contaminants at Site A-1.

1.3.2 Site A-2: Plating Building

Past activities in the plating building may or may not have caused groundwater contamination. As reported by Hart (1988), GE personnel observed discolored soil while repairing a leak in the underground sprinkler main beneath the plating building. It was therefore believed that heavy-metal contaminants from plating wastes may have been present and could have migrated to the groundwater. Water from the leaking sprinkler main could have accelerated any such migration of potential contaminants.

Prior to the current study, soil samples from test borings immediately south of the plating building and from beneath the plating building were submitted for laboratory analysis. Contaminants detected in these samples included arsenic, barium, lead, and total chromium. Concentrations of lead and total chromium were higher in the deeper of the two samples in each boring. Compared with the three soil borings, the subfloor sample contained a higher concentration of detected metals other than chromium. The highest concentration of total chromium (67.4 mg/kg) was found at a depth of 8–10 ft. No concentrations exceeded maximum allowable limits for EP Toxicity. During 1992–93, the plating room itself was decommissioned, decontaminated, and stripped of equipment, which was removed from the site.

1.3.3 Site A-3: WWII Oil/Water Separator Site

No contaminant data were available for Site A-3. The separator was reportedly filled with sand and capped with concrete sometime in the 1970s. Verbally supplied information, used in planning, indicated further that the separator was located beneath the floor of the Special Programs Facility. Therefore, angled borings beneath the floor were planned.

It was subsequently learned that the separator was actually outdoors, near the Programs Wing. Former GE employees identified a concrete box, the lid of which is visible, as the separator.

1.3.4 Site A-4: Storage and Settling Tanks

The storage and settling tanks are both below ground and located immediately south of the southwestern corner of the plating building (see Figure 1.2). The settling tank is open-topped and located nearest the GE building. The spent-plating storage tank is covered. These tanks were used in the handling of plating room liquids, which have historically been treated by using different methods (see Section 1.2.8.3). The storage tank previously held spent plating liquids that were to

be removed as hazardous material by a contractor. From December 1990 until June 1991, Burnite was also placed in the tank for disposal as hazardous waste. Burnite has since been neutralized and discharged to the POTW. The storage tank was pumped out in June 1991 and has not been used since to hold hazardous waste. (The tank held rinse water, which overflowed from the settling tank during the period of fieldwork for this study.) Plating rinse water (and neutralized Burnite) was run through the settling pond and into the sanitary system up until the time that plating was discontinued.

In May 1991, soil samples were recovered from immediately below each tank by means of angled boreholes. A single composited sample, representing material from 10-12 ft and 13-15 ft below surface, was taken from beneath each tank. Samples were submitted for heavy metals and volatiles analysis by means of the Toxicity Characteristics Leachate Procedure (TCLP) and for pH determination. Analytical results are listed in Table 1.3. Two pH values (8.80 ft beneath the settling tank and 7.58 ft beneath the holding tank) were within an acceptable range of 5 to 9. Barium and tetrachloroethene were detected in samples from beneath both tanks. Cadmium and chromium were found in soil from beneath the holding tank. Applicable state or federal regulations regarding soil contamination are lacking, although there are guidelines. All detections were reported to have been within appropriate guidelines and were well below RCRA TCLP regulatory levels. The removal of both tanks with appropriate soil testing is planned for 1993.

1.3.5 Site A-5: JP-4 Fluid Storage and Piping Area

Site A-5 consists of the area through which JP-4 fluid was once piped underground from a storage building to the manufacturing building. The ground surface is presently covered with grass. Leakage was considered a possibility. No contaminant data were available for this site.

1.3.6 Site A-6: Former Gasoline Storage Tank Area

No contaminant data were available for Site A-6. Information concerning the service history and the condition of the tank at the time of removal is unavailable. The tank was reportedly removed in 1975.

1.3.7 GE Deep Production Well

Results of several sampling events indicated that water from the GE production well was contaminated at low levels with organic compounds and lead. The production well analysis showed five organic compounds: 1,1-dichloroethane; trans-1,2-dichloroethene; CIS 1,2-dichloroethene; 1,1,1-trichloroethane; and trichloroethene (see Table 1.4). Data were insufficient to define the source or sources of the contamination detected.

TABLE 1.3 Analytical Results for Samples Taken from beneath Settling Tank (Borehole B-1)

Contaminant Detected	Concentration (ppm)	TCLP Regulatory Level (ppm)
Benzene	ND ^a	0.50
Trichloroethene	ND	0.50
Tetrachloroethene	0.05	0.70
Chlorobenzene	ND	100.0
1,4-Dichlorobenzene	ND	7.50
Vinyl chloride	ND	0.20
1,1-Dichloroethene	ND	0.70
Chloroform	<0.02	6.00
Carbon tetrachloride	ND	0.50
1,2-dichloroethane	ND	0.50
Methyl ethyl ketone	ND	200.0
Arsenic	ND	5.00
Barium	0.328	100.0
Cadmium	ND	1.00
Chromium	ND	5.00
Lead	ND	5.00
Mercury	ND	0.20
Selenium	ND	1.00
Silver	ND	5.00

^a Not detected.

Source: MARCOR Job No. NE1-119 report.

1.3.8 Historical Data

Three monitoring wells were sampled during earlier IRP investigations. Of these, only SW-3 contained detectable organic compounds. This might suggest that there is a deeper organic groundwater contamination problem emanating from an off-site source. Levels of metals found in the production well were consistent with levels found in the shallow wells.

Sixteen soil boring and five groundwater samples representing three shallow wells along the site periphery and three boreholes near the plating building were collected in 1986 during a Phase II, Stage I investigation at AFP 59 (Hart 1988). The General Electric production well was also sampled. A soil sample was also taken by GE employees from beneath the plating building.

Excluding the production well, only samples from shallow well number 3 on the southwestern edge of plant property contained a detectable concentration of an organic compound — 6 ppb of trichloroethene (TCE). Metals concentrations were low in these wells.

TABLE 1.4 History of AFP 59 Production Well Water Contamination to 1990

Organic Compound	Concentration ($\mu\text{g/L}$)					NYS	NYS
	1986 ^a	1988 ^a	Jan ^a 1990	June ^a 1990	LOD ^b	1988 DWS ^c	1990 DWS ^c
1,1-Dichloroethane	16	13	7	4	5	50	5
trans-1,2-Dichloroethene	66	ND ^d	ND	36	5	50	50
1,1,1-Trichloroethane	9	3	ND	8	5	50	5
Trichloroethene	11	8	10	6	5	50	50
cis-1,2-Dichloroethene	e	27	31	- ^e	5	50	50

^a All samples taken by independent laboratories with blank sample analyzed.

^b Limit of detection on analysis.

^c 1990 drinking water standards from Broome County Health Dept. and 1988 proposed regulations enacted in 1989.

^d Not detectable.

^e Not run in sample.

Source: Internal GE memos dated January 23, 1990, and June 25, 1990.

The deep-aquifer production well, however, contained concentrations of organic compounds as follows: 1,1-dichloroethane, 16 ppb; trans-1,2-dichloroethene, 1,1,1-trichloroethane, 9 ppb; and trichloroethene, 11 ppb. As noted by EA Engineering (1988), lead and organic compounds had been detected through several samplings of the deep production well.

The soil samples from near the plating building contained arsenic, barium, lead, and total chromium, all below the maximum allowable limit for EP toxicity. The highest chromium value was 67.4 parts per million (ppm) in soil from 8 to 10 ft below surface. Deeper samples contained higher concentrations than did shallower samples. Except for chromium, the GE sample contained higher metal concentrations than did the soil borings.

Soil samples were also taken from two holes bored beneath the settling ponds (Marcor 1991). Values determined by means of the Toxic Characteristics Leaching Procedure (TCLP) for each sample were below regulatory limits. Barium was detected via the TCLP in boring B-1, and barium, cadmium, and chromium were detected in boring B-2. Detectable levels of TCE were found via TCLP in B-1 (0.05 ppm) and in B-2 (0.02 ppm).

1.3.9 Outfalls

AFP 59 is currently permitted under the New York State Pollution Discharge Elimination System (SPDES) Permit No. 0004073, covering the period December 1, 1989, to December 1, 1994. This permit allows the discharge of noncontact cooling water and storm runoff into Little Choconut Creek via Outfalls 002 and 003. Noncontact cooling water, drawn from the plant production well, is cycled through a cooling tower prior to discharge. Maintenance-yard storm water is run through an oil/water separator prior to discharge through Outfall 002. Most contact cooling water, according to GE personnel, presently goes through Outfall 003. Prior to construction of Outfall 003, all nonprocess cooling water was discharged through Outfalls 001 and 002. Before the diversion of process waters to the Binghamton-Johnson City POTW in 1988, treated process wastewater from the plating room was discharged through Outfall 001.

Before the construction of Outfall No. 003 and the diversion of process waters to the Binghamton-Johnson City POTW in 1988, cooling water was discharged through Outfalls 001 and 002, and process wastewater from the plating room was discharged through Outfall No. 001.

Originally, ferrous sulfate was added to plating rinse water as it flowed into a baffled settling tank. This reduced hexavalent chromium to trivalent chromium and precipitated the trivalent chromium. The effluent from the settling tank was then discharged at Outfall No. 001. Specified effluent-monitoring parameters included chromium, nickel, and lead.

High levels of hexavalent chromium in the effluent were traced to treatment problems, notably mechanical failures of the ferrous sulfate addition mechanism and the general inability of the system to treat slugs of hexavalent chromium adequately. This problem was remedied in 1984 with a new treatment system. Cadmium, copper, and tin were also plated. General Electric had internally analyzed the water from Outfall No. 001 for cadmium, copper, and tin in the 1970s. These contaminants were found at such low levels that monitoring for them was not required under the original NPDES or subsequent SPDES permits. Additionally, although cyanide was present in several of the plating solutions, monitoring for cyanide was neither required nor performed.

From 1984 to 1988, plating rinse waters were treated by anion and cation exchange columns and stored in an underground tank for reuse. Except for a provision to handle upset flow conditions, there was no discharge to the creek. One estimate indicates that 200 gpd of treated plating rinse water were discharged through Outfall No. 001 just prior to diversion to the sanitary sewer.

Presently, only noncontact and surface runoff are discharged into the stream. According to estimated 1991 averages, Outfall No. 003 is discharging 50,000 gpd of cooling water, and Outfalls 001 and 002 are discharging 175,000 and 225,000 gpd, respectively. Under the current permit, all three outfalls are monitored monthly for pH, temperature, flow, oil, and grease. Because of the detection of contaminants in the production well water that is used in the cooling system, Outfall No. 003 is monitored quarterly for 1,2-dichloroethylene; 1,1,1-trichloroethane; and trichloroethylene.

1.3.10 Choconut Creek

The present course of Choconut Creek lies near, but beyond, the southern and eastern boundaries of AFP 59. The possibility that contaminated water from Choconut Creek could migrate beneath plant property was noted in the ANL Work Plan for this study. The current investigation has demonstrated that infiltration of water from the stream into the shallow aquifer beneath AFP 59 is, in fact, occurring (see Groundwater Flow Patterns in Section 1.2.3.2 and Groundwater Flow Modeling in Section 2.4.4).

Assuming interconnections between lower and upper aquifers, draw-down from the deep production well, and contaminated creek water, the deep aquifer beneath the plant could become contaminated from this off-site source. Potentially, contamination of surface water of the stream segment near AFP 59 could stem from upstream sources, from the Susquehanna River during floods, from accidental contaminant discharges through GE or NYSEG outfalls, or from previously contaminated stream sediments. Sources of sediment contamination, if any, could include treated process waters that were formerly discharged from AFP 59 outfalls.

1.4 Remedial Actions

USTs in two areas were removed as described during discussion of Sites A-1 and A-6. The plating room was dismantled and decontaminated during the past year. It is expected that the settling ponds will be removed in the near future.

1.5 Site Documents

A review of GE's AFP 59 environmental documents was conducted by ANL as part of a literature review during the planning stages of this investigation. This section contains a brief description of the documents seen and, in Table 1.5, a selectively annotated topical listing of them. An itemized review and a bibliography of these documents may be found in Appendix Q.

Most documents pertain to reportings required by regulators. A number of reports and correspondences pertaining to permits, chemical use, chemical spills, waste generation, waste storage, waste disposal, waste discharge, waste transport, and waste minimization were generated through the 1980s. Within and beyond standardized regulatory reports, the record contains materials pertaining to several subjects that received special attention from GE environmental managers:

1. *Chlorinated solvents.* General Electric introduced the recovery of chlorinated solvents to a practical extent and sent unrecyclable solvent-containing wastes off-site. Efforts to lessen the use of all chlorinated solvents continued through the 1980s. The use of trichloroethylene was discontinued in 1985. The most

recent document that was reviewed as part of this study and that mentioned 1,1,1-trichloroethane (TCA) indicated the presence of significant quantities of TCA-containing wastes at AFP 59 in 1989 (GE, 1990, in Appendix Q). TCA was still being used at the plant at the time of the field effort conducted for this report.

2. *PCBs.* A focus upon PCBs began in 1981. Most transformers and capacitors that contained PCBs were disposed of by 1988, although a few were found and removed after that time. Hydraulic fluids were analyzed to ensure the absence of PCBs. A PCB spill site was identified, and contaminated soil and concrete were removed.
3. *Off-site waste disposal.* In 1984, GE advocated the discontinuation, whenever possible, of land disposal of hazardous wastes. Planning towards this end, hazardous wastes were classified into three types for disposal: flammable liquids, cyanide-bearing waste plating solutions, and spent plating bath solutions. Flammable waste was to be blended with other fuel at the waste contractor's facility and used as a fuel source by cement manufacturers. Cyanide-bearing wastes were to be chlorinated at high pH to give nitrogen and carbon dioxide. Spent plating solutions could not be economically incinerated or treated; off-site burial continued for these solutions.
4. *Plating wastes.* Waste minimization measures, notably the use of ion-exchange resins to remove heavy metals from aqueous plating wastes, were instituted. General Electric received a permit to discharge plating room rinse water to the Binghamton-Johnson City publicly owned treatment works in 1989.
5. *Groundwater contamination.* The Johnson City water supply was slightly contaminated in 1985, and suspicion turned to AFP 59 as one of the possible sources of pollution. Analyses of AFP 59 outfalls, sediments, wells, and soils were initiated.

TABLE 1.5 Environmental Management Documents Generated by General Electric at AFP 59

Subject and Year	Document Title	Description
Disposal		
1984	Incineration haz waste	Unsuitability of incineration of heavy metals
1984	Lab waste disposal	
1984-85	Pennsylvania D.E.R.H.W. activity reports	Waste sent to Waste Conversion, Inc., Hatfield, Penn.
1988	NYSDEC haz waste inspection	
EPO		
1984	EPO environmental data base survey form	
1986	Memo	Hazardous waste disposal for GOCO transporters and treatment facilities used by AFP 59
1989	EPO/hazardous waste disposal	Information for in-house "Environmental Protection Operation"
Laboratory		
1985	O'Brien-Gere lab reports	
1986-90	Lab analyses	Various samplings and labs
Manifests		
1984	Uniform haz waste manifest	To Penn.; plating liquids; PCBs
1985-87	Manifests - waste shipment	
1988-89	Manifests - waste shipment	
Outfalls SPDES/ NPDES		
1982	SPDES permit renewal	
1983-84	SPDES permit	
1984	SPDES monitoring report	
1985	SPDES monitoring report	Period ending 12/21/84
	Memo	In-house about SPEDES report
1985	USEPA questionnaire/potential hazards lab results	Sediments near outfall 001, informal, analyses not yet complete
1986	NYSDEC outfall 002 audit results	
1987	Discharge monitoring report	Period ending March 31
1987	NPDES monitoring report	
1988	Outfalls 001/002 - permit renewal	
1989	Final permit outfalls 1,2,3	
1989-1994	NPDES permit outfalls 1,2,3	

TABLE 1.5 (Cont.)

Subject and Year	Document Title	Description
PCBs		
1981	Corporate environmental issues project CEIP - GE memo	
1981-90	PCB yearly reports	
1982-91	PCB yearly activity reports	
1985	PCB transformer equipment PCB transformer inventory PCB Friend lab results	List
1985-91	GE misc. items	Removals, inventory, etc.
1990-91	PCB transformer retrofill certification of compliance	
1991	Facility PCBs - memo	Remediation proposal
POTW		
1985-8	BTM/JC joint sewage treatment ^a File; inventory EPA pre-treatment standards BTM/JC rules and regulations	Includes plating/finishing 1985 questionnaires
1986	PWB laboratory effluent	Letter report; flow rates; analyses. Chester Engineers, Pittsburgh
1987	Sewage flow meter readings Lab results Letter to JC POTW	Schneider (GE) to Horrigan, Supt. POTW 75% reduction plating facility; request to tie into POTW; approximate contaminants concentrations.
	History of plating room ref sewer	Internal document
1980	BTM JC POTW survey quest	
1989	Baseline monitoring report	Waste sump composite results
1990	BTM/JC joint sewage treatment plant ind. water survey	
RCRA		
1980-82	Haz waste facility permit part B	Includes map of waste storage areas
1982	RCRA Part B application	Correspondence re: extension
1980-83	Haz waste facility permit part A	Completed application form, which includes a declaration of generator-only status, a permit history summary, and a 1982 hazardous waste activity.
1983-4	RCRA inspection	
1984	Letter: facility no longer TSD GE letter: identification of drum contents	

TABLE 1.5 (Cont.)

Subject and Year	Document Title	Description
1985	TSD interim status: reclass to generator only NYSDEC RCRA inspection	Completed response to national screening survey (OSW)
1989	Haz waste potential release transmittal NYSDEC letter: 30 day storage extension 7 drums	Schneider (GE) to USEPA 13 Aug. 85 Contains information on extant GE waste storage provisions
SARA		
1984-85	Pennsylvania D.E.R H.W. activity reports	Waste sent to Waste Conversion, Inc., Hatfield, Penn.
1985	List of gases and chemicals posing risk	GE internal transmittal
1987	Freon mass balance report Toxic chemical release inventory reporting form	
1987-88	Tier I and II emergency & hazardous chemicals inventory	
1988	SARA Title III SARA	Listing of extremely hazardous materials GE; 1988 TCA emissions Includes TCA fugitive and off-site quantities
1989	Tier I and II EPA toxic chemical release inventory reporting form (TCA) SARA Title III USEPA toxic chemical release inventory report Tier I emergency and hazardous chemicals inventory	Degreaser runs and TCA recalculation of emissions Includes water use, waste discharge
1990	Tier I and II emergency and hazardous chemicals inventory Tier II report EPA toxic chemical release inventory reporting form (freon) SARA Title III NY toxic chemical release inventory	Hand-written; current information on freon
Special Interest (re: current study)		
1980	JRB associates	Packet contains copy of formal report of 1975 environmental inspection
1980-84	JRB associates	Copies of info sent to JRB, includes environmental audit, SPDES, photographs, maps.

TABLE 1.5 (Cont.)

Subject and Year	Document Title	Description
1985	Chlorinated solvent use survey Chlorinated solvent use	GE Internal memo: Gilligan to Mitchell. 11 Apr. 85 Position ref federal ban on land disposal of TCE, PCE, TCA. Information on use of TCE, PCE, and TCA at AFP 59. Past and current use; threat to groundwater, etc. High values result of wrong monitoring point.
	Haz waste overview	In-house; includes waste min efforts and chemical inventory.
1986	Degreaser survey Ethylene glycol	Locations of solvents Letter report GE to USEPA ref incident in which ethylene glycol ultimately went through an outfall. TCE use discontinued in 1985.
	Statement Chromium contamination-plating room Haz waste storage facilities closure plan UST status questionnaire	About ponds. GE response to question by Hargis & Associates, Inc., Tucson, Ariz.; includes inventory of storage tanks and brief description of spills around UST prior to removal.
1988		
1991	Soil borings at storage and settling tanks/Marcor JC mayoral notification Statement	About TCA Testing of AFP 59 wells
Undated	JC well's 1, 2, 3 log JRB Assoc.; Formal report w/maps, etc.	
USEPA/ NYSDEC Misc.		
1977	NYSDEC industrial chemicals survey	Substances of concern since '71 and '77 inventory
1985	NYSDEC industrial water supply questionnaire	
1988	EPA questionnaire on Endicott landfill Injection well questionnaire	
1990	NYSDEC hazardous waste report Inventory of federal haz waste activity	

TABLE 1.5 (Cont.)

Subject and Year	Document Title	Description
Waste Generation		
1981-88	Annual haz waste gen report(s)	
1989/90	Generator annual report-1989 Memo	Minerly (GE) to NYSDEC 27 Feb. 1990; provides summary of 1989 waste reductions and status of recycling of TCA.
Waste Minimization		
1984-84	Waste stream reduction	
1985	Memo	1982-85 waste minimization summary
1987	Hazardous waste report	USEPA form IC
1987-88	USEPA waste min	USEPA hazardous waste report
Wastewater Discharge Compliance		
1990	Water permit appraisal Proposals by O'Brian & Gere, Dunn Completed questionnaire	Waste water discharge compliance About discharge
Undated	NYSDEC ind chem survey	Completed questionnaire

^a BTM/JC = Binghamton/Johnson City.

2 Project Activities

2.1 Project Objectives

Although three previous investigations provided site contaminant data, those data were not sufficient to adequately assess the source(s), extent, and degree of the contamination found. The primary objectives of the present study were (1) to provide comprehensive contaminant data of known quality so that the type of pollution at sites suspected of being contaminant source locations and within the plant boundaries as a whole could be determined more completely, (2) to determine the environmental media pathways that are contaminated, and (3) to delineate the areal and vertical extent of contamination. All field activities and laboratory analyses were performed in accordance with the methods and procedures detailed in ANL's Quality Assurance Project Plan (QAPP) (Appendix P).

This project was designed to accomplish the following:

- Determine whether and to what degree AFP 59 is contributing to groundwater contamination.
- Determine whether contaminated soils underlay AFP 59 property and if these soils are presently contributing or could potentially contribute to groundwater contamination in the area.
- Determine the extent (rate and direction) of contaminant migration.
- Define the subsurface geology and interconnectivity of the upper and lower aquifers.
- Develop a conceptual hydrological model for determining, via numerical modeling, groundwater flow directions and rates.
- Provide analytical data for evaluating potential sources of contaminants present in the deep aquifer.
- Provide data for valid site characterization for use in evaluating potential risks to human health from the presence and migration of contaminants.

- Provide site-specific data to support the future formulation of no-further-action, RI/FS, or RD/RA documents for each site, specifically to characterize the following suspected contaminant source areas (see Figure 1.2):

Site A-1: Former waste oil storage tanks area;

Site A-2: Plating building, below floor;

Site A-3: WWII oil/water separator site;

Site A-4: Settling and storage tanks area;

Site A-5: JP-4 fluid storage area and pipes to building; and

Site A-6: Former gasoline storage tank area.

2.2 Field Activities

2.2.1 Field Program

Fieldwork for the supplemental site investigation was conducted between late October 1991 and early February 1992. In summary, seven deep, one intermediate, and seven shallow monitoring wells were installed at AFP 59 to help determine the nature and extent of alleged groundwater contamination and to define the hydrogeologic characteristics and groundwater flow patterns at the site. Soil samples were collected from the monitoring well borings for chemical analyses and for the maintenance of lithologic logs. Five soil borings were also emplaced near suspected shallow contaminant source areas to collect soil samples for chemical analyses. Two rounds of groundwater samples for chemical analysis were collected from the completed monitoring wells. In addition, groundwater samples from two existing monitoring wells on the site were collected for analyses, along with the ANL monitoring well samples. Field screening of 18 locations was conducted by using portable analytical equipment. Water and sediment samples for laboratory analysis were collected from three off-site stream locations, and analytical water samples were collected from two AFP 59 outfalls. During the period between groundwater sampling events, slug tests were conducted in the upper and lower aquifers to determine representative values of permeability, and automatic water level recorders were installed in 10 wells to collect data for groundwater potentiometric surface maps. These and other associated activities are detailed below.

2.2.1.1 Site Surveying

The horizontal coordinates and elevations of all groundwater monitoring wells, the AFP 59 production well, the hand-augered soil sampling locations, the power-driven test borehole locations, the outfall locations, and two near-site creek sampling locations were surveyed by Purdy Engineering. Purdy is a New York State registered and licensed surveyor in Vestal, New York. The state plane coordinates for all sampling locations are shown in Appendix D. Elevations and horizontal locations were measured to an accuracy of 0.01 and 1.0 ft, respectively, except for the elevation and state plane coordinates of two background sampling locations that were situated several miles from AFP 59, which were derived by Purdy from a 10-ft-interval USGS map.

Horizontal control, on the state plane coordinate system, was based on control points established by the New York DOT for the construction of Route 201 to the east of AFP 59. Vertical control was based on a USC&GS standard disc located on the railroad underpass at Riverside Drive to the southeast of the site. All survey positions were recorded on a single-sheet Mylar base map drawn at a scale of 1 in. = 50 ft. Figure 1.2 is based upon a copy of that map.

Purdy Engineering coordinated with URS Engineering, the firm that conducted surveying for a nearly concurrent NYSDEC contaminant source investigation. Purdy verified that both surveys were conducted on the same vertical datum.

2.2.1.2 Installation and Development of Groundwater Monitoring Wells

Wells were constructed in accordance with the procedures outlined in the QAPP provided here as Appendix P. Well locations are shown in Figure 1.2.

Well Installation. Seven deep (DW1, DW3, DW4, DW5, DW6, DW8, and DW9), one intermediate (IW9), and six shallow (SW4, SW5, SW6, SW7, SW8, and SW9) monitoring wells were installed at the AFP 59 site between October 31 and December 13, 1991. The deep monitoring wells were installed to a depth ranging from 61.5 to 93 ft to monitor groundwater in the lower aquifer. The shallow wells were installed to a depth ranging from 23 to 30.5 ft to monitor groundwater in the upper aquifer. The locations of these monitoring wells are shown in Figure 1.2.

All monitoring wells were emplaced by using a Canterra CT-350 drilling rig. The monitoring well boreholes were sampled by using 2- or 3-in.-diameter split spoons. The samples were lithologically logged by ANL's supervising hydrogeologist. Lithologic logs are presented in Appendix B-1. Sampling to determine lithology was conducted at a maximum of 5-ft intervals (or more frequently at the direction of the supervising hydrogeologist).

To preclude cross-contamination from the upper to the lower aquifer, the upper portions of the deep wells were double cased. The upper portion of each deep well was constructed by using 10.25-in.-I.D., 14.25-in.-O.D., hollow-stem augers. The outer casing was constructed of 8-in.-diameter schedule 40 PVC monitoring well pipe, and the annular space was sealed with a 10:90 mixture of bentonite and cement grout. The lower portion of each deep well was installed by using drive and wash drilling techniques. A 6.25-in.-O.D. steel casing was driven at 2.5–5.0-ft intervals, and the casing was reamed with a 4.25-in. Tricone roller bit. Cuttings were washed to the surface with potable water.

The deep monitoring wells were constructed of 4-in. internally threaded schedule 40 PVC monitoring well pipe. Each deep well was constructed with 10–20 ft of 0.010 continuously slotted "wire-wound" PVC screen at the bottom. Monitoring well DW8 was constructed of standard 0.010 slotted screen, because wire wound screen was unavailable at the time of installation. All deep wells were constructed with No. 2 clean-sand filter packs emplaced to a depth of 3 ft above the screen. A 5-ft bentonite seal was slurried in place above the filter pack, and the remainder of the annular space was sealed with a 10:90 mixture of bentonite and cement grout to within 1 ft of the ground surface.

The shallow wells were constructed by using 4.25-in.-I.D., 8.25-in.-O.D., hollow-stem-auger techniques. Each shallow well was constructed of 2-in. internally threaded schedule 40 PVC monitoring well pipe, with 10–15 ft of 0.010 continuously slotted "wire-wound" PVC screen at the bottom. Monitoring Well SW8 was also constructed of standard 0.010 slotted screen. All shallow wells were constructed with a No. 2 clean-sand filter pack emplaced to a depth of 2 ft above the screen. A 3-ft bentonite seal was constructed by emplacing powdered bentonite above the filter pack. The remainder of the annular space was sealed with a 10:90 mixture of bentonite and cement grout to within 21 ft of ground surface.

All wells were capped at the surface with an internally seated locking cap and were finished with either an at-grade locking steel manhole or locking "stick-up" protective casing. A 2 × 2-ft concrete pad was installed at grade, and traffic balusters constructed of capped 3-in. steel pipe were installed around stick-up well casings in traffic areas. As-built specifications for each of the monitoring wells are shown in Appendix B.

Any wastes associated with drilling and well installation were containerized. The drilling firm supplied an 8,000-gal tank trailer for the storage of wastewater during performance of the work, as well as DOT drums for the handling of waste solids and fluids. The origin, temporary storage, and fate of the drummed waste was tracked through a program of labeling and formal logging. Argonne provided GE environmental personnel with the analytical data pertaining to each drum of waste, and GE arranged for the removal and disposal of the drums by a hazardous waste contractor. The two batches of wastewater contained in the tank trailer were analyzed by a laboratory for Marcor and removed from the site and disposed of by a contractor.

Well Development. After the monitoring wells were completed, each well was developed by pumping to remove fine-grained materials from the well and geologic formation around the screen. Each well was developed by using either a Groundwater Technology 4-in., or a Grundfos 2-in., submersible pump until pH, temperature, and conductivity measurements stabilized. The monitoring wells were also developed until turbidity measurements were less than 50 NTUs either at the time of post-installation well development or during purging prior to sampling. Well development logs are presented in Appendix C.

Postinstallation development to less than 50 NTUs was not possible in several of the wells for various reasons. Monitoring well DW6 was an extremely slow-yielding well, and it was not possible to pump the well at a rate sufficient to flush all fine material from the well to a clarity less than 50 NTUs turbidity. In the shallow 2-in. monitoring wells SW5, SW7, SW8, and SW9, the fittings on the flexible discharge hose attached to the Grundfos 2-in. submersible pump tended to wedge in the narrow wire-wound screen opening, and the pump could not be inserted plumbly into the narrow screen opening. These wells were developed by hand bailing, but were either too slow yielding or too agitated by the bailing to clear to less than 50 NTUs turbidity. These wells were developed until pH, temperature, and conductivity measurements stabilized.

All wells were allowed to remain undisturbed for approximately two weeks before the first round of sampling. During pre-sample purging of the shallow monitoring wells, rigid piping was attached to the 2-in. pump to facilitate plumb installation. The wells were then purged until the water clarity matched the water clarity in the wells that were developed to less than 50 NTUs turbidity. Before the second round of sampling, the wells were again allowed to remain undisturbed for approximately 10 days. After this period, it was possible to purge all monitoring wells to less than 50 NTUs turbidity. Turbidity is further discussed in Section 2.2.3.

2.2.1.3 Emplacement of Soil Borings

Five soil borings were emplaced near suspected shallow contaminant sources to collect soil samples for chemical analyses (Figure 1.2). Two soil borings (A4H1 and A4H2) were installed near the settling ponds by using spun casing techniques (4.25-in.-O.D. steel casing). The rest of the borings (A1H1, A3H1, and A6H1) were installed by using 4.25-in.-I.D., 8.25-in.-O.D., hollow stem augers. Soil boring A1H1 was installed near the center of the removed waste oil tank, and soil boring A3H1 was installed in the vicinity of the World War II separator, both in the southeastern corner of the site. Soil boring A6H1 was installed in the center of the removed gasoline tank area located in the northeastern corner of the site. Soil borings A4H1 and A4H2 were installed at an angle of 30 degrees from vertical to a depth approximately 1 ft below the base of the settling ponds. The lengths of soil borings A4H1 and A4H2 were 18 and 19 ft, respectively. Soil boring A1H1 was augered to a depth of 18 ft, and soil borings A3H1 and A6H1 were both augered to a depth of 14 ft. The boreholes were abandoned by backfilling with a 10:90 mixture of bentonite and cement grout.

2.2.1.4 Hydraulic Aquifer Testing and Groundwater Level Monitoring

Hydraulic Testing. Aquifer slug tests were performed on January 12 and 13, 1992, to determine representative permeability values for the aquifers. The upper aquifer was tested by using the shallow wells, and the lower aquifer was tested by using the deep monitoring wells. An intermediate well (IW9), installed in the FGIC deposits, was tested to determine the permeability of the semiconfining layer. Seven deep wells, eight shallow wells, and one intermediate well were tested.

The slug tests were performed by creating an instantaneous water-level change within the wells and measuring the rate at which the displaced water level stabilized to pretest conditions. The rate of water level recovery is related to the hydraulic conductivity of the surrounding aquifer material.

Positive water-level displacement was accomplished by inserting a solid rod of 7/8-in.-diameter stainless steel (shallow wells) or 2.0-in.-square solid PVC bar (deep wells) with a known volume into the water column in the well and allowing the well to recover. Negative water-level displacement data were also recorded as the slug was removed from the water column. TELOG 2100-01 automatic water-level data recorders were installed in each well to record the change in head caused by insertion or removal of the slug over time. Each TELOG was equipped with a DRUCK 5-50 psi pressure transducer with an accuracy of ± 0.01 ft for all transducers (except for the 50 psi unit, which has an accuracy of ± 0.1 ft). Water-level response curves for all monitoring wells are provided in Appendix C.

In addition to the aquifer slug tests, three undisturbed shelly-tube samples were recovered from the FGIC deposits in DW5 and DW6 for laboratory falling-head permeability testing. Shelly-tube sample recovery for geotechnical analysis was attempted at various depths, but was generally only successful in the FGIC deposits. The glacial outwash and CGIC deposits were generally cohesionless and would not remain in the tube during recovery attempts.

Water Level Monitoring. The monitoring well network was designed (1) to characterize up-gradient (background) and down-gradient on-site water quality within both the upper and lower water-bearing zones of the Clinton Street-Ballpark Valley Aquifer and (2) to monitor and accommodate natural variations in groundwater movement and induced shifts in groundwater flow directions that may occur as a result of pumping at Johnson City's nearby municipal water supply wells and the plant's production well.

To define groundwater flow patterns for the site, water levels in monitoring well clusters 1, 4, 5, 8, and 9 were recorded by electronic data loggers for 12 days, beginning on January 16, 1992. A 72-h pump test was conducted during that time by using the GE deep production well for draw-down. Water-level data were recorded at approximately 3-min intervals for the 12-day period by using TELOG 2100-01 automatic water-level data recorders equipped

with a DRUCK 5-50 psi pressure transducer. Data were downloaded from the recording devices on January 28, 1992. Water-level response curves for all monitoring wells are presented in Appendix C.

2.2.1.5 Overview of Sampling Strategy and Methods

- Well-Borehole Soil Sampling Strategy and Methods

1. Strategy

The collection of a minimum of two soil samples per well cluster was specified in the ANL Work Plan. Provision was also made for the collection of additional discretionary samples. The unsaturated zone and the soil near the top of the water table would be sampled in each cluster location.

A case-by-case sampling scheme was used to exploit the fact that most of the proposed groundwater monitoring wells were to be placed in clusters of two or more. (As exceptions, one new well was to be placed alone, and two of the well clusters would consist of a new and an existing well.) It was assumed that the subsurface geology and contamination states would not vary significantly between the closely placed boreholes of a given cluster. The following sampling strategy was implemented:

- a. Clustered wells. Where two or more new wells were placed in a given cluster, the initial well would be drilled without chemical sampling of geologic strata. The information derived through the geological examination and the visual and instrumental monitoring for organic contamination in the first boring would be used to target sampling depths in a subsequent nearby boring. Since the field geologist preferred to characterize and geologically sample the deep boring first, sampling of strata for chemical analyses would typically be conducted on the shallow boring.
 - If no signs of contamination were noted in the first drilled well of a cluster, the uppermost chemical sample would be targeted at a depth of about one-half the distance between the ground surface and the top of the water table.
 - If signs of contamination were noted as a result of using the OVM at a single depth in the first bored hole, the uppermost mandatory sample would target that depth.
 - If signs of contamination were noted at more than one depth in the first bored hole, additional samples could be taken as discretionary samples.

- The above could be modified in the event that unexpected signs of contamination were noted in the sampling hole.
- b. Solitary wells. Where a single new well was to have been placed in a test area, continuous cores would be taken and monitored for signs of contamination.
- In the event that no signs of contamination were detected at first, a sample would be taken at a depth of about one-half the distance between the ground surface and the estimated top of the water table.
 - If signs of contamination were detected above said point, the nondiscretionary sample would be taken there.
 - Additional signs of contamination at lower depths could result in the collection of a discretionary sample.
- c. Clustered and Solitary wells. One sample would always be taken at the water table in each sampling hole.

2. Methods

All tools that contacted sample media were chemically clean. All borehole soil samples were recovered with decontaminated 2 × 24-in. or 4 × 24-in. split barrel samplers. The samplers were partially dismantled on a clean sheet of plastic and placed on a disposable stainless-steel pan. The soil at the tip of the sampler was scanned with an OVM. The top half of the barrel was then dislodged and held partially open while the length of the core sample was scanned.

- Test Borehole Soil-Sampling Strategy and Methods

Test boreholes to about the top of the water table were to be placed in accessible named-site locations. Through continuous split-spoon sampling and, minimally, visual and instrumental (OVM) scanning of cores for signs of contamination, at least one sample per boring would be selected for laboratory analysis. Sample selection could be aided by on-site screening analyses by means of a portable GC/MS. Sampling methods would be the same as those for well boreholes.

- Groundwater Sampling Strategy and Methods

1. Strategy

Well placement was based upon geophysical, hydrological, and chemical sampling concerns. Deep-aquifer and shallow-aquifer wells were planned, and provisions were made for the placement of intermediate-depth wells if warranted by the geological conditions encountered in specified areas. In regard to chemical sampling, monitoring wells along the AFP 59 perimeter were planned to help assess differences in groundwater quality as it enters and exits the property as a whole. Emphasis was on the western boundary, the side nearest to Johnson City wells. Several wells near the manufacturing building were also planned. One well cluster would be placed near the plating room to assess groundwater quality in the vicinity of Sites A2 and A4. A shallow well would be placed near the GE deep-production well, in part to assess the integrity of the barrier between aquifers in that critical area and in part to assess shallow aquifer groundwater quality in the site interior. The GE deep-production well would be sampled to provide data for the complete TCL and to provide a comparison with historical data.

Two rounds of groundwater sampling were planned. Round two sampling would be conducted in part for confirmatory purposes and in part to assess changes caused by groundwater perturbation during the pump test. A single set of samples would be collected from an unspecified off-site well to provide background data.

2. Methods

- a. Purge Procedures

- The water level was measured by using an electronic indicator, which was formally decontaminated between clusters, and the tip of which was rinsed between same-cluster wells.
- Water was removed with a Grundfoss ("Redi-flo") 2-in. stainless-steel submersible pump fitted with 0.5-in. schedule 40 PVC pipe. Five-foot pipe sections below the groundwater table were joined with stainless-steel couplings, except as noted in Appendix O. The topmost section was fitted with flexible, 5-in. food-grade PVC tubing.
- Purge water from wells that were not suspected of being significantly contaminated was recharged down-gradient in accordance with the QAPP. Purge water from wells suspected of being contaminated was transferred to drums for off-site disposal.

- Ancillary field measurements consisted of pH, conductivity, and temperature. These measurements were obtained with a "Check-Mate 90" Corning meter during Round One sampling. During Round Two sampling, the above parameters, as well as turbidity, were measured by using a single instrument (Horiba "Water Checker U-10").
- Water-level readings were taken before purging, at the end of purging, and five minutes after the end of purging.

b. Purge Schedule

- Initially, an attempt was made to purge to constancy of pH, conductivity, temperature, and clarity. This attempt was abandoned after the first well cluster (Cluster 1) had been sampled. Thereafter, a standardized duration of purge was adopted, and the degree of constancy was evidenced in the recorded purge data.
- Shallow wells were consistently purged for 15 min in order to have enough time to obtain a set of readings. At least four volumes of water were removed from all wells. Exceptions were as follows: (a) SW-1 was purged for 25 min, (b) SW-5 was purged to dryness in 5 min, and (c) SW-4 was purged only long enough to remove four well volumes rather than for 15 min.
- Shallow-well field measures were taken at 5, 10, and 15 min.
- Column values were calculated for each well, and a minimum of four volumes were removed from all wells, except DW-6, which went dry after one volume was recovered. Visual clarity, though not the target value of 50 NTU, was achieved in all wells, in most instances.

c. Sampling Procedures

- All deep wells (except DW-4) were sampled with the bottom of the bailer 7 ft above the bottom of the well. DW-4, an 85-ft-deep well, was sampled at its bottom. All shallow wells were sampled with the bottom of the bailer 2 ft above the bottom of the well, except SW-1, which was sampled 7 ft above bottom.
- Sampling commenced as soon as possible after purging. In most wells, the groundwater was clear at the conclusion of purging, and there was no need to let the column settle.

- With NYSDEC concurrence, VOA samples were taken first and samples for metals analysis second.
 - Water-level readings were taken when necessary to confirm the recovery of slow-yielding wells.
 - A decontaminated and dedicated Teflon™ bailer was attached to a Teflon™-coated stainless-steel cable and carefully lowered through the water column to a predetermined depth marked by a knot on the line.
 - The bailers were slowly recovered, and each sample was decanted from the top. The first few samplings were made by inserting a Teflon™ tube into the bottom of the bailer until the tube dislodged the ball valve and allowed sample to run through the tube. As described in the general field log, this method was abandoned because of problems with tube insertion (recovery from the top necessitated the placement of a gloved finger over the bottom hole). Some difficulty was also encountered with failure of the balls to seat properly.
 - Dedicated Teflon™ bailers were used. All equipment that contacted the well water was decontaminated by using a steam generator. Equipment was placed in a plastic-lined wooden box and steamed between wells. Equipment was transported from the decontamination area to the well sites wrapped in clean plastic.
- Creek Water and Sediment Sampling Strategy and Methods

1. Strategy

Choconut Creek nears the east and south sides of AFP 59. The plant and the stream are separated by a system of levees, flood gates, and flood walls. There is no suspicion that plant activities affect the stream where it passes east of the plant. Three AFP 59 outfalls empty into the portion of the stream that flows parallel to the southern plant boundary. Three sets of creek water and of creek sediment samples were collected to assess possible contamination in this portion of the stream:

- a. A location up-gradient from Johnson City, near the source of the stream, was sampled to represent regional background chemical values that were unaffected by industries and other potential contaminant sources in the Johnson City area.
- b. A point upstream from the AFP 59 outfalls, near the southeast corner of the plant boundary, was sampled to represent local background chemical values.

These samples should reflect contaminant contributions of Johnson City, but not those of AFP 59.

- c. A location near the southwest corner of AFP 59 and downstream from the plant outfalls was sampled to represent the stream as potentially affected by plant activities. To exclude cooling water from Goudey station, a location about 50 ft upstream from the location shown on planning maps (and apparently sampled during a previous study) was chosen.

2. Methods

- a. *Water* was containerized by submerging and directly filling sample bottles. Containers were positioned to minimize bubble formation during filling. Downstream samples were taken first, and care was taken to avoid disturbing bottom sediments upstream from the sampling points. Water was collected before sediment at each sampling location.
- b. *Sediment* was collected by submerging a stainless-steel beaker on the downstream side adjacent to the sampling point and digging and pulling streambed material into it with a stainless-steel scoop. The beaker was emptied into a compositing pan, and large rocks were removed. This process was repeated until sufficient sample for analysis was accumulated.

To minimize aeration and loss of fines, the holding pan was kept partially full of water and the beaker was emptied so that material slid, rather than fell, into the pan. VOA sample material did not contact air before it was spooned into the collection bottle. After the VOA sample was taken, smaller material was concentrated and isolated for collection and was field-homogenized by shaking the pan. Samples consisted primarily of sharp-grained coarse sand with some interstitial fine material.

Decontaminated sampling tools were used. Tools were additionally rinsed in the stream at the sampling points immediately before use. The use of a coring-type sediment sampler had originally been planned. That method of sample recovery, however, did not work in the rocky streambed.

- Outfall Sampling Strategy and Methods

Three outfalls empty into Choconut Creek as it flows along the southern border of AFP 59. These outfalls are periodically tested for selected analytes in accordance with the GE discharge permit. Sampling of all active outfalls for a full suite of TCL analytes was planned by ANL. Outfall 3 carries noncontact cooling water and is active primarily in the summertime. Outfalls 2 and 3 are active year-round. Each outfall

consists of a large iron pipe equipped with a 48-in.-diameter iron flap-gate. Outfalls 1 and 2 empty onto a raised concrete platform adjacent to the creek. Outfall 3 empties onto the ground and flows overland an unmeasured distance to the creek. Sampling of all active outfalls by direct containerization at the discharge point was planned.

- Hand-Auger Sampling for Analysis by Means of Field-Portable Equipment.

(See Section 2.2.4 for further details.)

1. Strategy

- a. *Screening.* Field-portable analytical equipment would aid in the selection of samples to be submitted for laboratory analysis.
- b. *Assessment.* Field analyses would be used to approximate the contaminant state of areas that were not scheduled for assessment through CLP analyses.

2. Methods

- a. *Screening.* Core material from named sites was selected with the aid of instrumental organic vapor monitoring and visual inspection and was then containerized for transfer to a laboratory. Subsamples were further screened with a portable GC/MS. Depending upon screening results, some samples were discarded, while some were retained and sent to a laboratory.
- b. *Assessment.* Hand-auger samples from specified locations were containerized and carried to the truck-mounted GC/MS, where subsamples were analyzed. The samples were then taken to a regional off-site ANL field location for analysis by x-ray fluorescence spectrophotometry. Chain-of-custody and sample preservation procedures were preserved during the transfer of samples.

2.2.1.6 Description of Sampling for Laboratory Analyses

This section summarizes all sampling activities related to samples submitted for laboratory analysis. The samples collected at AFP 59 during this investigation and sent to Galson Laboratories for analysis are summarized and listed according to shipment number in Table 2.1. A sample listing categorized by origin, type, and matrix is presented in Table 2.2. The total numbers of the various kinds of samples collected are listed in Table 2.3.

TABLE 2.1 AFP 59 Sample Shipment Summary

Ship- ment No.	Sample ID	Type ^a	Matrix ^b	Description/ Location	Feet (below surface)	Collection Log Date and Time
Soil, Sediment, and Surface Water Sampling						
1	JCSW8AS	N	S	SW-8	7-9	4 Nov 91 1710
	JCSW8BS	N	S	SW-8	14-16	4 Nov 91 1715
	Trip # 1	Q	W	Trip blank		5 Nov 91 0800
					Begin	5 Nov 91 0800
					End	5 Nov 91 1018
2	JCDW3AS	N	S	DW-3	8-10	5 Nov 91 1315
	JCDW3BS	N	S	DW-3	24-28	5 Nov 91 1630
	JCQC1TW	Q	W	Hand tool rinse		6 Nov 91 1415
	JCQC2BW	Q	W	Split spoon rinse		6 Nov 91 1445
	Trip # 2	Q	W	Trip blank		7 Nov 91 0815
					Begin	7 Nov 91 0815
					End	7 Nov 91 1011
3	JCQC3XW	Q	W	Bailer rinse		7 Nov 91 1500
	Trip # 3	Q	W	Trip blank		7 Nov 91 1630
					Begin	7 Nov 91 1630
					End	8 Nov 91 1200
4	JCSW6AS	N	S	SW-6	8-10.5	16 Nov 91 1430
	JCSW6BS	N	S	SW-6	18-20	16 Nov 91 1530
	JCCW2AW	N	W	CW-2	c	17 Nov 91 1400
	JCSD2AS	N	S	SD-2	c	17 Nov 91 1430
	JCCW1AW	N	W	CW-1	c	17 Nov 91 1530
	JCSD1AS	N	S	SD-1	c	17 Nov 91 1600
	Trip # 4	Q	W	Trip blank		18 Nov 91 1000
					Begin	18 Nov 91 1000
					End	18 Nov 91 1145
5	JCCNCAW	N	W	Off-site creek	c	18 Nov 91 1315
	Trip # 5	Q	W	Trip blank		18 Nov 91 1715
					Begin	18 Nov 91 1715
					End	19 Nov 91 1021
6	JCSW5AS	N	S	SW-5	10-12	20 Nov 91 1710
	JCSW5BS	N	S	SW-5	23-27	20 Nov 91 0830
	JCSW5BS-M	Q	S	Field split (MS/MSD)		20 Nov 91 0830
	JCCNSCS	N	S	Off-site creek	c	20 Nov 91 1630
	JCDW1AS	N	S	DW-1	8-10	21 Nov 91 0840
	JCDW1BS	Q	S	Blind split JCDW1AS		21 Nov 91 0850
	JCDW1CS	N	S	DW-1	18-20	21 Nov 91 0945
	Trip # 6	Q	W	Trip blank		21 Nov 91 1500
					Begin	21 Nov 91 1500
					End	21 Nov 91 1705

TABLE 2.1 (Cont.)

Ship- ment No.	Sample ID	Type ^a	Matrix ^b	Description/ Location	Feet (below surface)	Collection Log Date and Time
7	JCOF1AW	N	W	Outfall 001	c	23 Nov 91 0730
	JCOF2AW	N	W	Outfall 002	c	23 Nov 91 0830
	JCOF2AW-M	Q	W	Duplicate (MS/MSD)		23 Nov 91 0840
	Trip # 7	Q	W	Trip blank		23 Nov 91 1000
					Begin	23 Nov 91 1000
					End	23 Nov 91 1180
8	JCSW4AS	N	S	SW-4	6-8	26 Nov 91 0815
	JCSW4BS	N	S	SW-4	15.2- 17.2	26 Nov 91 0845
	JCSW4CS	Q	S	Blind split JCSW4BS		26 Nov 91 0900
	Trip # 8	Q	W	Trip blank		26 Nov 91 1300
					Begin	26 Nov 91 1300
					End	26 Nov 91 1535
9	JC4H1AS	N	S	Site A4 hole 1	13-15.6	03 Dec 91 1155
	JC4H2AS	N	S	Site A4 hole 2	13-16.5	03 Dec 91 1630
	Trip # 9	Q	W	Trip blank		03 Dec 91 1830
					Begin	03 Dec 91 1830
					End	04 Dec 91 1048
10	JC1H1AS	N	S	Site A1 hole 1	8-10	04 Dec 91 0490
	JC1H1CS	N	S	Site A1 hole 1	12-14	04 Dec 91 1000
	JC3H1AS	N	S	Site A3 hole 1	10-14	04 Dec 91 1225
	JC6H1AS	N	S	Site A6 hole 1	10-14	04 Dec 91 1600
	Trip # 10	Q	W	Trip blank		04 Dec 91 1745
					Begin	04 Dec 91 1745
11	JCSW7AS	N	S	SW-7	7-9	06 Dec 91 0745
	JCSW7BS	N	S	SW-7	14-18	06 Dec 91 0800
	JCBG1AS	Q	S	Background SW corner	0.8-1.8	06 Dec 91 1100
	Trip blank	Q	W	Trip blank		06 Dec 91 1430
					Begin	06 Dec 91 1430
					End	07 Dec 91 1102
12	JCBG2AW ^d	Q	W	JC municipal well No. 7		09 Dec 91 1500
	JCSW9AS	N	S	SW-9	6-10	10 Dec 91 0740
	JCSW9BS	N	S	SW-9	12-16	10 Dec 91 0815
	JCSW9BS-M	Q	S	Duplicate (MS/MSD)		10 Dec 91 0815
	Trip # 12	Q	W	Trip blank		10 Dec 91 1230
					Begin	10 Dec 91 1230
					End	10 Dec 91 1530

TABLE 2.1 (Cont.)

Ship- ment No.	Sample ID	Type ^a	Matrix ^b	Description/ Location	Feet (below surface)	Collection Log Date and Time
Round One Groundwater Sampling						
13	JCDW1AW	N	W	DW-1		05 Jan 92 0142
	JCSW1AW	N	W	SW-1		05 Jan 92 1215
	JCDW5AW	N	W	DW-5		05 Jan 92 1700
	JCSW5AW	N	W	SW-5		05 Jan 92 1800
	JCDW6AW	N	W	DW-6		06 Jan 92 1418
	JCSW6AW	N	W	SW-6		06 Jan 92 1500
	Trip # 13	Q	W	Trip blank		06 Jan 92 1655
					Begin	06 Jan 92 1655
					End	06 Jan 92 1915
14	JCBG2BW	N	W	JC municipal well No. 7		07 Jan 92 0900
	JCDW3AW	N	W	DW-3		07 Jan 92 1100
	JCSW3AW	N	W	SW-3		07 Jan 92 1201
	JCDW9AW	N	W	DW-9		07 Jan 92 1650
	JCSW9AW	N	W	SW-9		07 Jan 92 1727
	JCDW4AW	N	W	DW-4		08 Jan 92 1505
	JCDW4AW-M	Q	W	Duplicate (MS/MSD)		08 Jan 92 1505
	JCSW4AW	N	W	SW-4		08 Jan 92 1625
	JCSW7AW	N	W	SW-7		08 Jan 92 1710
	Trip # 14	Q	W	Trip blank		08 Jan 92 1845
					Begin	08 Jan 92 1845
					End	08 Jan 92 2100
15	JCDW8AW	N	W	DW-8		09 Jan 92 1353
	JCDW8RW	N	W	Blind split of JCDW8AW		09 Jan 92 1430
	JCSW8AW	N	W	SW-8		09 Jan 92 1510
	JCDPWA	N	W	DPW (GE deep production well)		09 Jan 92 1551
	Trip # 15	Q	W	Trip blank		10 Jan 92 0950
					Begin	10 Jan 92 0950
					End	10 Jan 92 1225

TABLE 2.1 (Cont.)

Ship- ment No.	Sample ID	Type ^a	Matrix ^b	Description/ Location	Feet (below surface)	Collection Log Date and Time
Round Two Groundwater Sampling						
16	JCDW4BW	N	W	DW-4		29 Jan 92 1540
	JCDW4BW-M	Q	W	Duplicate (MS/MSD)		29 Jan 92 1540
	JCSW4BW	N	W	SW-4		29 Jan 92 1640
	JCSW7BW	N	W	SW-7		30 Jan 92 1050
	JCDW8BW	N	W	DW-8		30 Jan 92 1450
	JCSW8BW	N	W	SW-8		30 Jan 92 1535
	JCQC4WW	Q	W	ASTM II water sample		30 Jan 92 1755
	JCQC5XW	Q	W	Rinse of unused bailer		30 Jan 92 1810
	Trip # 16	Q	W	Trip blank		30 Jan 92 1830
					Begin	30 Jan 92 1860
					End	30 Jan 92 2020
17	JCDW5BW	N	W	DW-4		31 Jan 92 1100
	JCSW5BW	N	W	SW-5		31 Jan 92 1140
	JC2L1AS	N	S	Site A2 (plating building)		31 Jan 92 1700
	JCDW6BW	N	W	DW-6		01 Feb 92 1230
	JCSW6BW	N	W	SW-6		01 Feb 92 1305
	JCDW1BW	N	W	DW-1		01 Feb 92 1440
	JCSW1BW	N	W	SW-1		01 Feb 92 1521
	Trip # 17	Q	W	Trip blank		01 Feb 92 1715
					Begin	01 Feb 92 1715
					End	01 Feb 92 1920
18	JCDW3BW	N	W	DW-3		02 Feb 92 1110
	JCDW3RW	Q	W	(Blind split of JCDW3BW)		02 Feb 92 1120
	JCSW3BW	N	W	SW-3		02 Feb 92 1215
	JCDW9BW	N	W	DW-9		03 Feb 92 1045
	JCSW9BW	N	W	SW-9		03 Feb 92 1118
	JCDPW9BW	N	W	DPW		03 Feb 92 1215
	Trip # 18	Q	W	Trip blank		03 Feb 92 1500
					Begin	03 Feb 92 1800
					End	03 Feb 92 1850

^a N = normal environmental sample; B = background sample; Q = QA/QC sample.

^b S = soil/sediment; W = water.

^c Surface.

^d Sample negated by laboratory error.

TABLE 2.2 Categorical Sample List^a

Location	Sample ID	Comments	Shipment No.
Well Borehole Soil Samples			
DW-1	JCDW1AS, JCDW1BS, JCDW1CS		6
SW-1		Previously existing well. No soil samples.	
DW-2		Designation not used.	
SW-2		Previously existing well. No soil samples.	
DW-3	JCDW3AS, JCDW3BS		2
SW-3		Previously existing well. No soil samples.	
DW-4		No soil samples taken.	
SW-4	JCSW4AS, JCSW4BS, JCSW4CS		8
DW-5		No soil samples taken.	
SW-5	JCSW5AS, JCSW5BS, JCSW5BS-M		6
DW-6		No soil samples taken.	
SW-6	JCSW6AS, JCSW6BS,		4
DW-7		Designation not used.	
SW-7	JCSW7AS, JCSW7BS		11
DW-8		No soil samples taken.	
SW-8	JCSW8AS, JCSW8BS		1
DW-9		No soil samples taken.	
IW-9		Unsampled intermediate-depth geological hole.	
SW-9	JCSW9AS, JCSW9BS, JCSW9BS-M		12
Groundwater Samples			
DW-1	JCDW1AW		13
	JCDW1BW		17
SW-1	JCSW1AW		13
	JCSW1BW		17
DW-2		Designation not used.	
SW-2		Unsampled, existing damaged well.	
DW-3	JCDW3AW		14
	JCDW3BW		18
SW-3	JCSW3AW		14
	JCSW3BW, JCDW3RW		18
DW-4	JCDW4AW, JCDW4AW-M		14
	JCDW4BW, JCDW4BW-M		16

TABLE 2.2 (Cont.)

Location	Sample ID	Comments	Shipment No.
Groundwater Samples (Cont.)			
SW-4	JCSW4AW		14
	JCSW4BW		16
DW-5	JCDW5AW		13
	JCDW5BW		17
SW-5	JCSW5AW		13
	JCSW5BW		17
DW-6	JCDW6AW		13
	JCDW6BW		17
SW-6	JCSW6AW		13
	JCSW6BW		17
DW-7		Designation not used.	
SW-7	JCSW7AW		14
	JCSW7BW		16
DW-8	JCDW8AW, JCDW8RW		15
	JCDW8BW		16
SW-8	JCSW8AW		15
	JCSW8BW		16
DW-9	JCDW9AW		14
	JCDW9BW		18
IW-9		Unsampled intermediate-depth observation well.	
SW-9	JCSW9AW		14
	JCSW9BW		18
DPW	JCDPWA		15
	JCDPWB		18
Outfall Samples ^b			
OF-1	JCOF1AW		7
OF-2	JCOF2AW, JCOF2AW-M		7
OF-3		No laboratory sample was taken.	
Creek Sediment Samples			
CWS-1 ^c	JCSD1AS		4
SD-2 ^d	JCSD2AS		4
Creek Water Samples ^e			
CWS-1 ^f	JCCW1AW	Local stream background	4
CWS-2 ^g	JCCW2AW	Stream below outfalls	4

TABLE 2.2 (Cont.)

Location	Sample ID	Comments	Shipment No.
Named-Site Test Bore and Hand Soil Samples			
Site A-1	JC1H1AS, JC1H1CS	Borehole	10
Site A-2	JC2L1AS	Hand sample	17
Site A-3	JC3H1AS	Borehole	10
Site A-4	JC4H1AS	Hole 1 borehole	9
	JC4H2AS	Hole 2 borehole	9
Site A-5		No lab sample	
Site A-6	JC6H1AS	Borehole	10
QA/QC Samples			
Background Samples			
Soil (on-site)	JCBG1AS		11
Sediment (off-site Choconut Creek)	JCCNCAW		5
Surface Water (off-site Choconut Creek)	JCCNSCS		6
Groundwater (JC municipal well No. 7)	JCBG2AW		7
Equipment Rinsates			
Hand Tools	JCQC1TW		2
Split Spoon	JCQC2BW		2
Bailer	JCQC3XW		3
Bailer	JCQC5XW		16
Special Water	JCQC4WW		16
Field replicate for lab MS/MSD			
	JCSW5BS-M	Split of JCSW5BS	
	JCSW9BS-M	Split of JCSW9AS	
	JCDW4AW-M	Split of JCDW4AW	
	JCOF2AW-M	Split of JCOF2AW	
	JCDW4BW-M	Split of JCDW4BW	
Field replicate: blind			
	JCDW1BS	Split of JCDW1AS	
	JCSW4CS	Split of JCSW4BS	
	JCDW8RW	Split of JCDW8AW	
	JCDW3RW	Split of JCDW3BW	

TABLE 2.2 (Cont.)

Location	Sample ID	Comments	Shipment No.
Trip Blanks			
	Trip 1		1
	Trip 2		2
	Trip 3		3
	Trip 4		4
	Trip 5		5
	Trip 6		6
	Trip 7		7
	Trip 8		8
	Trip 9		9
	Trip 10		10
	Trip 11		11
	Trip 12		12
	Trip 13		13
	Trip 14		14
	Trip 15		15
	Trip 16		16
	Trip 17		17
	Trip 18		18

^a Field replicates are listed by location (in italics) and again by type (under QA/QC). Samples may be cross-referenced by shipment number to Table 2.1.

^b Outfall water was considered surface water for QA/QC purposes.

^c Originally identified as SD-1.

^d Originally identified as SD-2.

^e Stream is near, but not within, AFP 59 boundaries.

^f Originally identified as CW-1.

^g Originally identified as CW-2.

TABLE 2.3 Total Number of Samples Collected at AFP 59 by Matrix and Type^a

Sample Type	Number of Samples Collected
Soil/Sediment	
Well boreholes	15
Test bores	5
(VOC only)	(1) ^b
Hand sample	1
MS/MSD replicates	2
Blind replicates	2
Soil background	1
Creek sediment	2
Creek sediment background	1
	Full suite ^c 29
	VOC only 1
Water	
Groundwater (G.W.)	32
G.W. MS/MSD replicate	2
G.W. blind replicate	2
G.W. background	1
Surface water, creek	2
Surface water, background	1
Surface water, outfall	2
Surface water, MS/MSD replicate	1
Rinsate, equipment	3
Rinsate, equipment	1 ^b
Special water	1 ^b
Trip blank ^d	18
	Full suite ^c 46
	VOC only 2
	Method 524.2 VOC 18
Total full suite^c samples	75

^a NYS DEC ASP, except as noted.

^b VOC (volatile organic compounds) only.

^c Full suite: samples were submitted for analyses for (1) PCBs and pesticides, (2) inorganic compounds, and (3) volatile and semivolatile organic compounds.

^d Method 524.2 VOC.

Soil samples obtained during the monitoring well installation were collected from the shallow wells for each well cluster location. During the monitoring well installation phase of the study, the deep monitoring wells served as pilot holes to direct chemical sampling in the adjacent shallow wells. For clusters 1 and 3, the samples were obtained from DW1 and DW3, because no shallow monitoring wells were emplaced in these locations during the installation phase of the study. Soil samples from the monitoring well boreholes were collected by using either 2- or 3-in. decontaminated split-spoon samplers from a depth corresponding to approximately one-half the distance to the water table and from the water-table surface.

To determine the vertical and horizontal extent of groundwater contamination on the AFP 59 site, groundwater samples were obtained from the monitoring well clusters. After measuring water levels in the clusters, each well was purged of approximately four well volumes by using a 2-in. Grundfos submersible pump. Following purging, the monitoring wells were allowed to recover to their prepurged levels. After recovery, a groundwater sample was collected from the well by using a dedicated Teflon™ bailer. The bailer was lowered to the desired depth with Teflon™-coated stainless-steel wire attached to a PVC reel.

- Well Borehole Soil Sampling

Cluster 1 consists of an existing shallow well (SW-1) and a new deep well (DW-1). Sampling target depths were based upon SW-1 1986 drilling records. If no evidence of contamination was found, samples would be taken at 8–10 and 18–20 ft. The water table was expected at 20 ft.

Sampling was conducted on November 21, 1991. Two-inch spoons were driven continuously, observed, and scanned with an OVM. No evidence of contamination was detected. Three-inch spoons driven at the target depths produced adequate sample. Sample JCDW1AS and split sample JCDW1BS were taken from the 8- to 10-ft core. JCDW1CS was taken from the 18- to 20-ft core. (See also Appendix O.)

Cluster 3 consists of an existing shallow well (SW-3) and a new deep well (DW-3). Sampling target depths were based upon SW-3 1986 drilling records. If no evidence of contamination was encountered, samples would be taken from 8–10 and 18–20 ft below ground surface. The top of the water table was at 22.5 ft.

Sampling was conducted on November 5, 1991. Two-inch spoons were driven continuously, observed, and scanned with an OVM. No evidence of contamination was detected. Two adjacently driven three-inch cores from 8 to 10 ft were combined to create sample JCDW3AS. Because of recovery problems at target depth, sample JCDW3BS was taken at 24–28 ft. (See also Appendix O.)

Cluster 4 consists of a new shallow well (SW-4) and a new deep well (DW-4). Continuous observation spoons were driven at DW-4. No evidence of contamination was noted. Target sampling depths for SW-4 were based upon DW-4 observations. The top of the capillary fringe coinciding with the interface of a lower clay and upper gravel stratum at roughly 13 ft below surface and a point about half the distance between the interface and ground surface were targeted for sampling. The top of the water table was at 18 ft.

Sampling was conducted on November 26, 1991. Sample JCSW4AS was taken from 6–8 ft below surface with a 3-in. spoon. No odor or discoloration was noted. Sample JCSW4BS was taken from 15.2 to 17.2 ft. Sample JCSW4CS was a split of JCSW4BS. This sampling contained several irregularities, as detailed in Appendix O.

Cluster 5 consists of a new deep well (DW-5) and a new shallow well (SW-5). Continuous 2-in. observation spoons were driven at DW-5. No evidence of contamination was noted. Target sampling depths for SW-5 were set at 10–12 ft and 23–25 ft below surface.

Sampling was conducted on November 20, 1991. Sample JCSW5AS was collected from a single core from 10–12 ft below surface. Sample JCSW5BS and laboratory MS/MSD split sample JCSW5BS-M were taken from a composite of two cores from 23–27 ft below surface. Possible low-level OVM detections were taken into consideration during sampling. Two cores (from 23–25 ft and 25–27 ft below surface) contributed unequally to the sample. Further detail is provided in Appendix O.

Cluster 6 consists of a new deep well (DW-6) and a new shallow well (SW-6). No evidence of contamination was noted during the drilling of DW-6. The top of the DW-6 water table was 20 ft below surface. Depths of 8–10 ft and 18–20 ft below surface were targeted for sampling in SW-6.

Sampling was conducted on November 16, 1991. Two-inch inspection spoons were taken at 3–5 ft, 11–13 ft, and 15–17 ft in SW-6 for confirmatory geological purposes and confirmatory contamination scans (OVM/odor/visual). There were no signs of contamination. A two-inch spoon was mistakenly used at 8 ft and gave inadequate recovery. A second (3-in.) spoon was therefore driven adjacent to the first and was pushed to 10.5 ft. Sample JCSW6AS was taken from a composite of the two-inch and three-inch cores (8–10.5 ft below surface). Sample JCSW6BS was taken from a core from 18–20 ft below surface. (See also Appendix O.)

Cluster 7 consists of a new shallow well (SW-7) that was placed near the deep production well. A planned intermediate depth well was attempted, but the

geology at that location proved such that an intermediate-depth well would not have been useful. No evidence of contamination was detected during the drilling of the intermediate well. Depths of 7–9 ft (immediately below fill) and 14–16 ft (immediately above water table) were targeted for sampling in SW-6.

Sampling was conducted on December 6, 1991. Sample JCSW7AS was collected from a core taken at 7–9 ft below surface. Because of recovery problems, it was necessary to deviate from standard collection procedures. Because of poor recovery, two successive cores (14–16 ft and 16–18 ft below surface) were composited in the preparation of sample JCSW7BS. Further irregularities are noted in Appendix O.

Cluster 8 consists of a new deep well (DW-8) and a new shallow well (SW-8). The wells were placed about 5 ft apart. No instrumental or observable indications of contamination were noted during the boring of the deep well. The top of the water table was at about 14 ft.

Sampling was conducted on November 4, 1991. Sample JCSW8AS was collected from a 2-in. core recovered from 7 to 9 ft below surface. Unnatural dark staining and odor were observed, but OVM readings on the open core remained within background range. The soil beneath the sampling point and continuing to about 13 ft displayed the same evidence of contamination, but with a stronger odor. A brief OVM response of about 3 ppm above background was reported at the head of the borehole at an unrecorded depth within this range. It was decided that JCSW8AS was qualitatively representative of the contamination, though probably less concentrated than at some point below. Sample JCSW8BS was collected from a composite of a 2-in. and a 3-in. core recovered from 14 to 16 ft below surface. No evidence of contamination was noted.

Cluster 9 consists of a deep well (DW-9), an intermediate well (IW-9), and a shallow well (SW-9). SW-9 target depths of 6–8 ft and 12–14 ft were based upon DW-9 data. No evidence of contamination had been observed.

Sampling was conducted on December 10, 1991. Because of poor recovery, sample JCSW9AS was collected from a composite of two cores recovered from 6–8 ft and 8–10 ft below surface. Because of the need to collect enough sample for a duplicate, JCSW9BS and JCSW9BS-M were collected from a composite of two cores recovered from 12–14 ft and 14–16 ft below surface.

- Named-Site Borehole-Soil Sampling for Laboratory Analysis

SITE A-1: On December 4, 1991, a vertical bore was placed in the graveled area from which underground waste oil tanks had been removed. Continuous geological cores were examined. Two 3-in. cores were taken from beneath replacement fill at 8–10 ft. Recovered material exhibited a slight odor and an open-air OVM reading of 2.1 ppm above background. A GC screen confirmed the presence of contaminants. Recovery was so poor that all of the usable material in both cores was used to prepare the single 120-mL VOA sample that comprised sample JC1H1AS

Recovery was also poor in the succeeding 10–12 ft core, but good in a core from 12–14 ft. Both cores contained oily, strongly odorous material, but a GC scan indicated differences between this and Sample A material. Initially, a VOA sample (B) was taken from the 10–12 ft core and a separate set (C) from the 12–14 ft core. Sample B was subsequently discarded, as both cores represented the same geological stratum and the same contamination zone. The lowest core gave the highest OVM reading. A peak open-air reading of 30 ppm was obtained from the lower core, and a reading of 3.4 ppm was obtained from the upper core.

SITE A-2: On January 31, 1992, a soil sample was taken from beneath the porch of the plating building. This, according to GE employees, is the location where a water pipe had once broken; during the repair of the pipe, personnel had noted evidence of possible soil contamination by plating solutions. The space houses a riser and other piping that is protected against freezing by a wall-mounted electric heater. An ANL GC screen of sample HA-17 from this location had indicated the presence of polyaromatic hydrocarbons.

Laboratory analysis sample JC2L1AS was taken by enlarging the HA17 auger hole with a stainless-steel spoon. The sampling point was adjacent to buried concrete work associated with the porch. The soil was a mix of brown and red-brown sand and did not appear to have been a natural stratum. Sample material was placed directly into containers without field homogenization. Sample JC2L1AS was submitted as a stand-alone sample.

A cavity was noted beneath some concrete work in the general sampling area beneath the porch. The underside of the concrete showed a black oily substance, perhaps asphalt sealer, that had dripped onto the soil and loose aggregate below. This substance might be related to the hydrocarbons in HA-17.

SITE A-3: On December 4, 1991, a vertical bore was placed several feet east of the exposed concrete hatch of the abandoned WWII oil water separator. A transition from clay, which appeared "clean," to gravel and sand strata, which smelled and looked to have been contaminated with hydrocarbons, began near 10 ft below surface. A total of about 12 in. of material was recovered in two successive cores (10–12 ft and 12–14 ft). These cores were combined and composited to create sample JC3H1AS.

SITE A-4: On December 3, 1991, two holes were drilled, with spin casing, at a 60 degree angle beneath the west edge of the two adjacent "retention ponds," near the plating building. The pond bottoms are nine feet below surface. The top entry location of each hole was within two feet of the top entry location of two similarly angled non-ANL abandoned test bores. Continuous 2-in. geological core samples were taken, inspected, and screened for volatile organics on a Brucker portable GC. No unusual odors, discolorations, or significant GC results were noted.

Hole number one was drilled beneath the pond farthest from the building.

A single core, driven from 15 to 18 down-hole diagonal feet, provided brown, coarse sand for sample JC4H1AS. The calculated sampling depth below ground surface of the pond area was 13–15.6 ft, roughly 5 ft beneath the bottom of the tank.

Hole number two was drilled beneath the pond nearest the building. Because of recovery problems, three successive split spoon samplers were driven between 15 and 19 down-hole diagonal feet in order to obtain enough material for sample JC4H2AS. The calculated sampling depth below ground surface of the pond area was 13–16.5 ft, roughly 5 ft beneath the bottom of the tank.

SITE A-6: On December 4, 1991, a vertical bore was placed in a paved area from which underground gasoline tanks had previously been removed. Two-inch spoons were driven continuously for geological inspection. Three-inch spoons were used for collecting laboratory samples. No evidence of contamination was noted. Two separate spoons, containing a total of 12 in. of material from between 10 and 14 ft below surface, were composited to obtain JC6H1AS. The bottom of the former UST was an estimated 8 ft below surface. The water table at this site was predicted at about 18 ft.

- Groundwater Sampling

Two separate rounds of samples were collected from 13 new and 2 preexisting AFP 59 monitoring wells and from the GE deep production well. A single set

of background samples was collected from Johnson City Well No. 7, which is up-gradient from AFP 59. Round One sampling commenced January 5, 1992, and ended January 9, 1992. Round Two sampling was conducted, following slug and pump testing, between January 29 and February 3, 1992. The method used between wells and between samplings was consistent.

- Creek Water and Sediment Sampling

Water and sediment samples from the two Choconut Creek sampling locations near AFP 59 were made on November 17, 1991. A third set of samples was taken from the upper reaches of the same stream on November 20, 1991.

1. Near-Site Stream Sampling

One set each of water (JCCW1AW) and sediment (JCSD1AS) samples was collected at a midstream location above the outfalls near the southeast corner of the plant. A water sample (JCW2AW) was collected midstream, and a sediment sample (JCSD2AS) was collected near steam's-edge, downstream from the outfalls near the southwest corner of the plant. The water temperature was 2°C, and the air temperature was 5°C.

The sampling location designations that were used in planning and field documents, and that were incorporated into the sample identification numbers, were changed for IRPIMS-entry, final mapping, and final reporting. This step was taken because the same designators had been used for nearby but different locations during previous studies and had already been entered into the IRPIMS system. The following changes were made:

- a. The name of the up-gradient water sampling point near the southeast corner of the site was changed from CW-1 to CWS-1.
- b. The name of the up-gradient sediment sampling point near the southeast corner of the site was changed from SD-1 to CSS-1.
- c. The name of the down-gradient water sampling point near the southwest corner of the site was changed from CW-2 to CWS-2.
- d. The name of the down-gradient sediment sampling point near the southwest corner of the site was changed from SD-2 to CSD-2.

2. Regional Background Stream Sampling

A point on Choconut Creek, upstream from potential Johnson City contaminant sources, was chosen. The site selected was a point near the source of a branch of Little Choconut Creek where the stream passes beneath Chenango road. The stream to the north of the road was about 6 ft wide, rocky bottomed, 3–4 in. deep, and swiftly moving. It passed beneath the road through a large steel culvert and dropped 2 ft into a pooled area. Although the accumulation of fine sediments was greater in the pooled area south of the road, samples were collected about 20 ft north of the culvert, because conditions more closely approximated those encountered near AFP 59. Since the water was too shallow for easy sampling by submersion on the north side, water was sampled at the point where it exited the culvert.

Both water samples (JCCNCAW) and sediment samples were taken on November 18, 1991. One of the sediment samples was broken during shipment. A new set of sediment samples (JCCNCCS) was therefore collected on November 20, 1991. Water temperature was an estimated 2°C and air temperature an estimated 5°C on November 18. The measured water temperature was 9°C, and the measured air temperature was 16°C.

- Outfall Water Sampling

Water from Outfalls 001 and 002 was sampled on November 23, 1991, by direct-filling of sampling containers. No water sample was taken from Outfall 003 because of an absence of flow during the period of field activities. A soil sample for MEM analysis, as described in the MEM section, was instead taken near Outfall 003.

The Johnson City area experienced about 48 h of rain, which ended about 8 h before sampling. The stream appeared to have crested during the night. Water was milky brown and flowing bank to bank, but not overflowing the low bank of the main channel. The stream surface was 2 in. below the concrete pad associated with Outfall 001 and was flowing over the concrete pad associated with Outfall 002. While these conditions complicated sampling, the opportunity was present to sample a purged system.

OUTFALL #001: Sample JCOF1AS was collected at Outfall 001. The following temperatures were recorded at the time of sampling: air = 9°C, stream = 8.8°C, and outfall discharge = 16°C. The elevated discharge temperature indicates that at least part of the flow originated as something other than the anticipated parking lot runoff.

OUTFALL #002: Samples JCOF2AW and JCOF2AW-M, a lab QC sample, were collected at Outfall 002. The following temperatures were recorded at the time of sampling: air = 9°C, stream = 8.8°C, and outflow discharge = 10.8°C.

- Hand- and Power-Augered Soil Sampling for Analysis by Means of Portable Analytical Equipment.

Portable gas chromatograph/mass spectrometer (GC/MS) equipment was used to screen for volatile, semivolatile, and PCB/pesticide compounds. A Spectrace 6000 X-ray fluorescence unit was used to screen for metals.

Eighteen hand-driven, three-inch, bucket auger samples were taken from two to six feet below surface. Soil beneath asphalt was accessed by chiseling at most locations, after which the holes were plugged with cement. One sample was taken from beneath the porch of the plating room, six samples were taken from beneath the JP-4 lines (Figure 1.2), eight samples were taken from beneath the asphalt ditch adjacent to the rear parking lot, one sample was taken from the center of the rear parking lot, one sample was taken from near Outfall 3, and one sample was taken at the southeast corner of the GE building. One sample was taken from each of these locations for on-site analysis. Portable equipment was additionally used in a screening capacity at several named sites to help choose sampling points for laboratory analysis samples.

2.2.1.7 Record Keeping

Except as noted, field activities were recorded in thread- or spiral-bound notebooks containing consecutively prenumbered pages. Upon completion of field work, all logs were filed, along with other project records, in the Project Manager's office at ANL. The field logs used at AFP 59 were as follows:

Log Title	Field Custodian	Description
General Field Log A	Joe Hau	Contains general field activities and information from the perspective of the field geologist.
General Field Log B	Barney Nashold	Contains general field activities and information from the perspective of the field supervisor.
Sample Log A	Sampling Team	Contains details concerning individual borehole soil/sediment, surface soil/sediment, surface water, and QA/QC samplings.
Sample Log B	Barney Nashold	Contains details affecting sample QA/QC generally.
Sample Log C	Sampling Team	Contains details concerning individual groundwater samples.
Sample Shipment Records	Sampling Team	Loose file of carbon copies of chain-of-custody forms.
Boring Log	Joe Hau	Consists of a file of logs on unbound, pre-printed forms.
Well Development Log	Joe Hau	Consists of a file of logs on unbound, pre-printed forms.
Waste Drum Log	Laura Giblin	Contains use-histories of all waste drums employed during the project. A typed summary of all drums and their final contents, as made available to the waste-hauling firm that removed the drums, have been filed with the logbook.
Instrumentation Calibration Log	Field Team	
Diary	Harrison, Hau, Nashold	Contains decisions and agreements pertinent to field operations.
Bruker MEM and Spectrace 6000 Log	MEM/Spectrace Team	

2.2.1.8 Sample Preservation

All samples were placed in a cooler immediately upon collection. In warmer weather, field coolers containing "blue ice" were used to maintain temperatures at about 4°C. During cold weather, coolers without ice were used to prevent freezing. Field samples were transferred as soon as possible to a dedicated refrigerator maintained at about 4°C.

Prepared containers containing chemical preservatives were provided by Galson Laboratories. Water samples for metals analyses were preserved with nitric acid. Water samples for cyanide analyses were preserved with sodium hydroxide.

2.2.1.9 Identity of Field Team Members and Subcontractors

Supervisory Team

Barney Nashold (ANL)
Larry Reed (ANL)
Joe Hau (Hydro-Terra)
Randy Shaeffer (Marcor)

Field Operations Supervisor
On-Site Chemistry Supervisor
Geohydrologist
Drilling Supervisor

Sampling Team

Barney Nashold (ANL)
Laura Giblin (ANL)
Joe Hau (Hydro-Terra)

Drilling Team (Marcor)

(Average crew size = 3)

R. Sheffer (Chief Driller)
D. Bucher
B. Carey
D. Moore
B. Bystrak
D. Guida
K. Marcellas

On-Site Analytical Chemistry Team

L. Reed (ANL)
 D. Schug (ANL)
 L. Shephard (ANL)
 W. Harrison (ANL)
 Paul Kowalaski (Brucker Instruments)

Off-Site Support Personnel

R. Utesch (ANL)	Health and Safety Officer
J. Kelley (ANL)	QA Director
D. Wait (Gradient Corp.)	QA Officer

On-Site Subcontractors:

<u>Firm</u>	<u>Service</u>	<u>Contract Representative</u>
Hydro-Terra, Inc. 5513 Twin Knolls Road Columbia, MD 21045 (301) 596-3160	Hydrogeological	Tom Mills
Marcor of NY, Inc. 120 Elmgrove Park Rochester, NY 14624 (716) 247-6955	Drilling	Mary Angevine
Purdy Engineering 1811 Castle Gardens Road P.O. Box 156 Vestal, NY 13850 (607) 748-7379	Surveying	David Marnicki

Off-Site Subcontractors

<u>Firm</u>	<u>Service</u>	<u>Contract Representative</u>
E-CHEM, Corp. P.O. Box 1510 #32 Route 35, Sebago Common Windham, ME 04062 (207) 892-0002	Validation	Bruce Wallin
Galson Laboratories 6601 Kirkville Rd. East Syracuse, NY 13057 (315) 432-0506	Analysis	Gale Sutton
Gradient Corporation 44 Brattle St. Cambridge, MA 02138 (617) 576-1555	QA/QC	Dallas Wait

2.2.1.10 Miscellaneous Field Equipment

Turbidity and electrochemical measurements were obtained by using a Horiba U-10 W-10 m water quality checker, model 506603, and a Corning Checkmate 90 meter, model 5403, Cat. 473619. Water levels were measured by using a Solonist electronic water level recorder, model 10522. Each instrument was calibrated daily with standard pH, conductivity, and turbidity solutions.

A Dayton oil-fired steam cleaner, model 5Z170, was used for decontamination cleaning. A Honda ES6500 gasoline-powered 120/240-V generator was used for TELOG computer operations and miscellaneous electrical power needs.

2.2.1.11 Decontamination Procedures

Before work was undertaken at the site, the drill rig, all drilling tools, and the split-spoon samplers were thoroughly decontaminated by washing the rig and tools with laboratory-grade detergent by means of a steam-generating pressure washer. The rig, tools, and samplers were then rinsed with the steam pressure washer and staged under 6.0-mil (mil = 0.001 in.) plastic sheeting until used. The rig and all tools were also decontaminated between boreholes by using the same procedure, and the split-spoon samplers were decontaminated after every use.

All slug test, well purging, and well sampling equipment was washed with Alconox, rinsed with methanol, rinsed with the steam-generating pressure washer, and rinsed with distilled water. The equipment was also cleaned in the same manner between use in each well. The electronic water level recorder was decontaminated by using the same procedure and was rinsed with distilled water before and after every insertion into a given well. Rinsates for laboratory analysis were obtained from all sampling and testing equipment by using ASTM Type II deionized water.

2.2.2 Chronology of Field Work

Fieldwork activity dates were as follows:

- 28 OCT 91 Fieldwork commenced with arrival of ANL personnel at AFP 59.
- 31 OCT 91 Marcor initiated drilling.
- 1 DEC 91 ANL's MEM crew arrived.
- 7 DEC 91 ANL's MEM crew departed.
- 13 DEC 91 Marcor departed.
- 2 JAN 92 ANL and Hydroterra began Round One groundwater sampling.
- 11 JAN 92 Hydroterra began installing telogs for slug tests and for the GE production well pump test.
- 27 JAN 92 ANL and Hydroterra arrived on-site for collection of pump test data and for Round Two groundwater sampling.
- 5 FEB 92 Fieldwork terminated with departure of ANL from site.

(In late December, ANL additionally monitored NYSDEC's use of AFP 59 wells as part of a pump test.)

2.2.3 Field QA/QC

Except when otherwise noted, the field QA/QC procedures described in Revision 2 of the IRP SSI QAPP (Appendix P) were followed throughout the project. Exceptions and problems are described in Appendix O. Field activities were subject to an audit by Gradient Corporation. A formal report, concluding that prescribed QA/QC procedures were being followed, was sent to the ANL Program manager. Field control parameters and acceptance criteria are described below. As shown, stability of temperature, pH, and electrical conductivity were, except for a few very minor exceptions, attained in all presampling purging regimes. Two relatively minor and one serious instance of excessive turbidity were recorded.

Field Control Parameters and Acceptance Criteria. Raw field data are provided in Appendix C. Field control parameters were monitored during the purging of wells that preceded the sampling of groundwater. The project QAPP did not define stability. Air Force guidance (Version 3.0, 1989) defines stability as follows: temperature, $\pm 1^{\circ}\text{C}$; pH, ± 0.2 units; and EC $\pm 5\%$. Air Force guidance further states that six bore volumes shall be removed when parameters fail to stabilize and that wells pumped to dryness shall be sampled upon recovery. As shown in Tables 2.4a and b, stability within the Air Force definition was achieved in all but eight instances. Six or more well volumes were removed in three of those eight instances, and wells were purged to dryness and sampled in the remaining instances. Moreover, the amounts by which final parameter values exceeded maximum target values were negligible. No corrective actions were warranted.

Turbidity and Settling Times. In accordance with NYSDEC Region 7 instructions (Rodabaugh, October 3, 1991, as provided in Appendix G), well development was continued to a turbidity of <50 NTU. This target superseded the target of 5 NTU specified in the QAPP and was applied to the pre-sampling purge regime. As shown in Tables 2.4a and b, the reduction of Round B purging turbidities to 50 NTU was achieved in all but three instances, with only one of those instances representing a serious departure from target minimal clarity. The worst turbidity was seen in DW-6, a known "problem" well. Reduction to 5 NTU was achieved only twice, even though six well volumes were purged from most wells, and volumes ranging to 37 volumes were removed from some wells. Instrumentally measured values were not available during Round A sampling. Verbal descriptions were logged, but they are not shown in Tables 2.4a and b.

Turbidity was recognized as a problem in advance of the first round of sampling and was discussed with NYSDEC, as described in Appendix O. Because (1) turbidity, as anticipated, was a problem, (2) sampling from the top of the column was not desirable, and (3) NYSDEC does not allow the filtration of samples for analysis of inorganics, a settling between the end of purging and the beginning of sampling was allowed. Except for the cases of DW-1 and SW-1, where Round A field conditions necessitated an overnight delay, sampling events occurred within a few hours of purging.

TABLE 2.4a Field Control Parameter Data Collected while Purging Wells in Preparation for Groundwater Sampling

Well (Sample)/ Purge	Well Water Volume (gal)	Gallons Purged	Well Volumes Purged	Temp (°C)	pH	Conduc- tivity (mS/cm)	Turbi- dity (NTU)
SW-1 (JCSW1AW)	1.51						
Purge 1		1	0.7	8.9	6.29	2.12	—
Purge 2		26	17.2	9.9	6.55	2.44	—
Purge 3		36	23.8	11.1	6.58	2.58	—
Purge 4		50	33.1	10.4	6.61	2.45	—
SW-1 (JCSW1BW)	1.59						
Purge 1		0	0	2.6	6.94	3.21	602
Purge 2		20	12.6	1.6	6.81	3.89	56
Purge 3		40	25.2	2.9	6.89	3.43	6
Purge 4		50	31.4	3.8	6.98	3.52	6
SW-3 (JCSW3AW)	2						
Purge 1		0	0	3.3	5.97	1.001	—
Purge 2		17.5	8.8	13.1	6.35	0.965	—
Purge 3		45.5	22.8	14.1	6.61	1.013	—
SW-3 (JCSW3BW)	2						
Purge 1		0	0	1.7	7.51	1.01	299
Purge 2		30	15	0.7	7.36	0.922	2
Purge 3		45	22.5	0.9	7.37	1.51	1
SW-4 (JCSW4AW)	2.52						
Purge 1		0	0	11.6	5.75	0.842	—
Purge 2		4.5	2	12	6.15	0.937	—
Purge 3		7.5	3.3	12.4	6.25	0.961	—
Purge 4		9	4	11.8	6.24	0.936	—
SW-4 (JCSW4BW)	2.25						
Purge 1		0	0	9	7.49	0.684	22
Purge 2		4.5	2	8	7.61	0.675	80
Purge 3		9	4	7.9	7.56	1 ^a	11
Purge 4		^b	-	7.9	7.55	0.688	12
SW-5 (JCSW5AW)	1.3						
Purge 1		0	0	9.4	0.598	15.79	—
Purge 2		2	1.54	^c	^c	^c	—
Purge 3		^d	^d	11.2	0.605	15.7	—
SW-5 (JCSW5BW)	1.3						
Purge 1		0	0	3.3	7.46	0.769	66
Purge 2		1.5	1.2	^c	^c	^c	^c
Purge 3		3	2.3	3.5	4.54	1.67	12

TABLE 2.4a (Cont.)

Well (Sample)/ Purge	Well Water Volume (gal)	Gallons Purged	Well Volumes Purged	Temp (°C)	pH	Conduc- tivity (mS/cm)	Turbi- dity (NTU)
SW-6 (JCSW6AW)	2.3						
Purge 1		0	0	8.7	0.693	8.08	—
Purge 2		14	6.1	11.3	0.617	12.47	—
Purge 3		38	16.5	11.4	0.636	12.95	—
Purge 4		47	24.8	11.4	0.642	12.41	—
SW-6 (JCSW6BW)	2.25						
Purge 1		0	0	3.2	7.28	1.88	857
Purge 2		38	16.9	2.7	7.21	1.97	26
Purge 3		57	25.3	1.4	7.23	1.86	12
SW-7 (JCSW7AW)	1.75						
Purge 1		0	0	12	0.604	11.38	—
Purge 2		12.5	7.1	13.5	0.65	11.2	—
Purge 3		25	14.3	13.4	0.658	11.13	—
Purge 4		37.5	21.4	13.6	0.663	11.23	—
SW-7 (JCSW7BW)	1.74						
Purge 1		0	0	4.2	7.07	1.44	267
Purge 2		12.5	7.1	3.8	7.09	1.49	39
Purge 3		25	14.3	3.4	7.08	1.13	19
Purge 4		37.5	21.5	3.3	7.26	1.12	10
SW-8 (JCSW8AW)	1.65						
Purge 1		0	0	5.49	0.549	8.56	—
Purge 2		4	2.4	5.33	0.553	6.43	—
Purge 3		8	4.8	5.58	0.558	6.33	—
Purge 4		12	7.3	5.64	0.564	6.58	—
SW-8 (JCSW8BW)	1.54						
Purge 1		0	0	3.9	7.31	1.79	6
Purge 2		4	2.6	3.7	6.33	0.566	230
Purge 3		8	5.2	3.8	6.51	0.516	36
Purge 4		12	7.8	4.4	6.41	0.525	21
SW-9 (JCSW9AW)	1.6						
Purge 1		0	0	—	6.1	0.948	—
Purge 2		17.5	10.9	12.8	6.28	0.958	—
Purge 3		35	21.8	13.2	6.53	0.948	—
Purge 4		52.5	32.8	13.3	6.63	0.983	—
SW-9 (JCSW9BW)	1.5						
Purge 1		0	—	2	7.12	0.626	300
Purge 2		35	23.3	2.7	7.17	0.676	30
Purge 3		52.5	35	2.7	7.24	0.681	33

TABLE 2.4a (Cont.)

Well (Sample)/ Purge	Well Water Volume (gal)	Gallons Purged	Well Volumes Purged	Temp (°C)	pH	Conduc- tivity (mS/cm)	Turbi- dity (NTU)
SW-1 (JCDW1AW)	29						
Purge 1		90	3.1	9.7	5.51	1.407	—
Purge 2		125	4.3	10.2	6.01	1.392	—
Purge 3		160	5.5	9.2	6.31	1.487	—
Purge 4		175	6	—	—	—	—
DW-1 (JCDW1BW)	29						
Purge 1		0	0	2.8	7.32	1.17	62
Purge 2		90	3.1	1.5	7.16	1.46	54
Purge 3		150	5.2	1.7	7.03	1.89	52
Purge 4		180	6.2	2.4	7.04	1.85	15
DW-3 (JCDW3AW)	47						
Purge 1		0	0	9.8	5.33	1.09	—
Purge 2		90	1.9	11.1	6.42	1.028	—
Purge 3		150	3.2	11.8	6.69	1.094	—
Purge 4		180	3.8	11	6.74	1.03	—
Purge 5		216	4.6	11.6	6.67	1.024	—
DW-3 (JCDW3BW)	47						
Purge 1		0	0	0.3	9.89	0.674	25
Purge 2		90	1.9	2.6	7.6	0.916	123
Purge 3		150	3.2	0.8	7.64	0.977	61
Purge 4		180	3.8	2	7.42	0.949	81
Purge 5		210	4.5	1.3	7.38	0.953	52
DW-4 (JCDW4AW)	50.3						
Purge 1		0	0	8.5	5.79	0.681	—
Purge 2		50	1	9.6	6.01	1.068	—
Purge 3		100	2	8.2	6.24	1.069	—
Purge 4		150	3	9.3	6.41	1.065	—
Purge 5		175	3.5	8.9	6.52	1.063	—
DW-4 (JCDW4BW)	46						
Purge 1		0	0	127	7.767	0.578	50
Purge 2		30	0.7	10.97	7.48	0.761	27
Purge 3		60	1.3	10.9	7.467	0.7597	50
Purge 4		150	3.3	9.67	7.41	0.739	70
Purge 5		180	3.9	10	7.43	0.784	39

TABLE 2.4a (Cont.)

Well (Sample)/ Purge	Well Water Volume (gal)	Gallons Purged	Well Volumes Purged	Temp (°C)	pH	Conduc- tivity (mS/cm)	Turbi- dity (NTU)
DW-5 (JCDW5AW)	40						
Purge 1		0	0	8.5	8.01	0.615	—
Purge 2		30	0.8	19.2	5.94	1.011	—
Purge 3		55	1.4	9.7	6.15	1.014	—
Purge 4		95	2.4	10.4	6.35	0.951	—
Purge 5		160	4	10.4	6.43	0.988	—
DW-5 (JCDW5BW)	40						
Purge 1		0	0	9.7	7.23	0.754	40
Purge 2		75	1.9	9.1	7.41	0.702	134
Purge 3		125	3.1	6.9	7.29	0.753	84
Purge 4		150	3.8	6.5	7.4	0.755	62
Purge 5		175	4.4	6.4	7.41	0.766	64
DW-6 (JCDW6AW)	33						
Purge 1		0	0	8.4	9.28	0.538	—
Purge 2		9	0.3	11.6	10.59	0.604	—
Purge 3		13.5	0.4	11.8	10.79	0.623	—
Purge 4		21	0.6	11.2	10.87	0.69	—
Purge 5		28	0.9	11.3	10.92	0.688	—
DW-6 (JCDW6BW)	33						
Purge 1		0	0	1.1	11.46	0.461	677
Purge 2		15	0.5	0.5	11.74	0.606	88
Purge 3		25	0.8	0.9	11.97	0.654	133
Purge 4		30	0.9	0.1	11.73	0.587	321
DW-8 (JCDW8AW)	51						
Purge 1		0	0	10.5	6.11	1.622	—
Purge 2		10	0.2	8.5	6.38	1.595	—
Purge 3		150	2.9	8.9	6.41	1.615	—
Purge 4		180	3.5	9	6.48	1.591	—
Purge 5		210	4.1	9.2	6.5	1.616	—
DW-8 (JCDW8BW)	50						
Purge 1		0	0	5.1	7.32	1.74	14
Purge 2		90	1.8	5.5	7.3	1.48	52
Purge 3		150	3	5.8	5.46	1.43	23
Purge 4		180	3.6	5.1	7	1.53	18
Purge 5		210	4.2	5.2	7.08	1.53	13

TABLE 2.4a (Cont.)

Well (Sample)/ Purge	Well Water Volume (gal)	Gallons Purged	Well Volumes Purged	Temp (°C)	pH	Conduc- tivity (mS/cm)	Turbi- dity (NTU)
DW-9 (JCDW9AW)	47.2						
Purge 1		0	0	9.2	6.02	1.232	—
Purge 2		90	1.9	10.5	6.2	1.232	—
Purge 3		150	3.2	10.4	6.37	1.23	—
Purge 4		180	3.8	10.3	6.42	1.236	—
Purge 5		210	4.5	10.5	6.55	1.241	—
DW-9 (JCDW9BW)	47						
Purge 1		0	0	12.2	7.07	1.24	120
Purge 2		90	1.9	5	7.03	1.45	1
Purge 3		150	3.2	4.9	7.04	1.44	2
Purge 4		180	3.8	5.6	7.14	1.45	2
Purge 5		210	4.5	4.3	7.11	1.53	1
DPW (JCDPWAW)	622						
Purge 1		14,100	22.7	9.8	6.37	1.123	—
DPW (JCDPWBW)	622						
Purge 1		3,000	4.8	7.43	6.6	1.39	49
JC No. 7 (JCBG2BW) ^e							

^a Value assumed erroneous and ignored.

^b Unrecorded.

^c Dry.

^d Recharge.

^e Unmeasured.

TABLE 2.4b Summary and Conclusions of Field Control Parameter Data Collected while Purging Wells in Preparation for Groundwater Sampling

Well (Sample)	Turbidity <50 NTU (Exceedance ^b)	Volumes Removed ≥4	Stable Parameters ^a	Unstable Parameters ^a (Exceedance ^b)
SW-1 (JCSW1AW)	-	Yes	Temp, ph, cond	
SW-1 (JCSW1BW)	Yes	Yes	Temp, pH, cond	
SW-3 (JCSW3AW)	-	Yes	Temp, cond	pH (0.26)
SW-3 (JCSW3BW)	Yes	Yes	Temp, pH	Cond
SW-4 (JCSW4AW)	-	Yes	Temp, pH, cond	
SW-4 (JCSW4BW)	Yes	Yes	Temp, pH, cond	
SW-5 (JCSW5AW)	-	No	Cond	Temp (0.8), pH
SW-5 (JCSW5BW)	Yes	No	Temp, pH	Cond (0.87)
SW-6 (JCSW6AW)	-	Yes	Temp, pH, cond	
SW-6 (JCSW6BW)	Yes	Yes	pH, cond	Temp (0.3)
SW-7 (JCSW7AW)	-	Yes	Temp, pH, cond	
SW-7 (JCSW7BW)	Yes	Yes	Temp, pH, cond	
SW-8 (JCSW8AW)	-	Yes	Temp, pH, cond	
SW-8 (JCSW8BW)	Yes	Yes	Temp, pH, cond	
SW-9 (JCSW9AW)	-	Yes	Temp, pH, cond	
SW-9 (JCSW9BW)	Yes	Yes	Temp, pH, cond	
DW-1 (JCDW1AW)	-	Yes	Temp	pH (0.1), cond (0.025)
DW-1 (JCDW1BW)	Yes	Yes	Temp, pH, cond	
DW-3 (JCDW3AW)	-	Yes	Temp, pH, cond	
DW-3 (JCDW3BW, JCDW3RW)	No	Yes	Temp, pH, cond	
DW-4 (JCDW4AW)	-	No	Temp, pH	Cond (0.001)
DW-4 (JCDW4BW)	Yes	Yes	Temp, pH, cond	
DW-5 (JCDW5AW)	-	Yes	Temp, pH, cond	
DW-5 (JCDW5BW)	No (15)	Yes	Temp, pH, cond	
DW-6 (JCDW6AW)	-	No	Temp, pH, cond	
DW-6 (JCDW6BW)	No (272)	No	Temp	pH (0.04), cond (0.09)
DW-8 (JCDW8AW)	-	yes	Temp, pH, cond	
DW-8 (JCDW8BW)	Yes	Yes	Temp, pH, cond	
DW-9 (JCDW9AW)	-	Yes	Temp, pH, cond	
DW-9 (JCDW9BW)	Yes	Yes	pH, cond	Temp (0.3)
DPW (JCDPWAW)	-	Yes		
DPW (JCDPWBW)	Yes	Yes		
JC No. 7 (JCBG2BW) ^c				

^a Temp = temperature; cond = conductivity.

^b Exceedance means the amount, in appropriate units, by which the final value exceeds the maximum value that would be considered acceptable or stable (relative to the preceding value) as defined in Section 2.2.2.

^c Unmeasured.

Duplication of First-Round Sampling Conditions. The time lapse between purging and sampling and the number of well volumes purged were controlled during Round B sampling in an attempt to duplicate the conditions recorded for Round A. This concern was part of the overall effort to assure the comparability of Round B samples with those of Round A. Table 2.5 compares Round A and Round B settling times. Table 2.6 compares purge volumes. With the exception of the deep production well (DPW) purge volumes, all comparisons show excellent correspondence. DPW was purged longer than necessary during Round A, and a lot of water was involved. Nonduplication of purge volume during Round B was intentional.

2.2.4 Analyses Using Field-Portable Equipment

This section briefly describes the acquisition and on-site screening analysis of soil samples from AFP 59. Organic compounds were analyzed by using portable gas chromatography/mass spectrometry equipment; metals were analyzed by using x-ray fluorescence spectrometry.

TABLE 2.5 Comparison of Time Elapsed between the End of Purging and the Beginning of Sample Collection during Sampling Rounds A and B

Well Sampled	Sampling Round A (h:min)	Sampling Round B (h:min)	Disparity (min)
DW-1	18:60	23:25	265
SW-1	18:57	23:9	252
DW-3	2:10	1:25	45
SW-3	1:13	1:25	12
DW-4	4:5	2:25	100
SW-4	3:50	1:40	130
DW-5	1:33	1:45	12
SW-5	1:12	1:15	3
DW-6	2:58	3:15	57
SW-6	2:15	2:40	25
SW-7	3:5	0:40	145
DW-8	2:53	1:40	173
SW-8	2:20	1:20	140
DW-9	2:15	1:40	35
SW-9	1:37	1:18	19
DPW	0:0	0:0	0

TABLE 2.6 Comparison of Well Volumes
Purged during Sampling Rounds A and B

Well Sampled	Number of Well Volumes Purged		Disparity (volumes)
	Sampling Round A	Sampling Round B	
DW-1	6	6.2	0.2
SW-1	33.1	31.4	0.3
DW-3	4.6	4.5	0.1
SW-3	22.8	22.5	0.3
DW-4	3.5	3.9	0.4
SW-4	4	4	0
DW-5	4	4.4	0.4
SW-5	1.54	2.3	0.8
DW-6	0.9	0.9	0
SW-6	24.8	25.3	0.5
SW-7	21.4	21.5	0.1
DW-8	4.1	4.2	0.1
SW-8	7.3	7.8	0.5
DW-9	4.5	4.5	0
SW-9	32.8	35	2.2
DPW	22.7	4.8	17.9

Instrumentation. Field-deployable analytical instrumentation allows for minimal sample preparation, rapid sample turnaround time, and the analysis of a wide range of contaminant compounds and elements. Instrumentation consisted of a Bruker MEM (mobile environmental monitor) gas chromatograph/mass spectrometer (GC/MS) and a Spectrace 6000 energy-dispersive x-ray fluorescence (EDXRF) spectrometer. The utility and value of these two instruments for Superfund-type chemical-analytical work is discussed in recent papers by U.S. EPA (1990) and Watson et al. (1989).

Objectives. The primary objective of this phase of the supplemental investigation at AFP 59 was to provide rapid screening for trace-metal and organic soil contaminants at gross (low ppm) concentration levels. On-site screening was also used to help choose sampling depths for laboratory samples taken from within five soil test-borings at sites A1, A2, and A6. These screening results are not reported.

Field Activities. Soil sampling and organic testing was conducted December 2–6, 1991. Hand augers were decontaminated before each use by brushing to remove visible soil, washing with an Alconox (brand) solution, rinsing with tap water, rinsing with a 10% solution of nitric acid, rinsing with deionized water, and drying with paper towels. New, clean sampling containers were used. A total of 19 hand-driven, three-inch, bucket auger samples were taken from 2 to 6 ft below surface. Hand-driven auger sampling locations are shown and indicated with the prefix "HA:" in Figure 1.2. Soil beneath asphalt was accessed by chiseling at most locations, and the holes were plugged with cement. One sample was taken from beneath the porch of the plating room, six samples were taken from beneath the JP-4 lines, eight samples were taken from beneath the asphalt ditch adjacent to the rear parking lot, one sample was taken from the center of the rear parking lot, one sample was taken from near outfall 3, and one sample was taken at the southeast corner of the GE building.

The MEM was placed in an enclosed parking bay, and samples were hand-carried to the instrument. A small quantity of matrix was used in conducting the MEM analysis. Remaining sample material was then transferred to an ANL field laboratory for metals analysis.

Sampling locations are shown in Figures 1.2. Notable findings are shown in Table 2.7. These results are discussed in Section 3. Complete results are shown in Appendix I.

2.3 Laboratory Analyses

2.3.1 Analytical Program

All laboratory analyses of AFP 59 samples were performed by Galson Laboratories, 6601 Kirkville Road East, E. Syracuse, New York. Analyses were made for all volatile, semivolatile, and inorganic compounds on the NYSDEC Target Compound List, plus freon and cyanide. Analytical methods referenced NYSDEC ASP volumes 1–8 (1989) and conformed with Superfund CLP-Inorganics and Superfund-CLP-Organics. Volatile analyses for groundwater and surface water samples followed a modified NYSDEC ASP method to be able to reach lower detection limits than the NYSDEC ASP (9/89) methodology can meet. This modified method is described in Appendix D of the QAPP. The QAPP is included as Appendix P of this report.

2.3.2 QA/QC Program

The types, numbers, and acceptance criteria of laboratory QC samples, as well as laboratory problems and corrective actions, calculations of completeness, and QA activities, are fully discussed in the data usability report, as presented in Appendix A.

TABLE 2.7 Origin and Site Association of Hand-Augered Soil Samples
(contaminants detected through field analyses are noted.)

Location ID	Association and Significant Results	Sample Depth
HA-1	Site A5 JP-4 pipeline (2 samples)	
	Sample 01	3.25
	Sample 02	4
HA-2	Site A5 JP-4 pipeline	4
HA-3	Site A5 JP-4 pipeline	4.3
HA-4	Site A5 JP-4 pipeline	4.3
HA-5	Site A5 JP-4 pipeline	5
HA-6	Site A5 JP-4 pipeline	4
HA-7	parking lot ditch near waste oil storage tank (unidentified volatile organic compounds detected)	3
HA-8	parking lot ditch near toxic storage shed	3
HA-9	parking lot ditch near plating building	3
HA-10	parking lot ditch near settling ponds (chromium: 445 ppm)	3
HA-11	parking lot ditch near range building (poly-aromatic hydrocarbons detected; tentatively identified as follows: anthracene/phenanthrene, fluoranthene, pyrene)	2
HA-12	parking lot ditch near transformer pad	3
HA-13	center of parking lot (unidentified volatile organic compounds detected) (nickel 49 ppm cadmium 82 ppm chromium 109 ppm copper 546 ppm)	2
HA-14	soil near outfall 003	3
HA-15	parking lot ditch; rear of lot	3
HA-16	parking lot ditch near waste oil storage tank	3
HA-17	soil beneath porch of plating building (poly-aromatic hydrocarbons detected; tentatively identified as follows: anthracene/phenanthrene fluoranthene pyrene)	6
HA-18	surface soil at SE corner of GE building	surface

2.4 Data Evaluation

2.4.1 Identification of Valid Chemical Data

A Quality Assurance Project Plan (QAPP) was implemented to assess, ensure, and document that (1) all data generated, stored, and reported by ANL were scientifically valid and defensible and that (2) specific quality assurance (QA) and quality control (QC) activities were performed to ensure the validity of analytical data generated during the Supplemental Site Investigation. The QAPP is presented in Appendix P of this report.

All AFP 59 supplemental SI data were validated by ECHEM, Inc., Windham, Maine. The ECHEM validation report is presented in Appendix A, along with a data usability report by Gradient Corp. The data were evaluated on the basis of the following parameters:

- Data completeness,
- Holding times,
- Surrogate recovery,
- Matrix spike/matrix spike duplicate/matrix spike blank,
- Blanks,
- GC/MS tuning,
- Calibration,
- Internal standards performance,
- Field duplicates,
- TCL compound identification, and
- Tentatively identified compounds.

Separate reportings were made of evaluation results for each of the four analytical groups (volatiles, semivolatiles, pesticides/PCBs, and TAL inorganics) for each of six sample delivery groups (SDG Nos. 1-5554, 2-5807, 3-5983, 5-6384, 6-6703, and 7-6779). Each reporting

consisted of notations detailing evaluative findings, a validation action summary table, and a sample preparation and analysis summary for NYSDEC.

The original validation reportings are presented here in order of sample delivery group. For reference, only the first digit of each SDG number is used (SDG Nos. 1, 2, 3, 5, 6, and 7). The analytical groups within each SDG are presented in the following order: VOC, SVOC, pesticides/PCBs, and inorganics. The validation results for a given sample may be located through the use of the SDG number.

2.4.2 Hydrogeological Data Analysis and Synthesis

Daily records documented all activities conducted during the course of the field work. Field boring and monitoring well logs were maintained on standard forms and were transferred to final forms by using LOTUS 123 software. Slug-test and water-level data collected during the course of this field work was compiled on the TELOG 2100-01 database software and transferred to X, Y, Z data files by using LOTUS 123 software spreadsheets. Horizontal flow patterns were evaluated, and static and average groundwater potentiometric surface maps were generated for the upper and lower aquifers for the month of January 1992 by using SURFER software and Kriging interpolation techniques. Potentiometric maps were refined and presented by using DesignCAD computer-aided drafting and design software. As part of the Air Force's data management procedure, data on the site hydrogeology, monitoring wells, and borings were tabulated as per the Air Force IRPIMS requirements (Appendix C). The analytical procedures used in groundwater flow modeling are presented along with modeling results in Section 2.4.4.

2.4.3 Methodology for Risk Estimation

The following steps are required in conducting the risk assessment:

- Collection and evaluation of environmental concentration and distribution data to select contaminants of potential concern.
- Identification of receptors and plausible exposure pathways from sources of contamination to those receptors, with results incorporated in the conceptual site model.
- Use of contaminant fate and transport data to estimate exposure point concentrations (EPCs).
- Calculation of human intake factors (HIFs) that incorporate terms describing exposure as related to human activity and, for certain pathways, characterization of EPCs and HIFs.

- Calculation of daily intakes (DIs) of contaminants as the products of EPCs and HIFs.
- Selection of suitable toxicity indices for the contaminants of potential concern.
- Use of the toxicity indices and daily intakes to express hazard or risk from the individual contaminants, as well as overall hazard or risk. Here, hazard refers to the dangers from noncarcinogens and risk refers to those from carcinogens.

2.4.4 Groundwater Flow Modeling

2.4.4.1 Conceptual Model

As described in Section 1.2, the Clinton Street-Ballpark aquifer is a complex system of high-permeability sands and gravels separated in places by lower permeability fine-grained sediments. Successful simulation of this system requires the use of a three-dimensional groundwater flow model. On the basis of the hydrogeology of the area, the system can be represented with three vertical layers: (1) glacial outwash sands and gravels, (2) ice-contact deposits of fine-grained sand and silt, and (3) ice-contact deposits of coarse-grained sand and gravel. Vertical leakage from the lower unit of ice-contact deposits is assumed to have a minor influence on the overall flow pattern. Recharge to the system is assumed to occur through two mechanisms: (1) infiltration from rain and snow melt and (2) recharge from Little Choconut Creek. Extraction from the system occurs primarily via the city well field and the AFP 59 production well.

2.4.4.2 Numerical Model

The Coupled Fluid, Energy, and Solute Transport (CFEST) computer code, developed by Gupta et al. (1987), was selected to analyze groundwater flow at AFP 59. This numerical model was selected because it (1) has a full three-dimensional capability, it can perform transient and steady-state calculations, (2) incorporates heterogeneity and anisotropy, (3) allows recharge via infiltration, (4) has both pump and injection well capabilities, and (5) is formulated with a quadrilateral finite-element technique that allows easy representation of the physical boundaries of the site and vicinity properties.

Under conditions of constant fluid density (dilute solutions), CFEST solves the following partial differential equation for hydraulic head:

$$\rho K_{\alpha\beta} \nabla^2 H - Q = \rho \frac{\partial H}{\partial t} \quad (2.1)$$

where:

H = hydraulic head = $Z + P/\gamma$,

K = hydraulic conductivity,

P = pressure,

Q = sink or source terms for the fluid,

t = time,

Z = elevation,

α, β = indices of spatial coordinates,

γ = specific weight of water,

∇^2 = Laplacian operator ($\partial^2/\partial x^2 + \partial^2/\partial y^2 + \partial^2/\partial z^2$),

θ = effective porosity, and

ρ = density.

Darcy's groundwater velocity (U) is obtained by using the hydraulic head calculated with Equation 2.1 as follows:

$$U = -K\nabla H, \quad (2.2)$$

where ∇ is the gradient operator ($\partial/\partial x \hat{i} + \partial/\partial y \hat{j} + \partial/\partial z \hat{k}$).

Heterogeneity in aquifer permeability, porosity, and anisotropy (collinear with the Cartesian coordinate system) is also accounted for in the CFEST code. Heterogeneity can be described on a layer-by-layer basis or by individual elements.

To solve Equations 2.1 and 2.2, boundary and initial conditions are required. Options are provided for constant and time-dependent Dirichlet conditions, Neumann conditions (zero flux, i.e., no flow), and Cauchy conditions (specified flux). Initial conditions can be specified for hydraulic head, concentration, and temperature.

Originally, the CFEST computer code was developed to simulate confined aquifers; however, phreatic conditions exist in the shallow glacial outwash aquifer at AFP 59. Unconfined groundwater flow solutions were obtained by iterative execution of the code and updating the top elevation of the saturated zone.

The CFEST computer code is well documented and has undergone extensive verification and validation (Gupta et al. 1987). It is also being benchmarked, verified, and partially validated with test cases identified by HYDROCOIN (Hydrologic Code Intercomparison), an international project organized by the Swedish Nuclear Inspectorate.

2.4.4.3 Groundwater Flow Model

The planar area of interest for the groundwater model and the quadrilateral finite-element grid for numerical calculations are shown in Figure 2.1. This calculational region relative to the Clinton Street-Ballpark Aquifer is shown in Figure 2.2. The Susquehanna River was selected as a boundary because of its proximity to the site, its potential for recharging the shallow and deep aquifers, and because it is the southwestern boundary of the Clinton Street-Ballpark Aquifer. The remainder of the boundary was placed far enough from AFP 59 to avoid influence upon numerical calculations. In places, the grid extends beyond the boundaries of the aquifer (Figure 2.2). Inclusion of elements outside the boundary of the aquifer has no significant effect on the numerical simulations in the vicinity of AFP 59 and was done to simplify construction of the calculational domain.

The area of the model is approximately 1.7 mi² and encompasses 239 nodes and 211 elements. The highest density of elements is in the vicinity of AFP 59; elements become larger at the boundaries of the model, where little information is available and changes in element size do not significantly affect the calculations. Node locations correspond approximately with the locations of pumping and monitor wells and other surficial features.

For the numerical modeling, the Susquehanna River was treated as a constant head boundary (time independent) with a known gradient in the direction of flow (10 ft per 9,500 ft). The northern boundary was represented with a no-flow condition on the basis of extrapolated shallow and deep potentiometric surfaces that were determined during this study and shown in Figures 1.13 and 1.15. Constant-head boundary conditions were used for the other two boundaries (east and west). The values assigned to these boundaries were derived from the potentiometric surface shown in Figure 1.13. (Because of a lack of water-level data at large distances from the plant, the shallow and deep zones of the aquifer were assumed to have the same hydraulic head.) Although groundwater flow calculations were performed by using the large grid shown in Figure 2.1, a smaller region of elements (Figure 2.3) is used to show the results of the model calibration and the different pumping scenarios performed for this study.

FIGURE 2.1 Finite-Element Grid for the Numerical Model

FIGURE 2.2 Calculational Domain for AFP 59 Groundwater Modeling Relative to Regional Aquifer Boundaries

FIGURE 2.3 Localized Finite-Element Grid to Show Calibration and Scenario Results

In the vertical direction, three layers are used to simulate the Clinton Street-Ballpark Aquifer. The uppermost layer consists of glacial outwash deposits and was estimated to be 60 ft thick with an effective porosity of 0.3. The second layer consists of either 10 ft of fine-grained ice-contact deposits (effective porosity of 0.1) or glacial outwash sands and gravels (effective porosity of 0.3) for regions in which the low-permeability material is not present. The delineation of the fine-grained ice-contact deposits is shown in Figure 2.1 as a heavy line that parallels the Susquehanna River and bisects AFP 59 from northwest to southeast. The approximate location of this material was established by using the stratigraphic cross sections of the plant and vicinity properties, as developed by URS (1992) and by ANL during this study (Figures 1.8–1.11). The third and bottom layer of the model consists of coarse-grained ice-contact deposits of sand and gravel 30 ft thick. It is assumed that no vertical leakage occurs across the bottom of the model, either to or from the underlying bedrock.

Recharge to the model was provided by two mechanisms: (1) infiltration from rain and snow melts and (2) infiltration from Little Choconut Creek. For the rain and snowmelt infiltration, a constant flux value of 24 in./yr was assigned to the top layer of the model. For Little Choconut Creek, a series of injection wells that corresponded to node locations were assigned along its flow path. The rates of injection were established to be consistent with Randall's (1978) infiltration value of 0.12 ft³/s per 1,000 ft of channel.

2.4.4.4 Model Calibration

Calibration of the model was performed by varying the hydraulic conductivities of the three layers and the anisotropy of the model until the sum of the squared differences between model predicted water elevations and measured heads was minimized. The water levels in the calibration were obtained from monitoring wells installed to support this investigation (Figures 1.13 and 1.15). Recharge was assumed to be known (because of the high hydraulic conductivity of the Clinton Street-Ballpark Aquifer, variations in recharge on the order of 25% do not significantly affect the potentiometric surface). To facilitate the fitting process, the calibration was performed under steady-state conditions with City Well 2 pumping at a rate of 2,100 gpm, with two-thirds of the flow coming from the bottom layer (confined aquifer) and one-third of the flow coming from the top layer (unconfined aquifer).

The best-fit hydraulic conductivities for the calibrated model were 250, 1, and 250 ft/d for layers one through three, respectively. These values are in very good agreement with results discussed earlier for the AFP 59 pumping test and the USGS regional flow model (Randall 1986). The calibrated anisotropy ratios were found to be 2:1, 10:1, and 2:1 for the three layers, respectively. These values are typical for fine- and coarse-grained sands and gravels. Although these values provided the best fit to measured values, the overall sensitivity of the model to anisotropy was small.

Figures 2.4 and 2.5 show the calibrated potentiometric surfaces for the shallow and deep aquifer, respectively. Most of the draw-down from City Well 2 occurs in the deep aquifer (Figure 2.5). Figures 2.6 and 2.7 show the direction of groundwater flow in layers one and three (shallow and deep aquifer, respectively). As illustrated by these figures, flow across the site is west to northwest, with a substantial amount of flow directed to the pumped well.

2.4.4.5 Operational Scenarios

Five operational scenarios were analyzed for this study: (1) City Well 2 pumping at 2,100 gpm and all other wells off (calibration scenario); (2) all wells off; (3) City Well 2 on (2,100 gpm), City Well 5 on (700 gpm), and the Plant 59 deep production well (DPW) 1 off; (4) Plant 59 DPW 1 on (310 gpm) and all other wells off; and (5) City Well 2 on (2,100 gpm), City Well 5 on (700 gpm), and Plant 59 DPW 1 on and pumping at 310 gpm. City Well 7 is not included in any of the extraction scenarios; when operated, City Well 7 is a backup to the primary City Well 2, and even when pumped, its distance from the plant precludes any significant impacts to the local flow field. In the simulations, two-thirds of the City Well 2 pumping rate was from the confined aquifer, and one-third of the pumping rate was from the unconfined aquifer, consistent with this well's completion. Plant 59 DPW 1 and City Well 5 were both simulated as pumping from the deep aquifer.

Of these five scenarios, 1 and 5 can be used to bracket potential contaminant movement from the vicinity of AFP 59; other scenarios were performed for completeness. With only City Well 2 pumping, contaminants released from the plant would move under maximum gradient toward the city well field. With City Wells 2 and 5 pumping and the DPW on, the movement of contaminants would be limited because of a groundwater divide that would be established between City Well 2 and Plant 59 DPW 1. The results for scenarios 1 and 5 will be discussed below. Because of their intermediate nature, results for the other scenarios will not be discussed.

2.4.4.6 Results for Groundwater Modeling Scenarios

As indicated in Figures 2.4 and 2.5 (Scenario 1, or the calibration scenario in which only City Well 2 is pumping), groundwater flow in the vicinity of City Well 2 is vertically downward (water elevations are higher in the shallow aquifer than in the deep aquifer) and directed toward the pumping well. In the vicinity of the plant, the flow of groundwater is slightly upward from the deep to the shallow aquifer (production well not on) and in a general west to northwest direction. In the vicinity of Little Choconut Creek, recharge from the creek creates a small perturbation in the potentiometric surface in the shallow zone of the aquifer. This perturbation has a negligible effect on regional groundwater flow (Figures 2.6 and 2.7).

FIGURE 2.4 Model-Predicted Water Elevations in the Upper Zone or Aquifer with City Well 2 Pumping

FIGURE 2.5 Model-Predicted Water Elevations in the Lower Zone or Aquifer with City Well 2 Pumping

FIGURE 2.6 Groundwater Flow Directions and Relative Velocities in Upper Zone with City Well 2 Pumping

FIGURE 2.7 Groundwater Flow Directions and Relative Velocities in Lower Zone with City Well 2 Pumping

Although Scenario 1 is the most representative, the results of Scenario 5 are also provided. If Plant 59 DPW 1 and City wells 2 and 5 are pumped (Scenario 5), a downward vertical gradient is maintained across most of the site (Figures 2.8 and 2.9). In addition, a groundwater divide forms in the deep aquifer in the southwest section of the site, near SW-9 and DW-9; pumping from Plant 59 DPW 1 has little effect on the shallow aquifer. Flows to the north and east of this divide flow toward Plant 59 DPW 1, while flows to the south and west of the divide flow toward City Well 2 (Figures 2.10 and 2.11).

2.4.4.7 Travel Time Results

Travel times and paths were calculated with the three-dimensional numerical model discussed in Section 2.4.4.2. The calculations were performed for two scenarios: (1) City Well 2 pumping from the shallow and deep portions of the Clinton Street Ballpark Aquifer at a total rate of 2,100 gpm and the rest of the wells idle (Scenario 1, the calibration scenario) and (2) City Well 2 (2,100 gpm) pumping from both the shallow and deep aquifer and Plant 59 DPW 1 (310 gpm) and City Well 5 (700 gpm) both pumping from the deep aquifer (Scenario 5). Particles were released from five positions associated with AFP 59. In all cases, the particles were released in the uppermost layer of the model (just below the water table) and allowed to migrate laterally and vertically under the influence of the pumping wells.

For the calibration scenario, all five of the released particles (1 through 5 of Figure 2.12) would travel to City Well 2 (Figure 2.13). As indicated in Table 2.8, travel times range from about 0.6 yr for a particle released from the northeast corner of AFP 59 (particle 4) to 1.6 yr for a particle released from the southeast corner of the plant (particle 5). A particle released from the Settling Pond (particle 1) would take about 1.1 yr to reach the vicinity of City Well 2.

Figure 2.14 shows the predicted travel paths for the same five particles when all wells are pumping; travel times are given in Table 2.8. When all of the wells are pumping, travel times are increased and range from 1.6 yr (particle 1) to 2.1 yr (particle 2 in Figure 2.13). Particle 4, which is released from the northeast corner of the plant, eludes capture by the pumping wells for this scenario, and the particle moves off the computational grid on the western boundary. These increases in travel times and changes in flow paths occur for two reasons. First, AFP 59 DPW 1 creates a cone of depression that slows, but does not capture, particles released into the shallow portion of the groundwater aquifer on the south side of the facility (e.g., particles 1, 2, and 5). Second, City Well 5 creates a cone of depression that further retards contaminant migration by reducing the gradient towards City Well 2. This decreased gradient permits particle 4 to escape the well field.

FIGURE 2.8 Model-Predicted Water Elevations in the Upper Zone with City Wells 2 and 5 and the AFP 59 Production Well Pumping

FIGURE 2.9 Model-Predicted Water Elevations in the Lower Zone with City Wells 2 and 5 and the AFP 59 Production Well Pumping

FIGURE 2.10 Groundwater Flow Directions and Relative Velocities in Upper Zone with City Wells 2 and 5 and the AFP 59 Production Well Pumping

FIGURE 2.11 Groundwater Flow Directions and Relative Velocities in the Lower Aquifer with City Wells 2 and 5 and the AFP 59 Production Well Pumping

FIGURE 2.12 Location of Potential Sources for Groundwater Travel Time Calculations

FIGURE 2.13 Flow Paths for Particles 1 through 5 with City Well 2 Pumping

FIGURE 2.14 Flow Paths for Particles 1 through 5 with City Wells 2 and 5 and the AFP Production Well Pumping

TABLE 2.8 Calculated Travel Times

Particle	Calibration Scenario ^a	All Wells Pumping ^a
1	1.1	1.6
2	0.8	2.1
3	1.3	1.8
4	0.6	(1) ^b
5	1.6	1.8

^a Travel time in years.

^b Particle is not captured by the well field and disappears at the west boundary of the model.

2.4.4.8 Summary

The following list summarizes the findings of the groundwater modeling study performed for AFP 59:

- Calibrated values for the hydraulic conductivity of the Clinton Street-Ballpark Aquifer are within the range of values previously estimated.
- Groundwater flows in a west-northwest direction underneath AFP 59.
- Infiltration from Little Choconut Creek has little effect on regional groundwater flow.
- When pumping occurs from City Well 2, a limited amount of recharge occurs from the Susquehanna River in the shallow Clinton Street-Ballpark Aquifer. A more substantial recharge occurs in the coarse-grained ice-contact deposits.
- When City Well 2 and the AFP 59 production well are both pumping, a groundwater divide occurs in the lower portion of the Clinton Street-Ballpark Aquifer in the southwest sector of the site near SW-9 and DW-9. Groundwater to the north of the divide flows toward the production well; groundwater to the

south of the divide flows toward the city well. In the shallow portion of the aquifer, the local gradient is reduced.

- Pumping City Well 5 at 700 gpm has a minor effect on groundwater in the vicinity of AFP 59. When pumping, City Well 5 induces a draw-down cone that reduces the local gradient and allows contaminants released in the northeast portion of the site to elude capture at City Well 2.
- Pumping at City Well 2 induces a downward gradient in the vicinity of AFP 59. Groundwater flows from the potential sources to City Well 2 under the influence of the induced hydraulic gradient.
- In the absence of pumping at AFP 59 DPW 1, travel times calculated for five potential sources associated with AFP 59 ranged from 0.6 to 1.6 yr. These estimates do not include the travel time for contaminants released at the ground surface to infiltrate the surface and travel through the unsaturated zone to the underlying water table.
- With the deep production well pumping, travel times to City Well 2 are increased because the cone of depression created by the pumped well reduces the local hydraulic gradient. In addition, in the lower portion of the Clinton Street-Ballpark Aquifer, the local gradient is reversed and a groundwater divide is created near the southwest corner of the plant.
- Under historical pumping conditions, contaminants introduced into the shallow aquifer could migrate to City Well 2 from any of the on-site locations investigated. In all cases, the travel times would be on the order of two years or less.

2.4.4.9 Recommendations

Analyses of the calculations performed for this study indicated areas where additional modeling or field work could substantially increase the accuracy of the model predictions. These areas are indicated below:

- The resolution of the finite-element grid should be increased (smaller distance between grid points) to improve the overall accuracy of the model calculations. An increase in grid resolution could alter the direction of flow of particles released from fringe areas that are subject to draw-down cones from multiple extraction wells (e.g., particle 4 released from the northeast section of the plant, or particle 5 released from the northwest corner of the facility).

- Additional field work should be performed to better define groundwater recharge from Little Choconut Creek. Under the present assumed recharge rate, the creek has little effect on the predictions. However, if the local value of recharge is higher, the model results could be changed.
- Additional field work should be performed off-site to determine more precisely the location and extent of the fine-grained lacustrine deposits that separate the upper and lower portions of the Clinton-Street Ballpark Aquifer. This delineation is crucial for properly characterizing flow paths to the west and northwest of the site.

A general recommendation is to update the numerical model as new data are collected so that a greater understanding of the hydrological processes at the site will be achieved. As new data are collected, the calibration may be improved, and the model could be used for future issues related to groundwater contamination.

3 Remedial Investigation

Six potentially contaminated areas within the boundaries of AFP 59 were identified in the work plan and assigned site numbers as follows:

- Site A-1 — Former location of waste oil tanks,
- Site A-2 — Plating building and surroundings,
- Site A-3 — Former location of oil/water separator,
- Site A-4 — Settling pond area,
- Site A-5 — JP-4 fluid storage and piping area, and
- Site A-6 — Former location of a gasoline storage tank.

Additional areas were sampled during the field investigation, as described in the work plan and in Section 3.2 of this report. The sample types formally and exclusively associated with named sites, and the sample types collected in the sampling areas not designated as sites, are listed below. Sampling locations that are not formally associated with a specific named site are grouped into five "interpretive units," as follows:

Perimeter Wells — Clusters 1, 3, 5, 6, 8, and 9 boreholes and wells;

Interior Wells — Cluster 4 and shallow-well 7 boreholes and wells and the GE deep production well;

Outfalls — Outfall no. 1 + no. 2 + sampling point HA-14 in the path of outfall #3;

Creek — Surface water and sediment; and

MEM Screening Locations — All Mobile Environmental Monitor (MEM) locations, except for HA-14, which is treated with the outfalls.

3.1 General Information

The following subsections present (1) general information applicable to AFP 59 and (2) sampling and analysis results for each site or zone. Some of the information presented, which is so identified, is the result of ANL's MEM field analyses described earlier in this report. The data are not to be construed as having CLP laboratory validity. Where appropriate, comparisons are also made with results from the prior study by Frederick C. Hart Associates (1988). The most important analyses, the data actually used for quantitative risk assessment, were produced, validated, and reviewed following CLP provisions.

3.1.1 Review of Site Data

The measures taken to ensure the validity of the analytical data used for quantitative risk assessment are described in this section.

3.1.1.1 Review of Field Records

Completeness of Field Records. The completeness and the accuracy of field notebooks were checked as part of a field audit performed by Gradient Corporation. When the field work was concluded, field records had been reviewed by the field supervisor. Inconsistencies in detail had been corrected with initialed and dated annotations at the time. According to Gradient, the records were complete and acceptable.

Field Identification of Valid Samples. A few QC samples were identified by the field QC officer as nonrepresentative and were discarded rather than analyzed. Problems that could have affected the representativeness of the remaining samples were noted in the field and are detailed in the sampling section of this report. None of these problems were considered serious enough to have warranted sample rejection.

Anomalous Field Data. No anomalous field data were noted, with the exception of occasional anomalies in well-water temperature during purging. These anomalies were recognized in the field, being attributed to slight differences in the time taken to collect the measurement samples. This effect was exaggerated by exceptionally cold weather, which increased the differences between well and air temperatures.

3.1.1.2 Review of Laboratory Data

All AFP 59 sample analyses performed by Galson Laboratories were validated in accordance with Section 9 of the QAPP (Appendix P). Data validation was performed by ECHEM, Inc., Windham, Maine. Validation actions were in accordance with USEPA Region II CLP Organics Data Review and Preliminary Review, March 1990, SOP No. HW-6, Revision #7, and the NYSDEC ASP, September 1989. The results of the validation are shown in Appendix A.

In accordance with state guidelines, several sample analytes were considered non-detects, with the detection limits raised to the levels found in the samples because of laboratory blank contamination. This modification contradicts AF IRP guidance (ref. p. 2141 of the AFP IRP 1989, version 3, handbook), but follows instructions by the AF Project Manager to give primacy to New York guidelines in cases where they are in conflict with IRP guidelines.

3.1.2 Data Summary

Laboratory analysis results are shown in Appendix F. Sampling locations are shown in Figure 1.2.

3.1.3 Data Usability

A critique of the analyses performed for this investigation and an assessment of data usability were made by Gradient Corporation, Cambridge, Massachusetts. An evaluation of field duplicate results, field- and laboratory-blank results, and matrix effects formed a part of that assessment. The data usability report is presented in Appendix A. As a general summary, validation actions were upheld, and all data were found usable. The results in Appendix F reflect the final conclusions of the data usability study.

Chemicals that were analyzed for but not detected were reported in Appendix F with a "U." These sample results, including those qualified with a "UJ," were not included in the tables associated with Sections 3.1-3.3.

Any concentration values for organic compounds or inorganic analytes deviating in minor ways from requirements for holding times, analytical spikes, duplicates, or other quality control parameters were considered estimated values and reported with a "J." Further, any inorganic concentration values reported as less than the contract-required detection limit (CRDL) but greater than the instrument detection limit were qualified with a "B." Values reported with either "J" or "B" qualifiers have been utilized as if they were not qualified (i.e., as if they were fully acceptable). Because they were not utilized in any decision making, neither "J" nor "B" qualifiers have been attached to concentration values that appear in tables associated with Sections 3.1-3.3.

All values qualified with an "R," indicating sample results rejected by the validation personnel, were purged from the data set and were not used.

3.1.4 Background Sampling

Because the plot of land containing AFP 59 is small and fully utilized, and because the surrounding area is highly developed, finding locations that were definitely unaffected by site activities was difficult. This subsection discusses the background locations chosen, the sampling results, and the degree to which those results represent true background conditions.

3.1.4.1 Groundwater Background Samples

A sample from up-gradient Johnson City Municipal Well #7 provided the designated groundwater background values. This source was less than ideal. Aside from not having been constructed according to monitoring well standards, the well is located several miles from the site. However, in addition to the aforementioned municipal well, the Cluster 1 (northeast-corner) wells and the Cluster 8 (southeast-corner) deep well must be considered as background sites for groundwater. These monitoring wells would nearly always provide samples of groundwater flowing generally westward into the aquifer underlying the AFP 59 property, from outside the property. This would be a matter of certainty for the times of the year — times of relatively low river levels — when the groundwater samples were acquired. These cluster well samples may have furnished more acceptable background samples than the distant Johnson City well, because these wells are proximal to the AFP 59 area. (It would be wrong to attribute any contaminants present in such samples to AFP 59 releases.)

Semivolatile organic compounds, pesticides, and PCBs were absent from all AFP 59 groundwater samples.

Among the volatile organic compounds (VOCs), a low level — 3 ppb — of 1,1,1-trichloroethane (1,1,1-TCA) was found in the one sample of water from JC Well #7; barely detectable levels were observed in most of the other background samples. A very low level of trichloroethene (or trichloroethylene, TCE) — ± 0.75 ppb — was found in water from JC Well #7, and slightly higher levels were found in the shallow-well Cluster 8 samples. The second deep well sample from Cluster 8 contained a low level of methylene chloride — 4 ppb — that equaled the highest level found in any other groundwater sample. Scattered, very low level concentrations of bromoform, dibromochloromethane, toluene, and xylene complete the list of background observations. The results are summarized in Table 3.1.

As discussed above, there is good justification to accept as background groundwater samples for the inorganic analytes not only from Johnson City Well #7, but also those from

TABLE 3.1 Concentrations of Volatile Organic Compounds in Background Wells

Compound	Concentration (µg/L) in Samples							
	JCBG2BW ^a	JCDW1AW ^b	JCDW1BW ^b	JCSW1AW ^c	JCSW1BW ^d	JCDW8AW ^d	JCDW8RW ^{d,e}	JCDW8BW ^d
Methylene chloride	-	-	-	-	-	0.7	-	4
1,1,1-Trichlorethane	3	0.4	0.6	-	0.5	0.3	0.2	0.6
Trichloroethene	0.7	-	-	-	-	-	-	-
Dibromochloromethane	-	-	0.2	-	-	-	-	-
Bromoform	-	-	0.3	-	-	-	-	-
Toluene	-	-	-	-	0.2	-	-	-
Xylene (total)	-	-	-	-	-	0.2	0.2	-

^a Background: Johnson City Well No. 7.

^b Cluster 1, deep well.

^c Cluster 1, shallow well.

^d Cluster 8, deep well.

^e Field replicate of JCDW8AW.

Cluster 1 shallow and deep wells and Cluster 8 deep wells. The concentrations of inorganics in these samples were generally low or average, as compared with the other AFP 59 groundwater samples. Standards were exceeded only for iron, manganese, nickel (one instance) and sodium, as well as the surface water limit for aluminum. It would appear that aluminum, iron, and manganese show up regularly at high levels in Johnson City groundwater. Conspicuously high concentrations for silver in one sample of water from the Cluster 1 deep well and for nickel from a single Cluster 8 shallow-well sample are to be viewed as transient phenomena. Because the Cluster 8 shallow well water might have been influenced by surface contamination, the high nickel concentration should not be considered as a background level. The results are summarized in Table 3.2.

3.1.4.2 Soil Background Samples

An on-site, above-grade, slope-sided location in a cut bank near the western AFP 59 boundary was selected to provide a designated soil background sample. The soil at that location was of the same geological unit as that from which many of the uppermost borehole samples were taken. The high slope-sided nature of the location should assure that it is free of contamination by on-site surface runoff or informal on-site dumping. A boundary fence, at least in recent years, should have discouraged dumping from the off-site side of the boundary. Although much of the slope surface contains discarded coal clinkers, the sampled area was free of them.

Cluster 1 is regarded as contamination-free and, therefore, as a second suitable source of background soil.

Cluster 8 was intended as a background site, but borehole soil contaminant concentrations were high and soil results will be examined as for contaminated sites. However, as expressed above, the deep well water is considered free of AFP 59 pollutants, and the condition of the shallow aquifer is problematic. No VOCs were detected in soil samples from any of these sites.

Initial analysis of the designated soil background sample for semivolatiles indicated only very low concentrations of phenanthrene and fluoranthene; these were not detected on reanalysis. Cluster 1 had relatively low concentrations of four noncarcinogenic polynuclear aromatic hydrocarbons (PAHs) and a noncarcinogenic phthalate ester. Background soil SOC and pesticide values are summarized in Table 3.3.

The designated soil background sample contained no pesticides. Cluster 1 soil samples showed only low levels of the pesticide aldrin (7.6 and 9.2 μg). The three sites showed unexceptional levels of metals, such that these analyses may all be considered representative of the natural soil background concentrations. (Refer to Table 3.4.)

TABLE 3.2 Concentrations of Inorganic Analytes in Background Wells

Inorganic Analyte	Concentration (µg/L) in Samples								NYSDEC Water Qual. Std. (GA)
	JCBG2BW ^a	JCDW1AW ^b	JCDW1BW ^b	JCSW1AW ^c	JCSW1BW ^c	JCDW8AW ^d	JCDW8RW ^{d,e}	JCDW8BW ^d	
Aluminum	-	818	152	355	1000	174	146	591	100 ^f
Antimony	-	-	-	-	-	-	-	-	3
Arsenic	-	-	-	-	-	-	-	2.4	25
Barium	170	109	71	101	122	55	46	30	1,000
Beryllium	-	-	-	-	-	-	-	-	3
Cadmium	-	-	7	-	8	-	-	4	10
Calcium	123,000	132,000	93,900	165,000	168,000	90,100	92,000	80,700	-
Chromium	-	17	16	10	-	26	18	17	50
Cobalt	-	-	-	-	-	-	-	-	5
Copper	-	9	-	7	3	5	-	-	200
Iron	-	1,970	151	848	1,340	378	386	1,130	300
Lead	-	5.5	1.7	1.5	1.9	1.3	-	-	25
Magnesium	25,800	31,400	22,400	26,000	26,900	28,100	27,900	28,200	-
Manganese	3	255	100	40	78	407	408	304	300
Mercury	-	-	-	-	-	-	-	-	2
Nickel	-	-	-	-	-	-	-	-	100 ^g
Potassium	2,390	4,600	7,630	2,380	2,690	50,300	45,600	43,400	-
Selenium	-	1.1	-	1.3	-	-	-	-	10
Silver	-	9	-	-	-	-	-	-	50
Sodium	70,600	91,200	75,600	283,000	301,000	112,000	104,000	93,800	20,000
Thallium	-	1.4	-	-	-	1.2	-	-	4
Vanadium	-	-	-	-	-	-	-	-	14 ^f
Zinc	-	85	92	80	-	38	39	-	300

^a Background: Johnson City Well No. 7.^e Field replicate of JCDW8AW.^b Cluster 1, deep well.^f Surface water.^c Cluster 1, shallow well.^g USEPA.^d Cluster 8, deep well.

TABLE 3.3 Semivolatile Organic Compounds and Pesticides in Background Soil

Compound	Sample Number and Depth (concentration in $\mu\text{g/kg}$)				
	JCBG1AS ^a (0.8–1.18 ft)	JCBG1AS-RE ^{a,b} (0.8–1.8 ft)	JCDW1AS ^c (8–10 ft)	JCDW1BS ^{c,d} (8–10 ft)	JCDW1CS ^c (18–20 ft)
Phenanthrene	63	-	160	-	-
Anthracene	-	-	17	-	-
Di-n-butyl phthalate	-	-	220	260	-
Fluoranthene	96	-	140	65	-
Pyrene	-	-	110	52	-
Aldrin	-	-	7.6	9.2	-

^a Background sample from near southwest corner of AFP 59.

^b Replicate analysis of background sample JCBG1AS.

^c Sample from cluster 1 borehole.

^d Replicate of sample JCDW1AS.

3.1.4.3 Surface Water Background Samples

Two creek water background sampling locations that were free of the influence of site activities were used for background sampling. One location provided regional and the other local stream conditions — both for creek water and for the outfalls. No VOCs, semivolatile organics, pesticides, or PCBs were detected in the background samples. The regional background levels exceeded regulatory limits for iron, aluminum, and zinc, whereas the local sample was slightly excessive only for aluminum. (See Table 3.5.)

3.1.4.4 Sediment Background Samples

Regional and local sediment background samples, free of the influence of site activities, were collected from the same locations as the aforementioned creek surface water background samples. The regional sediment contained no detectable organic compounds, whereas the local background sediment contained low levels of di-n-butyl phthalate, bis(2-ethylhexyl) phthalate, fluoranthene, and the pesticide aldrin (Table 3.6). Whereas the regional sediment appeared to contain unexceptional levels of inorganic analytes, lead and zinc appeared somewhat high in the local sediment, though still well within the normal ranges for U.S. soils. (See Table 3.7.)

TABLE 3.4 Concentrations of Inorganic Analytes in Background Soil

Analyte	Concentration (mg/kg) in Samples				Regional and Worldwide Backgrounds (mg/kg)			
	JCBG1AS ^a	JCDW1AS ^b	JCDW1BS ^{b,c}	JCSW1CS ^d	Eastern United States ^e		Worldwide ^f	
					Geom. Mean	Range	Median	Range
Aluminum	9,310	9,830	10,200	5,070	33,000	7000->100,000	71,000	10,000-300,000
Antimony	-	-	-	-	0.52	<1-8.8	1	0.2-10
Arsenic	8.2	5.2	5.5	3.2	4.8	<0.1-73	6	0.1-40
Barium	47.8	46.2	54.3	23.5	290	10-1,500	500	100-3,000
Beryllium	-	-	-	-	0.55	<1-7	0.3	0.01-40
Cadmium	-	-	-	-	-	-	0.35	0.01-2
Calcium	1,340	988	307	52,200	3,400	100-280,000	15,000	700-500,000
Chromium	14.3	14.6	16.4	8.3	33	1-1,000	70	5-1,500
Cobalt	6.1	10.5	10.9	6.9	5.9	<0.3-70	8	0.05-65
Copper	24.8	13.7	14.5	15.0	13	<1-700	30	2-250
Iron	19,400	22,000	22,800	13,600	14,000	100->100,000	40,000	2,000-550,000
Lead	19.9	10.5	10.8	5.2	14	<10-300	35 ^f	2-300
Magnesium	2,250	3,230	3,280	5,240	2,100	50-50,000	5,000	400-9,000
Manganese	555	505	533	401	260	<2-7,000	1,000	20-10,000
Mercury	0.1	-	-	-	0.081	0.01-3.4	0.06	0.01-0.5
Nickel	13.4	19.2	20.0	13.0	11	<5-700	50	2-750
Potassium	653	695	642	537	12,000	50-37,000	14,000	80-37,000
Selenium	0.38	-	-	-	0.3	<0.1-3.9	0.4	0.1-2
Silver	-	-	-	-	-	-	0.05	0.01-8
Sodium	-	-	-	-	2,500	500-50,000	5,000	150-25,000
Thallium	-	-	-	-	-	-	0.2	0.1-0.8
Vanadium	13.2	12.9	14.0	11.0	43	<7-300	90	3-500
Zinc	60.5	60.8	73.5	41.8	40	<5-2,900	90	1-900

^a Designated background sample; depth of 0.8-1.8 ft.^b Cluster 1 well borehole sample; depth of 8-10 ft.^c Field replicate of JCDW1AS.^d Cluster 1 well borehole sample; depth of 18-20 ft.^e Shacklette and Boerngen (1984).^f Bodek et al. (1988).

TABLE 3.5 Detected Inorganic Analytes in Background Surface Water ($\mu\text{g/L}$)

Analyte	Sample		NYSDEC Surface Water Quality Standard
	Regional JCCNCAW	Local JCCW1AW	
Aluminum	317	122	100
Calcium	18,400	33,400	-
Iron	362	145	300
Lead	1.3	-	50
Magnesium	4,530	6,590	35,000
Manganese	83	13	300
Mercury ^a	-	-	2
Potassium	1,090	1,950	-
Sodium	10,800	23,400	20,000 (groundwater)
Zinc	418	-	300

^a Mercury was detected in an environmental surface water sample.

3.1.5 Overall State of Contamination at AFP 59

3.1.5.1 Groundwater Contamination

Volatile Organic Compounds (VOCs). Overall groundwater contamination with VOCs was not high at AFP 59 (see Table 3.8). Less than background levels of 1,1,1-TCA were found in most monitoring well samples, but levels of this compound rose to 12 and 15 ppb in shallow well samples at Cluster 3 and Cluster 9. Although present in several wells below or somewhat above New York groundwater standards, TCE was found at relatively high levels (95 and 97 ppb) in the Cluster 4 shallow well. The contaminant 1,1-dichloroethane was seen in both deep and

TABLE 3.6 Detected Organic Compounds in Local Background Sediment

Compound	Concentration ($\mu\text{g/kg}$) in Sample
Di-n-butyl phthalate	270
Bis(2-ethylhexyl) phthalate	210
Fluoranthene	150
Aldrin	8.8

TABLE 3.7 Concentrations of Inorganic Analytes in Background Sediment

Analyte	Concentration (mg/kg) in Samples		Regional and Worldwide Backgrounds (mg/kg)			
			Eastern United States ^c		Worldwide ^d	
	Regional ^a	Local ^b	Geom. Mean	Range	Median	Range
Aluminum	10,500	9,240	33,000	7,000->100,000	71,000	10,000-300,000
Arsenic	4.3	5.6	4.8	<0.1-73	6	0.1-40
Barium	58.9	49.3	290	10-1,500	500	100-3,000
Beryllium	-	1.0	0.55	<1-7	0.3	0.01-40
Calcium	1,210	12,200	3,400	100-280,000	15,000	700-500,000
Chromium	16.5	16.0	33	1-1,000	70	5-1,500
Cobalt	13.4	10.0	5.9	<0.3-70	8	0.05-65
Copper	16.3	16.5	13	<1-700	30	2-250
Iron	30,500	27,000	14,000	100->100,000	40,000	2,000-550,000
Lead	13.4	92.1	14	<10-300	35 ^e	2-300
Magnesium	3,330	4,430	2,100	50-50,000	5,000	400-9,000
Manganese	584	464	260	<2-7,000	1,000	20-10,000
Mercury	-	0.07	0.081	0.01-3.4	0.06	0.01-0.5
Nickel	22.2	20.5	11	<5-700	50	2-750
Potassium	602	834	12,000	50-37,000	14,000	80-37,000
Selenium	-	0.29	0.3	<0.1-3.9	0.4	0.1-2
Sodium	-	72.4	2,500	500-50,000	5,000	150-25,000
Vanadium	13.7	13.4	43	<7-300	90	3-500
Zinc	66.4	134	40	<5-2,900	90	1-900

^a Sample JCCNSCS.^b Sample JCSD1AS.^c Shacklette and Boerngen (1984).^d Bodek et al. (1988).^e 12 mg/kg prior to global contamination; up to 1,000 mg/kg in urban soils.

TABLE 3.8 Concentrations of Volatile Organic Compounds Detected in Groundwater Samples^a

Analyte	Groundwater (µg/L)	JCDW3AW	JCDW3BW	JCDW3RW	JCSW3AW	JCSW3BW	JCDW4AW	JCDW4BW	JCSW4AW
Methylene chloride									
Acetone									
1,1-Dichloroethene									0.3J
1,1-Dichloroethane			0.3J	0.3J	5	2			0.4J
Chloroform					0.3J				
1,1,1-Trichloroethane		0.3J	0.2J	0.3J	12		0.3J	0.9J	2
Trichloroethene					9	7		0.2J	95
Dibromochloromethane									
Bromoform									
Tetrachloroethene									
Toluene			0.2J						
Styrene									
Xylene			0.2J						
Analyte	JCSW4BW	JCSW5AW	JCDW5BW	JCSW5BW	JCSW6AW	JCSW6BW	JCSW7AW	JCSW7BW	JCSW8AW
Methylene chloride	4								0.7J
Acetone		35							
1,1-Dichloroethene									
1,1-Dichloroethane	0.6J					0.2J			
Chloroform									
1,1,1-Trichloroethane	2	1.5	2	0.3J	1	1	0.2J	0.2J	
Trichloroethene	97				1	1	0.4J	0.4J	1.3
Dibromochloromethane		0.3J	0.2J						
Bromoform		0.6J	0.3J						
Tetrachloroethene									
Toluene		0.3J	0.3J						
Styrene									
Xylene			0.4J						

TABLE 3.8 (Cont.)

Analyte	JCSW8BW	JCDW9AW	JCDW9BW	JCSW9AW	JCSW9BW	JCDPWAU	JCDPWBW	NYSDEC Standard
Methylene chloride					0.9JB		0.6JB	5
Acetone								50
1,1-Dichloroethene								5
1,1-Dichloroethane				1.9	2	3	3	5
Chloroform								100
1,1,1-Trichloroethane		0.2J		15.2	15	2	3	5
Trichloroethene	1			9.5	10	5	7	5
Dibromochloromethane								50
Bromoform	0.2J							50
Tetrachloroethene						0.2J	0.2J	5
Toluene								5
Styrene		0.1J						5
Xylene								5 (each)

^a Values at or below background are shaded. Values at or above NYSDEC standard are boxed.

shallow wells at levels as high as 5 ppb, the groundwater standard. It appears, with exclusion of deep well contamination, that the distributions of 1,1,1-TCA, TCE, and 1,1-dichloroethane follow similar patterns; although the evidence is weak, it is not impossible that these distribution patterns are related to AFP 59 activities.

Four VOCs found at low concentrations (primarily in the deep wells) — dibromochloromethane, bromoform, xylene and toluene — appear to be area contaminants unrelated to site activities.

The compounds listed below are probably of little or no environmental concern because of their low concentration, infrequency of occurrence, failure to appear in both sampling rounds, and/or association with directly related laboratory or trip blanks:

- Acetone was detected only once, at DW-5. Considering the depth and isolated location of the well, as well as the transience of the occurrence, the value is suspicious. If not originating as laboratory contamination, the acetone could have come from an off-site source.
- Several trace detections of methylene chloride may be attributed to non-environmental contamination, because traces of the compound were also detected in associated laboratory or trip blanks. Alternatively, they can be considered as background contamination.
- All other VOCs occurred so sporadically, and at such low concentrations, that they can be considered insignificant.

Semivolatile Organic Compounds (SVOCs), Pesticides, and PCBs. None of these compounds was detected in AFP 59 groundwater.

Inorganic Analytes. Aluminum, barium, calcium, iron, magnesium, manganese, potassium, and sodium were detected in all groundwater samples; chromium and lead were present in most samples. Iron, manganese, and sodium frequently exceeded New York State regulatory standards. Other analytes that exceeded regulatory standards in some instances were antimony, cadmium, cobalt, and nickel. Although not exceeding groundwater standards, aluminum, chromium, magnesium, and vanadium were sometimes detected at concentrations above surface water standards, the only New York regulatory values available (see Table 3.9).

TABLE 3.9 Inorganic Analytes Detected in Groundwater Samples^a (µg/L)

Analyte	Concentration (µg/L) in Samples												
	JCDW3AW	JCDW3BW	JCDW3RW	JCSW3AW	JCSW3BW	JCDW4AW	JCDW4BW	JCSW4AW	JCSW4BW	JCDW5AW	JCDW5BW	JCSW5AW	JCSW5BW
Aluminum	1,040	4,330	8,750	1,270	808	2,930	1,250	1,850	5,900	218	1,450	1,360	497
Antimony						3.7					28.5		
Arsenic	2.4	2.5	4.1	4.1	2.8			3.1	3.3				
Barium	123	125	182	71	64.0	91.0	72.0	123	133	44.0	67.0	57	101
Beryllium									3.0	1.0			
Cadmium		6	8		6		7		14				9
Calcium	82,100	67,500	87,000	122,000	115,000	130,000	115,000	120,000	109,000	30,800	45,500	163,000	158,000
Chromium	25	22	23		7.0			38	29	59	41	63	47
Cobalt													
Copper		3.0	17.0	6.0	3.0				14.0			13.0	
Iron	2,070	6,170	12,400	1,640	1,070	4,200	1,560	2,930	7,390	489	1,840	3,070	674
Lead	2.3	4.1	5.9	1.0	1.1	2.5	1.3	4.9	4.2	1.8	1.5	14.6	1.9
Magnesium	24,600	22,900	25,900	21,400	21,400	31,800	28,900	23,800	22,300	9,370	14,200	32,100	29,100
Manganese	385	380	554	65	33.0	659	528	1,380	795	133	263	3,090	451
Mercury								0.10					
Nickel									57			100	39.0
Potassium	42,000	41,200	34,500	4,050	3,770	6,700	10,300	2,860	3,830	45,800	34,300	4,840	4,430
Selenium													
Silver							7.0		7.0				
Sodium	50,200	52,300	47,800	49,400	41,300	30,600	33,200	49,500	42,900	52,900	45,500	92,100	106,000
Thallium			1.0			1.2	1.4	1.3					
Vanadium				8.0									
Zinc	29.0		87.0	72.0		28.0		44.0	73.0	66.0		153	

TABLE 3.9 (Cont.)

Analyte	Concentration (µg/L) in Samples													
	JCDW6AW	JCDW6BW	JCSW6AW	JCSW6BW	JCSW7AW	JCSW7BW	JCSW8AW	JCSW8BW	JCDW9AW	JCDW9BW	JCSW9AW	JCSW9BW	JCDP6AW	JCDP6BW
Aluminum	1,640	2,120	3,990	19,800	1,060	2,290	9,590	11,300	1,150	3,940	9,750	8,290	70.0	151
Antimony		13.8												
Arsenic	4.8	4.1	2.9	6.7			4.3	5.2	2.7	2.8	4.9	5.1		
Barium	93.0	94.0	122	211	108	147	124	128	44.0	53.0	124	100	90.0	94.0
Beryllium				1.0										
Cadmium				14		10		5		7		7		7
Calcium	49,500	30,200	186,000	181,000	163,000	151,000	96,700	96,300	95,900	113,000	157,000	121,000	143,000	145,000
Chromium			13	30		5.0	15	19	27	16	24	12		
Cobalt							10.0				24			
Copper	5.0	4.0	15.0	26		8.0	23.0	20.0		10.0	35	19.0	10.0	12.0
Iron	3,280	2,860	9,030	26,700	1,760	4,590	10,300	12,100	2,810	7,800	12,100	10,900	358	547
Lead	1.5	2.7	5.3	14.6	2.1	3.5	7	10.5	1.5	4.1	8.1	8.7		3.3
Magnesium	17,000	10,100	31,800	36,600	26,700	25,400	15,500	16,500	16,900	18,800	28,100	20,700	27,000	28,600
Manganese	122	65.0	521	1,010	234	722	4,400	4,030	1,090	1,430	736	656	452	444
Mercury							0.11				0.10			
Nickel							115				48			
Potassium	12,700	17,800	4,240	9,970	4,120	3,960	4,330	4,730	33,100	25,800	6,350	6,490	1,900	1,840
Selenium					2.1	1.4								
Silver														
Sodium	31,800	34,500	41,700	40,000	50,400	46,000	23,800	20,700	59,200	58,100	21,600	21,100	48,300	48,700
Thallium					1.1								1.0	
Vanadium				35.0										
Zinc	26.0		81.0	106	64.0		195.0	70.0	74	88.0	110	73.0		72.0

^a Cyanide not detected.

3.1.5.2 Soil Contamination

VOCs were seen sporadically in soil at low concentrations. The two highest contaminant concentrations detected were 37 ppb of acetone (sample JC4H1AS, Site 4) and 14 ppb of trichloroethene (sample JCSW9AS, Cluster 9) (see Table 3.10). The amounts present were far too small to provide a reservoir capable of sustaining detectable VOC groundwater or air contamination.

Semivolatile soil contamination consisted almost exclusively of polynuclear aromatic hydrocarbons and phthalate esters (Table 3.11). In some cases, these were attributable to past activities; in others (e.g., Cluster 6), they were not. In addition to the authenticated laboratory analyses, field analyses (HA-series) with the Bruker Mobile Environmental Monitor (MEM) showed the presence of phenanthrene or anthracene, fluoranthene, and pyrene beneath the parking lot in samples HA-7 and HA-13 (Subsection 3.2.11).

Pesticides and PCBs were detected in soil only rarely and at low concentrations, with no pattern to their occurrence (Table 3.11).

TABLE 3.10 Volatile Organic Compounds Detected in Soil Samples ($\mu\text{g/kg}$)

Description	Sample ID JC_	Compound			
		Methylene Chloride	Acetone	1,1,1-Tri- chloro- ethane	Trichloro- ethene
Well Borehole Soil					
	SW4CS ^a				6
	SW6AS	6			
	SW7AS	6	8		
	SW7BS		12		
	SW9AS	3	10		14
	SW9BS	10		1	8
Named-Site Soil					
	1H1AS	7			
	3H1AS		37		
	4H1AS		9		
	4H2AS		9		

^a Split of JCSW4BS.

TABLE 3.11a Concentrations of Semivolatile Organic Compounds, Pesticides, and PCBs Detected in Named-Site Soil Samples

Compound	Concentration (µg/kg) in Samples							
	1H1AS	1H1CS	1H1CS-DL ^a	2L1AS	3H1AS	3H1AS-DL ^b	4H2AS	6H1AS
4-Methylphenol	210							
2,4-Dimethylphenol	100							
Naphthalene	4,100	3,000	2,500		3,900	4,200		35
2-Methylnaphthalene	1,400	1,100			1,300	970		
Acenaphthylene	88							
Acenaphthene	1,900							120
Dibenzofuran	2,100							43
Fluorene	2,900							120
Phenanthrene	9,800	2,000		55	990			1,000
Anthracene	2,800			12				250
Fluoranthene	9,900	1,700		180				2,000
Pyrene	7,900	1,000		140	67			1,900
Benzo(a)anthracene	4,200			120				1,000
Bis(2-ethylhexyl) phthalate	94	600			770		91	74
Chrysene	3,500	450		120				1,000
Benzo(b)fluoranthene	4,900	570		150	89			1,300
Benzo(k)fluoranthene	1,400	170		48	92			600
Benzo(a)pyrene	3,500	320		89	75			830
Indeno(1,2,3-cd)pyrene		190		67	62			
Dibenzo(a,h)anthracene	400							140
Benzo(ghi)perylene	1,700	180		89	64			470
Endosulfan II	84 ^b							
Gamma-chlordane	24							
Arochlor-1260				130				

^a DL = secondary dilution.^b Sample 1H1AS-DL.

TABLE 3.11b Concentrations of Semivolatile Compounds and Pesticides Detected in Well Borehole Soil Samples

Compound	Concentration (µg/kg) in Samples									
	DW-3	SW-4	SW-5	SW-6		SW-7			SW-8	SW-9
	JCDW3AS	JCSW4CS-RE	JCSW5BS	JCSW6AS ^a	JCSW6BS	JCSW7AS	JCSW7AS-RE	JCSW7BS	JCSW8BS	JCSW9AS JCSW9BS
2-Chlorophenol				110						
4-Methylphenol										
2,4-Dimethylphenol										
Naphthalene				240					1,300	
4-Chloro-3-methylphenol				100						
2-Methylnaphthalene				92					550	
Acenaphthylene									280	
Acenaphthene				1,100					230	
Dibenzofuran				390					510	
Fluorene				740					750	
Phenanthrene	390			6,000		33			2,700	
Anthracene	60			1,600					520	
Di-n-butyl phthalate		140	200	210	410		160			120 110
Fluoranthene	980			9,800	110	100	100		2,000	140
Pyrene	1,100			9,100	110		84		1,800	
Benzo(a)anthracene	530			5,300					850	
Bis(2-ethylhexyl) phthalate			530	11,000	230	330	540	210	150	
Chrysene	520			4,900	68				780	
Benzo(b)fluoranthene	550			5,200					850	
Benzo(k)fluoranthene	180			1,900					220	
Benzo(a)pyrene	340			3,700					580	
Indeno(1,2,3-cd)pyrene	140			1,600					280	
Dibenzo(a,h)anthracene				440						
Benzo(ghi)perylene				1,500					140	
4,4'-DDE				6						
Heptachlor epoxide				62					84	

^a Sample underwent secondary dilution.

The highest levels of inorganic contamination (Table 3.12), as expected, were associated with the Site A-2 plating area. These concentrations are not considered extreme. At all events, according to Hart (1988), EP toxicity limits (for eight important metals) were not reached at Site A-2; this indicates that the contaminants are firmly bound to the soil and are not necessarily connected with groundwater concentrations of those metals. Besides the authenticated laboratory analyses, field analyses with the Spectrace 6000 energy-dispersive X-ray fluorescence (EDXRF) spectrometer indicated relatively high concentrations of certain heavy metals at scattered points beneath the AFP 59 parking lot (Subsection 3.2.11), as listed below (in mg/kg):

- HA-9: cadmium, 10.
- HA-10: chromium, 446.
- HA-12: mercury, 2.3.
- HA-13: chromium, 110; copper, 547; nickel, 50; zinc, 156; silver, 3.9; and cadmium, 82.
- HA-15: mercury, 2.6.
- HA-18: arsenic, 374; copper, 4,722; lead, 201; selenium, 8.9; silver, 5.6; and zinc, 1,522.

3.1.5.3 Surface Water Contamination

Water in Little Choconut Creek. Only one sample, other than the two background samples, was taken from this source. It contained no detectable organics (i.e., VOCs, SVOCs, pesticides or PCBs). All inorganic analytes were within regulatory limits (Table 3.13), except mercury, which had a reported concentration of 4.9 $\mu\text{g/L}$ (vs. the standard of 2 $\mu\text{g/L}$). Because of the transience of stream pollutants, and especially in view of the absence of mercury from the two sampled outfall streams, the result for mercury should be viewed with skepticism; by itself, it should not become a basis for any kind of remedial action.

AFP 59 Outfalls. Of the VOCs, acetone, 1,1,1-TCA, TCE (exceeding the surface water regulatory value), and bromoform were detected in water from one or both outfalls. Among the SVOCs, fluoranthene, pyrene, bis(2-ethylhexyl) phthalate, and chrysene were reported to be in water from the second outfall; bis(2-ethylhexyl) phthalate and chrysene exceeded surface water limits (Table 3.14). No pesticides or PCBs were found. Of the inorganic analytes, only aluminum, iron, and sodium exceeded surface water standards (see Table 3.15).

TABLE 3.12 Concentrations of Inorganic Analytes Detected in Soil Samples

Analyte	Concentration (mg/kg) in Well Borehole Soil Samples										
	JCDW3AS	JCDW3BS	JCSW4AS	JCSW4BS	JCSW4CS	JCSW5AS	JCSW5BS	JCSW6AS	JCSW6BS	JCSW7AS	JCSW7BS
Aluminum	9,060	5,260	7,150	9,360	8,200	6,720	12,900	7,390	9,130	13,200	6,070
Antimony											
Arsenic	4.7	6.3	5.9	6.7	9.0	3.6	7.9	4.1	4.2	6.9	3.5
Barium	60.7	75.9	42.2	32.4	30.3	47.6	52.3	35.1	46.9	66.7	30.6
Beryllium	0.97	0.86						0.83	0.77		
Calcium	24,500	80,400	21,000	3,790	2,660	44,400	5,740	63,800	12,000	4,550	29,900
Chromium	13.6	8.1	11.5	14.9	12	10.6	18.6	11.4	12.5	18.2	10.2
Cobalt	8.2	5.7	8.1	10.1	9.0	6.9	13.3	6.4	8.3	10.0	5.2
Copper	21.2	13.9	18.4	13.9	11.5	13	16.7	13.9	24.8	22.3	16.1
Iron	21,400	15,000	18,900	21,700	18,300	17,100	27,200	16,100	21,400	23,900	13,200
Lead	7.4	8.2	7.1	14.4	13.5	5.5	12.7	14.8	9.9	7.5	5.8
Magnesium	5,120	6,030	6,380	3,840	3,060	6,330	5,900	10,800	4,040	3,410	3,940
Manganese	451	2,110	528	336	346	484	601	420	608	701	368
Mercury								0.05	0.06	0.08	
Nickel	17.1	13	15.8	18.2	14	13.2	24.5	13.9	16.5	21.2	
Potassium	961	451	582	885	867	623	1,520	878	935	1,380	1,120
Selenium								0.19		0.22	
Sodium	46.1				89.7				50.9	59.4	
Thallium											
Vanadium	13.8	13.4	12.3	11.4	10.5	11.8	17.3	75.2	13.6	14.6	8.8
Zinc	54.3	43.4	49.5	50.8	45.1	45.6	65.4	50.5	67.6	64.2	36.5
Cyanide			3.2		7.9						

TABLE 3.12 (Cont.)

Sample ID	Concentration (mg/kg) in Well Borehole Soil Samples				Concentration (mg/kg) in Named-Site Soil Samples					
	JCSW8AS	JCSW8BS	JCSW9AS	JCSW9BS	JC1H1CS ^a	JC2LIAS ^b	JC3H1AS ^c	JC4H1AS ^d	JC4H2AS ^d	JC6H1AS ^e
Aluminum	16,300	14,100	7,770	7,120	9,910	11,500	10,300	7,690	9,190	10,100
Antimony						1.6				
Arsenic	3.0	5.7	4.5	5.4	6.8	10.2	6.6	4.7	2.9	7.8
Barium	92.9	61.8			79.9	109	78.9	40	52.6	55.5
Beryllium						0.79				
Cadmium						7.5				
Calcium	915	2,960	35,700	49,800	5,600	28,200	1,270	3,700	1,980	4,260
Chromium	22.6	20.5	11.2	10.1	14.6	428	14.6	21.4	91.3	15.2
Cobalt	12.1	12.9			7.4	12.7	8.2		8.8	9.6
Copper	14.5	20.3	19.8	21.2	28.6	85.9	28.1	21.6	45.7	22.3
Iron	26,200	24,200	18,000	16,900	18,000	28,400	21,300	18,500	23,300	22,700
Lead	15.8	13.3	5.9	8.1	13.2	572	13.4	12.2	12.3	41.1
Magnesium	3,800	4,130	5,100	4,140	2,840	6,530	2,970	2760	2,990	3,460
Manganese	682	405	403	506	1,360	1,160	864	657	856	700
Mercury			0.07	0.06	0.07	0.13	0.07	0.06	0.10	0.07
Nickel	26.6	25.8	13.2	13.2	17.5	124	22.6	45.6	41	20.1
Potassium	828	1,330	808	760	1,300	1,370	885	818	735	972
Selenium	0.35	0.38				0.40	0.23			
Silver						2.8				
Sodium						578	33.4	25.3	31.3	58.0
Thallium						0.67				
Vanadium	19.5	18.5	9.5	9.9	10.4	19.4	10.1			13.4
Zinc	72.9	79.2	74.2	53.1	52.5	109	57.4	50.3	72.3	64.7
Cyanide					2.6					

^a Site A-1.^d Site A-4.^b Site A-2.^e Site A-6.^c Site A-3.

Field analyses by EDXRF of a soil sample from the bed of inactive Outfall #3 showed somewhat elevated values for silver and zinc (Section 3.2.9).

3.1.5.4 Sediment Contamination

One VOC, methylene chloride, was reported for the nonbackground sediment sample at a concentration of only 8 µg/kg. About 16 SVOCs, mostly PAHs and phthalate esters, were found in this sediment sample, along with one pesticide — aldrin (Table 3.16). In this sample, only copper, mercury, and vanadium were higher (by factors of less than 1.25) than both of the two background values (see Table 3.17).

3.1.6 Trend Analysis

In this section, relevant data for September 1986 samples reported by Fred C. Hart Associates, Inc. (1988), are compared with the more extensive (current) 1991/1992 data. The purpose of the comparison is to examine possible trends — increases or decreases in the concentrations of certain contaminants.

Hart sampling procedures differed in several respects from the ANL procedures. Water samples for metal analyses were filtered by Hart. In accordance with NYSDEC guidance, ANL water samples were not filtered. Hart VOC samples were preserved with thiosulfate; ANL VOC samples were not chemically preserved. In terms of laboratory methods, Hart and ANL organic analysis results are comparable. However, Hart's results from inorganic analyses were based on the Extraction Procedure Toxicity (EP TOX) methodology (since replaced by the related Toxicity Characteristic Leaching Procedure — TCLP); they are therefore not directly comparable with ANL results. Groundwater from shallow wells SW-1 and SW-3 and from the GE deep production well (DPW) were sampled by both Hart and ANL. Concentrations of VOCs that were detected in at least one location during both investigations are listed in Table 3.18. Inorganic analytes that were detected in groundwater during both studies are listed in Table 3.19.

The extent to which the above-mentioned procedural differences compromised comparability is not known. At face value, the 1986 results for groundwater (SW-1 and SW-3) are comparable with the 1991/1992 values. TCE was very slightly higher for the later set of samples. (However, the 1991/1992 TCA results were inconsistent, the compound having been

TABLE 3.13 Inorganic Analytes Detected in Creek Water (µg/L)

Sample ID	JCCW2AW
Aluminum	136
Calcium	345,400
Iron	183
Magnesium	6,470
Manganese	40
Mercury	4.9
Potassium	1,680
Sodium	19,200

Undetected: antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, nickel, selenium, silver, thallium, vanadium, zinc, and cyanide.

TABLE 3.14 Organic Compounds Detected in Outfalls^a

Compound	Concentration in Samples (µg/L)		New York State Surface Water Standards
	Outfall No. 1 JCOF1AW	Outfall No. 2 JCOF2AW	
Acetone	-	17	50
1,1,1-Trichloroethane	0.6	-	5
Trichloroethene	0.3	4	3
Bromoform	0.4	-	50
Fluoranthene	-	4	50
Pyrene	-	3	50
Bis(2-ethylhexyl) phthalate	-	8	4 ^b
Chrysene	-	2	0.002

^a Outfall No. 3 was not sampled.^b 0.6 µg/L for aquatic effects.TABLE 3.15 Inorganic Analytes
Detected in Outfalls^a (µg/L)

Sample ID	JCOF1AW	JCOF2AW
Aluminum	72.0	399
Barium	94.0	
Calcium	99,100	32,600
Chromium	6.0	
Iron	134	310
Lead	1.6	5.3
Magnesium	21,400	6,190
Manganese	168	36
Potassium	2,010	795
Selenium	1.1	
Silver	5.0	
Sodium	57,200	19,300
Zinc		93

Undetected: antimony, arsenic,
beryllium, cadmium, cobalt, copper,
mercury, nickel, thallium, vanadium.

^a Outfall No. 3 was not sampled.TABLE 3.16 Organic Compounds
Detected in Creek Sediment Samples
(µg/kg)

Sample ID	JCSD2AS
Methylene chloride	8
Naphthalene	270
2-Methylnaphthalene	110
Acenaphthene	380
Dibenzofuran	230
Fluorene	430
Phenanthrene	230
Anthracene	520
Di-n-butyl phthalate	300
Fluoranthene	2200
Pyrene	1800
Chrysene	790
Benzo(b)fluoranthene	830
Benzo(k)fluoranthene	330
Benzo(a)pyrene	610
Indeno(1,2,3-cd)pyrene	190
Benzo(ghi)perylene	190
Aldrin	18

detected in the first — but not the second — round of sampling.) Examination of water from the deep production well (DPW) in 1991/1992 indicated the disappearance of DCE since 1986 and a pronounced reduction in 1,1-dichloroethane (1,1-DCA). Concentrations of 1,1,1-TCA and TCE in groundwater were essentially the same in 1991/1992 as in 1986. Barium concentrations decreased from 1986 to 1991/1992 in water from SW-1 and DPW, but increased in SW-3. All three wells showed a decrease in arsenic and a small increase in cadmium. Lead evidenced the most dramatic change from 1986 to 1991/1992; while it ranged from 70 to 300 ppb in the three wells in 1986, the highest value in 1991/1992 was 3.3 ppb. Values for chromium were below the detection limit of 20 ppb in the 1986 samples and no more than 10 ppb in all the 1991/1992 samples.

In sum, several sets of analytical results were compared for groundwater samples taken in 1986 and in 1991/1992. The general trend was toward lower contaminant levels, with lead completely disappearing, and there were very few instances of increases in contamination.

3.1.7 Migration Pathways

It is evident from geohydrologic studies that, in general, groundwater passes under AFP 59 from the eastern side and emerges from the western side. The building and asphalt that cover the site minimize rainwater recharge through the AFP 59 property; as a result, it is highly unlikely that rainwater contaminants are leached to any degree into the upper aquifer (and even less likely into the lower aquifer). This phenomenon is especially true during winter, the season when samples were taken. During the spring, when the Susquehanna has reached flood stage, the groundwater would rise and might come into equilibrium with higher levels of inorganics that underlie part of AFP 59. Whether this happens or not, the low EP toxicity results for several metals recorded by Hart (1988) suggest that only very small amounts of the Site 2 metals would be extracted into the groundwater. Similarly, the high octanol-water partition coefficients of the carcinogenic PAHs would greatly retard their movement into the groundwater, even if they were exposed to significant quantities of recharge water or rising groundwater.

TABLE 3.17 Inorganic Analytes Detected in Sediment Samples (mg/kg)

Sample ID	JCSD2AS
Aluminum	9260
Arsenic	5.4
Barium	46.3
Beryllium	0.94
Calcium	7450
Chromium	16.5
Cobalt	10.3
Copper	20.5
Iron	26100
Lead	22.2
Magnesium	3410
Manganese	461
Mercury	0.08
Nickel	19.7
Potassium	851
Selenium	0.21
Sodium	82.0
Vanadium	14.1
Zinc	119

Note: Cadmium was not detected at or above the detection limit of 1.0 mg/kg.

TABLE 3.18 Comparison of Concentrations of Volatile Organic Compounds in Groundwater in 1986 and in 1991–1992^a

Compound	Concentration (µg/L) in Shallow Well No. 1 ^b			Concentration (µg/L) in Shallow Well No. 3			Concentration (µg/L) in Deep Production Well		
	1986	1991/1992		1986	1991/1992		1986	1991/1992	
		JCSW1AW	JCSW1BW		JCSW3AW	JCSW3BW		JCDPWA	JCDPWB
1,1-Dichloroethane	<1	<1	<1	<1	5	2	16	3	3
Trans-1,2-dichloroethene	<1	<1	<1	<1	<1	<1	66	<1	<1
1,1,1-Trichlorethane	<2	<1	0.5	<2	12	<6	9	2	3
Trichloroethene	<2	<1	<1	6	9	7	11	5	7

^a 1986 values come from Hart (1988); 1991/1992 values are from the current study.

^b Background values.

TABLE 3.19 Comparison of Concentrations of Detected Inorganic Analytes in Groundwater in 1986 and in 1991-1992^a

Analyte	Concentration (µg/L) in Shallow Well No. 1 ^b			Concentration (µg/L) in Shallow Well No. 3			Concentration (µg/L) in Deep Production Well		
	1986		1991-1992	1986		1991-1992	1986		1991-1992
	JCSW1AW	JCSW1BW		JCSW3AW	JCSW3BW		JCDPWAU	JCDPWBW	
Arsenic	20	<2	<2	10	4.1	2.8	10	<2	<2
Barium	210	101	122	50	71	64	140	90	94
Cadmium	7	<4	8	<5	<4	6	<5	<4	7
Chromium	<20	10	<5	<20	<5	7	<20	<5	<5
Lead	300	1.5	1.9	140	1	1.1	130	<1	3.3
Selenium	<5	1.3	<1	<5	<1	<1	<5	<1	<1

^a 1986 values come from Hart (1988); 1991/1992 values are from the current study.

^b Background values.

As discussed above, the total inventory of VOCs in the soil is probably far too small to constitute a reservoir from which these compounds could be carried into the groundwater. If that is indeed the case, any significant contribution of VOCs to the aquifer from AFP 59 must result from ongoing operations. Alternatively, the VOCs would have to originate upgradient of AFP 59. Note that the various VOCs are subject to microbial degradation during the time it takes to migrate from AFP 59 to the well fields. Specifically, Howard et al. (1991) considered the upper ends of the ranges for half-lives in groundwater to be as follows: 1,1-DCA, 22 weeks; TCA, 78 weeks; and TCE, 4.5 years. The first of these contaminants may biodegrade significantly before reaching the water distribution system.

3.2 Site/Interpretive Unit Sampling and Analysis Results

The identification of contaminants, along with the definition of their penetration into the environment, are the foundation upon which risk evaluation and remediation of sites are based. The goal of the RI conducted at AFP 59 was to accurately and sufficiently characterize the physicochemical conditions at the facility. The material presented in this section, along with site and regional features introduced in Section 3.1, help to establish site conditions. The format employed to describe site conditions involves the following three elements:

1. A data summary of analytical results for the environmental media sampled, compared with background levels. This summary includes identification of the sample location, followed by a review of the site data packages to show concentration ranges and means for chemicals detected above background levels.
2. The definitions of the sources of contamination, addressing the processes that generated the contamination.
3. The nature and extent of contamination at the surface or subsurface.

The following subsections present data on a site-specific basis.

3.2.1 Former Location of Waste Oil Tanks — Site A-1

3.2.1.1 Data Summary

Borehole samples were analyzed from depths of 8–10 ft (sample JC1H1AS) and 12–14 ft (sample JC1H1CS, just above the water table). The first of these samples was analyzed only for organics (VOCs, SVOCs, pesticides, and PCBs), whereas the second was analyzed for these organics plus inorganic analytes. A low concentration of methylene chloride (a common laboratory

contaminant), the only VOC, was present at 7 µg/kg at the shallower depth. A variety of SVOCs were detected in the first sample, while somewhat fewer SVOCs — and at generally lower concentrations — were detected in the second sample (Table 3.20). The inorganics in the second sample were quite unremarkable, except for a low level of cyanide, which is normally absent in soil samples (Table 3.21).

3.2.1.2 Definition of the Sources of Contamination

Site A-1 is located in an area of the plant where waste oil was formerly stored in tanks that have since been removed. Waste oil, containing a variety of petroleum PAHs, could have been spilled during transfer for disposal; also, oil could have leaked through loose piping joints or

TABLE 3.20 Organic Compounds Detected in Hand Soil Samples from Site A-1

Compound	Sample Number and Depth (concentration in µg/kg)			
	JC1H1AS 8-10 ft	JC1H1CS 12-14 ft	JC1H1CS-DL	JC1H1AS-DL
Methylene chloride	7			
Phenol	250			
4-Methylphenol	210			
2,4-Dimethylphenol	100			
Naphthalene	4,100	3,000		
2-Methylnaphthalene	1,400	1,100	2,500	
Acenaphthylene	88			
Acenaphthene	1,900			
Dibenzofuran	2,100			
Fluorene	2,900			
Phenanthrene	9,800			
Anthracene	2,800			
Fluoranthene	9,900			
Pyrene	7,900			
Benzo(a)anthracene	4,200			
Bis(2-ethylhexyl) phthalate	94	600		
Chrysene	3,500	450		
Benzo(b)fluoranthene	4,900	570		
Benzo(k)fluoranthene	1,400	170		
Benzo(a)pyrene	3,500	320		
Indeno(1,2,3-cd)pyrene		190		
Dibenzo(a,h)anthracene	400			
Benzo(ghi)perylene	1,700	180		
Endosulfan II				84
Gamma chlordan	24			

through holes caused by corrosion. But it is also possible that asphalt paving over the site is primarily responsible for the PAHs. This contamination does not seem to be dissolving in the groundwater.

The occurrence of metals at environmental levels was to be expected. The detection of cyanide, at such a distance from the plating operations of Site A-2, cannot, however, be explained easily.

3.2.1.3 Nature and Extent of Contamination

The contaminant profile in the subsurface, to the extent that two samples can provide such information, is as would be expected for the relatively immobile PAHs. Because of the proximity of Site A-3, it is not possible to determine whether the PAHs found at Site A-1 have spread laterally or represent a distinct and narrowly defined distribution.

TABLE 3.21 Inorganic Analytes Detected in a Hand Soil Sample from Site A-1 (Sample JC1H1CS)^a

Analyte	Concentration (mg/kg)
Aluminum	9,910
Arsenic	6.8
Barium	79.9
Calcium	5,600
Chromium	14.6
Cobalt	7.4
Copper	28.6
Iron	18,000
Lead	13.2
Magnesium	2,840
Manganese	1,360
Mercury	0.07
Nickel	17.5
Potassium	1,300
Vanadium	10.4
Zinc	52.5
Cyanide	2.6

^a Sample depth 12–14 ft.

3.2.2 Plating Building — Site A-2

3.2.2.1 Data Summary

Fred C. Hart Associates conducted preliminary sampling and analyses for seven heavy metals in soil at the Plating Building site (SB-1, SB-2, SB-3, and Plating Room East); however, only EP toxicity determinations were reported (three metals detected, Table 3.22). There was one exception, chromium, in which case EP toxicity concentrations were not detected, but total concentrations were reported. The EP toxicities were all at acceptable levels. The sample from beneath Plating Room East showed the highest values in the group for arsenic, barium, lead, and total chromium.

Hand-auger sample HA-17 was taken in early December 1991 from soil beneath the porch of the AFP 59 plating building, at a depth of 6 ft below the surface (see Section 3.2.11). Field

TABLE 3.22 Inorganic Analytes Detected in Preliminary Samples from Site A-2^a

Analyte	Hole Number and Depth (Concentration in $\mu\text{g/kg}$)						
	SB-1 (ft)		SB-2 (ft)		SB-3 (ft)		Plating Room East
	2-4	4-6	0.5-2	6-8	2-4	8-10	Near Surface
Arsenic — EP Tox. ^b	<10	<10	10	10	10	<10	20
Barium — EP Tox. ^b	<50	<50	<50	60	<50	<50	190
Lead — EP Tox. ^b	<20	80	60	100	40	70	310
Total Chromium ^c	7,700	12,400	12,600	16,100	18,000	67,000	43,600

^a Hart 1988.

^b Concentration in $\mu\text{g/L}$.

^c Concentration in $\mu\text{g/kg}$.

analytical instrumentation was used to qualitatively identify the presence in the soil of fluoranthene, pyrene, and anthracene/phenanthrene. Nine metals were present in the soil, according to field analyses with the Spectrace 6000 energy-dispersive X-ray fluorescence (EDXRF) spectrometer, at quantitatively determinable but not especially high levels (Table 3.23). The same hole was enlarged and soil sample JC2L1AS was taken (for authenticated laboratory analysis) with a stainless-steel split spoon at the end of January. The four previously identified PAHs, as well as seven other PAHs and Arochlor-1260, were determined in the laboratory (Table 3.24). In this sample, some relatively high metal concentrations were found (Table 3.23). These values may be compared with those of the nearby Cluster 4 well borehole samples (see Section 3.2.8), which were remarkably clean of organic contaminants and near background levels for inorganic analytes, except that cyanide was present.

3.2.2.2 Definition of the Sources of Contamination

A source for organic contamination is not readily apparent from the operational history of the site, but contamination may be the result of the use of an asphalt sealer for concrete work in the vicinity of the porch, as indicated by a black oily substance on the underside of the concrete. The metals and cyanide would most likely be attributed to leakage of plating solution.

3.2.2.3 Nature and Extent of Contamination

It would not appear that there is good linkage between concentrations of contaminants in the soil and groundwater media. The one possible exception, trichloroethene, could easily be a case of volatilization of the VOC from groundwater (see Section 3.1.5.2) into the soil, rather than dissolution of soil TCE by the aqueous medium. High concentrations of SVOCs and metals in sample JC2L1AS and undetectably low concentrations for almost all of these materials in the nearby borehole soil suggest that the contaminants are very localized.

3.2.3 WWII Oil/Water Separator Site — Site A-3

3.2.3.1 Data Summary

Laboratory analysis of a hand soil sample (JC3H1AS) from a depth of 10–14 ft indicated the presence of a single, but somewhat suspect, VOC (acetone, 37 µg/kg) at a fairly high concentration, bis(2-ethylhexyl) phthalate, and nine PAHs (Table 3.25). Concentrations of inorganic analytes were within normal ranges (Table 3.26).

TABLE 3.23 Inorganic Analytes Detected in Hand-Auger 17 and Test Bore Samples at Site A-2

Analyte	Concentration (µg/kg)	
	HA-17	Test Bore Sample JC2L1AS
Aluminum	-	11,500,000
Arsenic	11,000	10,200
Antimony	-	1,600
Barium	311,000	109,000
Beryllium	-	790
Cadmium	2,400	7,500
Calcium	-	28,200,000
Chromium	67,000	428,000
Cobalt	-	12,700
Copper	19,000	85,900
Iron	-	28,400,000
Lead	17,000	572,000
Magnesium	-	6,530,000
Manganese	-	1,160,000
Mercury	-	130
Nickel	-	124,000
Potassium	-	1,370,000
Selenium	-	400
Silver	1,200	2,800
Sodium	-	578,000
Thallium	-	670
Vanadium	64,000	19,400
Zinc	70,000	109,000

3.2.3.2 Definition of the Sources of Contamination

Site A-3 is located in an area of the plant where there was apparently a concrete oil-water separator. Reportedly, the separator was filled with sand and capped with concrete sometime in the 1970s. The lid of a concrete box is visible at the site. Waste oil, containing a variety of petroleum PAHs, could have been spilled during transfer for disposal; also, oil could have leaked through loose piping joints. It is also possible that asphalt paving over the site is primarily responsible for the PAHs.

3.2.3.3 Nature and Extent of Contamination

The single sample taken (A-3) provides no information on the vertical distribution of contaminants. It would not appear that there is any linkage between concentrations of contaminants in the soil and groundwater media. Because Site A-1 is nearby, it is not possible to determine whether the PAHs found at Site A-3 have spread laterally to adjacent sites or represent a distinct and narrowly defined distribution.

3.2.4 Settling Pond Area — Site A-4

3.2.4.1 Data Summary

Laboratory samples JC4H1AS and JC4H2AS, composited from cores at 13.0–15.6 ft and 13.0–16.5 ft, were taken from two angled boreholes, one beneath each tank (or "pond"). Acetone was the only reported VOC, at 9 µg/kg in each sample. A relatively low concentration of

TABLE 3.24 Organic Compounds Detected in Test Bore Sample JC2L1AS at Site A-2

Compound or Mixture	Concentration (µg/kg)
Phenanthrene	55
Anthracene	12
Fluoranthene	180
Pyrene	140
Benzo(a)anthracene	120
Chrysene	120
Benzo(b)fluoranthene	150
Benzo(k)fluoranthene	48
Benzo(a)pyrene	89
Indeno(1,2,3-cd)pyrene	67
Benzo(ghi)perylene	89
Arochlor 1260	130

TABLE 3.25 Organic Compounds Detected in Hand Soil Samples JC3H1AS and JC3H1AS-DL from Site A-3

Compound	Concentration (µg/kg)	
	JC3H1AS	JC3H1AS-DL
Acetone	37	No sample
Naphthalene	3,900	4,200
2-Methylnaphthalene	1,300	970
Phenanthrene	990	-
Pyrene	67	-
Bis(2-ethylhexyl) phthalate	770	-
Benzo(b)fluoranthene	89	-
Benzo(k)fluoranthene	92	-
Benzo(a)pyrene	75	-
Indeno(1,2,3-cd)pyrene	62	-
Benzo(ghi)perylene	64	-

bis(2-ethylhexyl) phthalate, 91 µg/kg, determined in sample JC4H2AS, was the only SVOC detected. There was no evidence of pesticides or PCBs. The only slightly abnormal metal concentrations were those of nickel and chromium (in JC4H2AS) (see Table 3.27). These results are rather similar to those for soil from the well cluster 4 area about 15 m to the north (see Section 3.2.8). Although soil contamination could have resulted from past leakage or overflow, no leakage has been documented. Overflow has occurred, but surrounding asphalt paving inhibits its penetration into the soil.

3.2.4.2 Definition of the Sources of Contamination

The underground sealed-masonry storage and settling tanks immediately southwest of the plating building are informally related to Site A-2. Except for a slightly above-average nickel concentration, metals concentrations were close to background levels; organic contaminants were not present.

3.2.4.3 Nature and Extent of Contamination

At the sampled depths, the area appears to be clean.

3.2.5 JP-4 Fluid Storage and Piping Area — Site A-5

3.2.5.1 Data Summary

Field analyses by means of the MEM (see Section 3.2.11) were unable to detect organics above the instrumental detection limit in site-related soil samples HA-1 through HA-6 (see Section 3.2.11.1).

TABLE 3.26 Inorganic Analytes Detected in Hand Soil Sample JC3H1AS at Site A-3

Analyte	Concentration (µg/kg)
Aluminum	10,300,000
Arsenic	6,600
Barium	78,900
Calcium	127,000
Chromium	14,600
Cobalt	8,200
Copper	28,100
Iron	21,300,000
Lead	13,400
Magnesium	2,970,000
Manganese	864,000
Mercury	70
Nickel	22,600
Potassium	885,000
Selenium	230
Sodium	33,400
Vanadium	10,100
Zinc	57,400

Although not formally site-related, SW-7 (see Section 3.2.8) is nearby, and soil from that area could contain contaminants related to Site A-5. Soil samples JCSW7AS and JCSW7AS-RE were collected for laboratory analysis from a core taken at 7–9 ft below the surface; sample JCSW7BS was a composite of cores at 14–16 ft and 16–18 ft. They showed low concentrations of the VOCs methylene chloride and acetone. As for other organics, the shallower sample showed low concentrations of four PAHs and of two phthalate esters, whereas the deeper sample showed only bis(2-ethylhexyl) phthalate (see Table 3.28).

Soil metal concentrations both in field analysis samples HA-1 to HA-6 and in the laboratory-analyzed soil samples from well borehole SW-7 were within normal ranges (Table 3.29).

TABLE 3.27 Inorganic Analytes Detected in Hand Soil Samples from Site A-4

Analyte	Sample No. and Depth (concentration in mg/kg)	
	JC4H1AS 13–15.6 ft	JC4H2AS 13–16.5 ft
Aluminum	7,690	9,190
Arsenic	4.7	2.9
Barium	40	52.6
Calcium	3,700	1,980
Chromium	21.4	91.3
Cobalt	-	8.8
Copper	21.6	45.7
Iron	18,500	23,300
Lead	12.2	12.3
Magnesium	2,760	2,990
Manganese	657	856
Mercury	0.06	0.10
Nickel	45.6	41.0
Potassium	818	735
Sodium	25.3	31.3
Zinc	50.3	72.3

TABLE 3.28 Organic Compounds Detected in Well Borehole SW-7 and Possibly Related to Site A-5

Compound	Sample Number and Depth (concentration in µg/kg)		
	JCSW7AS 7–9 ft	JCSW7AS-RE ^a 7–9 ft	JCSW7BS 19–18 ft
Methylene chloride	6	-	-
Acetone	8	-	12
Phenanthrene	33	-	-
Di-n-butyl phthalate	-	160	-
Fluoranthene	100	100	-
Pyrene	-	84	-
Bis(2-ethylhexyl) phthalate	330	540	210

^a RE = reanalysis.

TABLE 3.29 Concentrations of Inorganic Analytes Detected in Hand Auger Soil Samples and Well Borehole SW-7, Possibly Related to Site A-5

Analyte	Concentration (mg/kg) in Samples								
	HA-1(1) ^a	HA-1(2) ^b	HA-2 ^b	HA-3 ^c	HA-4 ^c	HA-5 ^{d,e}	HA-6 ^b	JCSW7AS ^f	JCSW7BS ^g
Aluminum	NA ^h	NA	NA	NA	NA	NA	NA	13,200	6,070
Arsenic	7.1	8.0	10.8	15.9	6.8	9.6, 17	10.9	6.9	3.5
Barium	329	334	341	402	395	365, 310	285	66.7	30.6
Cadmium	-	-	-	2.8	1.3	-, -	1.8	-	-
Calcium	NA	NA	NA	NA	NA	NA	NA	4,550	29,900
Chromium	47	52	49	52	40	58, 52	45	18.2	10.2
Cobalt	NA	NA	NA	NA	NA	NA	NA	10.0	5.2
Copper	26	15	27	14	17	12, 14	17	22.3	16.1
Iron	NA	NA	NA	NA	NA	NA	NA	23,900	13,200
Lead	16.7	16.8	14.5	11.2	10.6	16.5, 16.3	13.7	7.5	5.8
Magnesium	NA	NA	NA	NA	NA	NA	NA	3,410	3,940
Manganese	NA	NA	NA	NA	NA	NA	NA	701	368
Mercury	-	0.98	1.91	-	1.14	-, -	1.41	0.08	-
Nickel	-	-	-	-	-	-, -	-	21.2	-
Potassium	NA	NA	NA	NA	NA	NA	NA	1,380	1,120
Selenium	-	-	-	0.10	-	1.04, -	2.34	0.22	-
Silver	1.47	-	-	-	-	1.24, 5.1	1.37	-	-
Sodium	NA	NA	NA	NA	NA	NA	NA	59.4	-
Vanadium	97	93	76	79	91	80, 69	66	14.6	8.8
Zinc	79	66	74	80	92	89, 68	73	64.2	36.5

^a Depth of 3.25 ft.

^e Duplicate samples.

^b Depth of 4 ft.

^f Depth of 7–9 ft.

^c Depth of 4.3 ft.

^g Depth of 14–18 ft.

^d Depth of 5 ft.

^h Not analyzed.

3.2.5.2 Definition of the Sources of Contamination

JP-4 fuel was formerly piped underground through Site A-5 from a storage building to the manufacturing building. Some of the fuel may have leaked and been responsible for the relatively low-level soil concentrations of a few SVOCs in nearby soil. There is no evidence of heavy contamination by fuel residues. Because the ground surface is unpaved, the observed PAHs probably did not come from asphaltic materials.

3.2.5.3 Nature and Extent of Contamination

Minor soil contamination was observed at the levels sampled. No lateral spread of contaminants or their migration into groundwater is indicated.

3.2.6 Former Location of a Gasoline Storage Tank — Site A-6

3.2.6.1 Data Summary

Analysis of a borehole sample (JC6H1AS) from a depth of 10–14 ft indicated the absence of VOCs, pesticides, or PCBs, but revealed the presence of dibenzofuran, bis(2-ethylhexyl) phthalate, and 14 PAHs (Table 3.30). Concentrations of inorganic analytes were within normal ranges for the area (Table 3.31).

TABLE 3.30 Organic Compounds Detected in Hand Soil Sample JC6H1AS (10–14 ft) from Site A-6

Compound	Concentration (µg/kg)
Naphthalene	35
Acenaphthene	120
Dibenzofuran	43
Fluorene	120
Phenanthrene	1,000
Anthracene	250
Fluoranthene	2,000
Pyrene	1,900
Benzo(a)anthracene	1,000
Bis(2-ethylhexyl) phthalate	74
Chrysene	1,000
Benzo(b)fluoranthene	1,300
Benzo(k)fluoranthene	600
Benzo(a)pyrene	830
Dibenzo(a,h)anthracene	140
Benzo(ghi)perylene	470

TABLE 3.31 Inorganic Analytes Detected in Hand Soil Sample JC6H1AS (10–14 ft) from Site A-6

Analyte	Concentration (mg/kg)
Aluminum	10,000
Arsenic	7.8
Barium	55.5
Calcium	4,620
Chromium	15.2
Cobalt	9.6
Copper	22.3
Iron	22,700
Lead	41.1
Magnesium	3,460
Manganese	700
Mercury	0.07
Nickel	20.1
Potassium	972
Sodium	58
Vanadium	13.4
Zinc	64.7

3.2.6.2 Definition of the Sources of Contamination

Contamination could have come about through spillage and leakage of PAH-containing gasoline formerly stored at the

site. It could also have come from asphalt paving. Perhaps a reasonable hypothesis in this case is that the PAH constituents of asphalt pavement were dissolved by leaking or spilled gasoline and carried deeper into the ground.

3.2.6.3 Nature and Extent of Contamination

As stated in Section 3.1.4.2, this site is at a distance from manufacturing operations and may be considered a background site for inorganic contaminants. The contaminants, except for dibenzofuran and the often-found bis(2-ethylhexyl) phthalate, are all PAHs common to the heavier fractions of petroleum. The horizontal and vertical extent of contamination was not defined.

3.2.7 Perimeter Wells

3.2.7.1 Data Summary

The following soil sample numbers and corresponding core sampling depths apply to well boreholes in cluster areas 3, 5, 6, 8 and 9: JCDW3AS, 8–10 ft; JCDW3BS, 24–28 ft; JCSW5AS, 10–12 ft; JCSW5BS, 23–27 ft; JCSW6AS, 8–10.5 ft; JCSW6BS, 18–20 ft; JCSW8AS, 7–9 ft; JCSW8BS, 14–16 ft; JCSW9AS, 6–10 ft; and JCSW9BS, 12–16 ft. Note that soil samples from deep well borehole DW-1 are considered background samples.

VOCs were detected in samples JCSW6AS, JCSW9AS, and JCSW9BS (Table 3.32). These sampling points are situated along the western boundary of the plant property.

Ten PAHs were reported in soil sample JCDW3AS; two phthalate esters were reported in sample JCSW5BS; two phenols, two phthalate esters, dibenzofuran, fifteen PAHs, and 4,4'-DDE were reported in sample JCSW6BS; dibenzofuran, bis(2-ethylhexyl) phthalate, heptachlor epoxide, and fifteen PAHs (some at rather high levels) were reported in sample JCSW8BS; di-n-butyl phthalate and fluoranthene were reported in JCSW9AS; and di-n-butyl phthalate was reported in JCSW9BS (see Table 3.32).

Soil concentrations of inorganic analytes were within normal ranges (Table 3.33).

TABLE 3.32 Concentrations of Organic Compounds Detected in Perimeter Well Borehole Soil Samples

Compound	Concentration (µg/kg) in Samples ^a						
	JCDW3AS ^b	JCSW5BS ^c	JCSW6AS-DL ^d	JCSW6BS ^e	JCSW8BS ^f	JCSW9AS ^g	JCSW9BS ^h
Methylene chloride	-	-	6	-	-	3	10
Acetone	-	-	-	-	-	10	-
2-Chlorophenol	-	-	110	-	-	-	-
Naphthalene	-	-	240	-	-	-	-
4-Chloro-3-methylphenol	-	-	100	-	-	-	-
2-Methylnaphthalene	-	-	92	-	550	-	-
Acenaphthylene	-	-	-	-	280	-	-
Acenaphthene	-	-	1,100	-	230	-	-
Dibenzofuran	-	-	390	-	510	-	-
Fluorene	-	-	740	-	750	-	-
Phenanthrene	390	-	6,000	-	2,700	-	-
Anthracene	60	-	1,600	-	520	-	-
Di-n-butyl phthalate	-	200	210	410	-	120	110
Fluoranthene	980	-	9,800	110	2,000	140	-
Pyrene	1,100	-	9,100	110	1,800	-	-
Benzo(a)anthracene	530	-	5,300	-	850	-	-
Bis(2-ethylhexyl) phthalate	-	530	11,000	230	150	-	-
Chrysene	520	-	4,900	68	780	-	-
Benzo(b)fluoranthene	550	-	5,200	-	850	-	-
Benzo(k)fluoranthene	180	-	1,900	-	220	-	-
Benzo(a)pyrene	340	-	3,700	-	580	-	-
Indeno(1,2,3-cd)pyrene	140	-	1,600	-	280	-	-
Dibenzo(a,h)anthracene	-	-	440	-	-	-	-
Benzo(ghi)perylene	-	-	1,500	-	140	-	-
4,4'-DDE	-	-	6	-	-	-	-
Heptachlor epoxide	-	-	-	-	84	-	-

^a No organic contaminants were detected in samples JCDW3BS, JCSW5AS, or JCSW8AS.

^b Depth of 8–10 ft.

^d Depth of 8–10.5 ft.

^f Depth of 14–16 ft.

^h Depth of 12–16 ft.

^c Depth of 23–27 ft.

^e Depth of 18–20 ft.

^g Depth of 6–10 ft.

TABLE 3.33 Concentrations of Inorganic Analytes Detected in Perimeter Well Borehole Samples

Analyte	Concentration (mg/kg) in Samples									
	JCDW3AS	JCDW3BS	JCSW5AS	JCSW5BS	JCSW6AS	JCSW6BS	JCSW8AS	JCSW8BS	JCSW9AS	JCSW9BS
Aluminum	9,060	5,260	6,720	12,900	7,390	9,130	16,300	14,100	7,770	7,120
Arsenic	4.7	6.3	3.6	7.9	4.1	4.2	3.0	5.7	4.5	5.4
Barium	60.7	75.9	47.6	52.3	35.1	46.9	92.9	61.8		
Beryllium	0.97	0.86			0.83	0.77				
Calcium	24,500	80,400	44,400	5,740	63,800	12,000	915	2,960	35,700	49,800
Chromium	13.6	8.1	10.6	18.6	11.4	12.5	22.6	20.5	11.2	10.1
Cobalt	8.2	5.7	6.9	13.3	6.4	8.3	12.1	12.9		
Copper	21.2	13.9	13	16.7	13.9	24.8	14.5	20.3	19.8	21.2
Iron	21,400	15,000	17,100	27,200	16,100	21,400	26,200	24,200	18,000	16,900
Lead	7.4	8.2	5.5	12.7	14.8	9.9	15.8	13.3	5.9	8.1
Magnesium	5,120	6,030	6,330	5,900	10,800	4,040	3,800	4,130	5,100	4,140
Manganese	451	2,110	484	601	420	608	682	405	403	506
Mercury					0.05	0.06			0.07	0.06
Nickel	17.1	13	13.2	24.5	13.9	16.5	26.6	25.8	13.2	13.2
Potassium	961	451	623	1,520	878	935	828	1,330	808	760
Selenium					0.19		0.35	0.38		
Sodium	46.1					50.9				
Vanadium	13.8	13.4	11.8	17.3	75.2	13.6	19.5	18.5	9.5	9.9
Zinc	54.3	43.4	45.6	65.4	50.5	67.6	72.9	79.2	74.2	53.1

Water from the Cluster 8 deep well is considered part of the background (see Section 3.1.4.1). Water from the Cluster 8 shallow well (samples JCSW8AW and JCSW8BW) is somewhat questionable in this regard and will be considered a source of water potentially contaminated by AFP 59 in the present discussion. Of 19 monitoring-well water samples, 4 (JCSW5AW, JCDW6AW, JCDW6BW and JCSW6AW) were free of VOC contamination; VOC contaminants in the others are listed in Table 3.34. No SVOCs, pesticides, or PCBs were detected in any of these groundwater samples. Among the inorganic analytes, iron and sodium concentrations were invariably too high; manganese usually too high; and vanadium, cobalt, and nickel each excessive in one sample (JCSW6BW, JCSW8AW, and JCSW8AW, respectively; refer to Table 3.35).

3.2.7.2 Definition of the Sources of Contamination

The source for the heavy SV organics contamination in several of the soil samples is not known, but the contaminants are essentially immobile. The soil VOCs are present at concentrations low enough that they could not be the source of VOCs in the groundwater. Inorganic groundwater solutes present at high levels, such as aluminum, iron, sodium, and manganese, most likely entered the site at such levels. This is also probably true of VOCs in the deep well samples and is perhaps true of at least some VOCs in the shallow well samples. In any event, there is currently no information linking plant operations with the contaminants flowing away from the AFP 59 area beneath the western boundary (i.e., in the vicinity of Clusters 3, 5, 6, and 9). More soil sampling and analysis should be undertaken to clarify the situation.

3.2.7.3 Nature and Extent of Contamination

It would seem that some petroleum or coal products penetrated a considerable distance into the ground to cause the observed SVOC contamination, but neither the mechanism nor the extent of the contamination is known. The well cluster 8 area is near a former railroad spur and in the general area through which the pipe connecting the WWII separator with a former outfall probably passed. Either of these features could relate to the SVOC contaminants in cluster 8 soil. The SVOC contamination also occurs, however, in the perimeter soils that are distant from sites of known operations that might provide an explanation. This distribution of SVOC contamination might suggest that such soil contamination may extend across much of the soil beneath the plant. It might contrarily suggest that perimeter locations prior to grading or paving were selectively subject to activities resulting in contamination.

TABLE 3.34 Concentrations of Volatile Organic Compounds Detected in Perimeter Well Water Samples

Compound	Concentration (µg/L) in Samples									
	JCDW3AW	JCDW3BW	JCDW3RW	JCDW3AW	JCSW3BW	JCDW5AW	JCDW5BW	JCSW5BW	JCSW6AW	JCSW6BW
Methylene chloride										
Acetone						35				
1,1-Dichloroethane		0.3	0.3	5	2					0.2
Chloroform				0.3						
1,1,1-Trichloroethane	0.3	0.2	0.3	12		1.5	2	0.3	1	1
Trichloroethene				9	7				1	1
Dibromochloromethane						0.3	0.2			
Bromoform						0.6	0.3			
Toluene		0.2				0.3	0.3			
Styrene										
Xylene		0.2					0.4			

Compound	Concentration (µg/L) in Samples									
	JCDW8AW	JCDW8RW	JCDW8BW	JCSW8AW	JCSW8BW	JCDW9AW	JCDW9BW	JCSW9AW	JCSW9BW	
Methylene chloride	0.7		4	0.7					0.9	
Acetone										
1,1-Dichloroethane								1.9	2	
Chloroform										
1,1,1-Trichloroethane	0.3	0.2	0.6			0.2		15.2	15	
Trichloroethene				1.3	1			9.5	10	
Dibromochloromethane										
Bromoform						0.2				
Toluene										
Styrene							0.1			
Xylene	0.2	0.2								

TABLE 3.35 Concentrations of Inorganic Analytes Detected in Perimeter Well Water Samples^a

Analyte	Concentration (µg/L) in Samples								
	JCDW3AW	JCDW3BW	JCDW3RW	JCSW3AW	JCSW3BW	JCDW5AW	JCDW5BW	JCSW5AW	JCSW5BW
Aluminum	1,040	4,330	8,750	1,270	808	218	1,450	1,360	497
Antimony							28.5		
Arsenic	2.4	2.5	4.1	4.1	2.8				
Barium	123	125	182	71	64.0	44.0	67.0	57	101
Beryllium						1.0			
Cadmium		6	8		6				9
Calcium	82,100	67,500	87,000	122,000	115,000	30,800	45,500	163,000	158,000
Chromium	25	22	23		7.0	59	41	63	47
Cobalt									
Copper		3.0	17.0	6.0	3.0			13.0	
Iron	2,070	6,170	12,400	1,640	1,070	489	1,840	3,070	674
Lead	2.3	4.1	5.9	1.0	1.1	1.8	1.5	14.6	1.9
Magnesium	24,600	22,900	25,900	21,400	21,400	9,370	14,200	32,100	29,100
Manganese	385	380	554	65	33.0	133	263	3,090	451
Mercury									
Nickel								100	39.0
Potassium	42,000	41,200	34,500	4,050	3,770	45,800	34,300	4,840	4,430
Sodium	50,200	52,300	47,800	49,400	41,300	52,900	45,500	92,100	106,000
Thallium			1.0						
Vanadium				8.0					
Zinc	29.0		87.0	72.0		66.0		153	

TABLE 3.35 (Cont.)

Analyte	Concentration (µg/L) in Samples									
	JCDW6AW	JCDW6BW	JCSW6AW	JCSW6BW	JCSW8AW	JCSW8BW	JCDW9AW	JCDW9BW	JCSW9AW	JCSW9BW
Aluminum	1,640	2,120	3,990	19,800	9,590	11,300	1,150	3,940	9,750	8,290
Antimony		13.8								
Arsenic	4.8	4.1	2.9	6.7	4.3	5.2	2.7	2.8	4.9	5.1
Barium	93.0	94.0	122	211	124	128	44.0	53.0	124	100
Beryllium				1.0						
Cadmium				14		5		7		7
Calcium	49,500	30,200	186,000	181,000	96,700	96,300	95,900	113,000	157,000	121,000
Chromium			13	30	15	19	27	16	24	12
Cobalt					10.0				24	
Copper	5.0	4.0	15.0	26	23.0	20.0		10.0	35	19.0
Iron	3,280	2,860	9,030	26,700	10,300	12,100	2,810	7,800	12,100	10,900
Lead	1.5	2.7	5.3	14.6	7	10.5	1.5	4.1	8.1	8.7
Magnesium	17,000	10,100	31,800	36,600	15,500	16,500	16,900	18,800	28,100	20,700
Manganese	122	65.0	521	1,010	4,400	4,030	1,090	1,430	736	656
Mercury					0.11				0.10	
Nickel					115				48	
Potassium	12,700	17,800	4,240	9,970	4,330	4,730	33,100	25,800	6,350	6,490
Sodium	31,800	34,500	41,700	40,000	23,800	20,700	59,200	58,100	21,600	21,100
Thallium										
Vanadium				35.0						
Zinc	26.0		81.0	106	195.0	70.0	74	88.0	110	73.0

^a Deep Well No. 8 samples were excluded from this group because they are considered part of the background.

3.2.8 Interior Wells

3.2.8.1 Data Summary

Cluster 4 well borehole soil samples, namely JCSW4AS (at 6–8 ft) and JCSW4BS/CS (at 15.2–17.2 ft), were remarkably clean of organic contaminants and were near background levels for inorganic analytes, except that cyanide was present (Tables 3.36 and 3.37, cf. Section 3.2.2). Shallow well SW-7 borehole soil sample JCSW7AS was collected for laboratory analysis from a core taken at 7–9 ft below surface; sample JCSW7BS was a composite of cores at 14–16 ft and 16–18 ft. In comparison with many of the site soil samples, VOC and SVOC contamination was fairly low. Analyses for these samples have been presented in Tables 3.29 and 3.30.

Cluster 4 water samples (Table 3.38) contained five VOCs, with high concentrations of TCE in the shallow well (95 and 97 $\mu\text{g/L}$). Those high TCE values may be compared to the low concentration of this contaminant in the deeper borehole soil (6 $\mu\text{g/kg}$ in one of a pair of replicates). Shallow well SW-7 groundwater showed traces of contamination by 1,1,1-TCA (0.2 $\mu\text{g/L}$) and TCE (0.4 $\mu\text{g/L}$) in both rounds of sampling (JCSW7AW and JCSW7BW), echoing the higher concentrations of these and other VOCs in the GE deep production well (samples JCDPWA and JCDPWB; see Table 3.38). Water samples from the GE deep production well (DPW) contained four VOCs in both rounds of sampling (Jan. 9 and Feb. 3), namely 1,1-DCA, 1,1,1-TCA, TCE, and PCE; in addition, a low concentration of methylene chloride was reported for the second round (see Table 3.38).

There were no striking similarities or differences among inorganic analyte concentration patterns in groundwater samples from Cluster 4, shallow well SW-7, and the deep production well or between first- and second-round samples from the same well (Table 3.39). As they were in groundwater sampled elsewhere beneath AFP 59, aluminum, iron, manganese, and sodium concentrations tended to be high.

TABLE 3.36 Organic Compounds Detected in Well Borehole Soil Samples from Cluster 4, an Interior Well Cluster

Compound	Concentration ($\mu\text{g/kg}$) in Samples			
	JCSW4AS	JCSW4BS ^a	JCSW4CS	JCSW4CS-RE
Trichloroethene	-	-	6	-
Di-n-butyl phthalate	-	-	-	140

^a Field replicate of JCSW4AS.

TABLE 3.37 Inorganic Analytes Detected in Well Borehole Samples from Cluster 4, an Interior Well Cluster

Sample	Concentration (mg/kg)		
	JCSW4AS	JCSW4BS	JCSW4CS
Analyte			
Aluminum	7,150	9,360	8,200
Arsenic	5.9	6.7	9.0
Barium	42.2	32.4	30.3
Calcium	21,000	3,970	2,660
Chromium	11.5	14.9	12.0
Cobalt	8.1	10.1	9.0
Copper	18.4	13.9	11.5
Iron	18,900	21,700	18,300
Lead	7.1	14.4	13.5
Magnesium	6,380	3,840	3,060
Manganese	528	336	346
Nickel	15.8	18.2	14.0
Potassium	582	885	867
Sodium	-	-	89.7
Vanadium	12.3	11.4	10.5
Zinc	49.5	50.8	45.1
Cyanide	3.2	-	7.9

A case might be made for the hypothesis that relatively clean water from the unconfined (upper) aquifer had mixed with more heavily contaminated water from the lower stratum.

3.2.8.2 Definition of the Sources of Contamination

Sources of soil contamination by organic compounds cannot be identified. The soil inorganics are not out of the ordinary and are probably natural for the area. The exception of low concentrations of cyanide in Cluster 4 soil may be attributable to plating operations. The occurrence of strikingly high TCE levels in Cluster 4 shallow groundwater is inexplicable; because the soil did not show high levels of TCE, it may be necessary to seek an explanation by tracking current use and disposal of this solvent in the AFP 59 plant. Excess concentrations of certain metals in groundwater would appear to be mostly from off-site sources.

TABLE 3.38 Concentrations of Organic Compounds Detected in Interior Well Water

Compound	Concentration ($\mu\text{g/L}$) in Samples							
	JCDW4AW	JCDW4BW	JCSW4AW	JCSW4BW	JCSW7AW	JCSW7BW	JCDPWAU	JCDPWBU
Methylene chloride				4				0.6
1,1-Dichloroethene			0.3					
1,1-Dichloroethane			0.4	0.6			3	3
1,1,1-Trichloroethane	0.3	0.9	2	2	0.2	0.2	2	3
Trichloroethene		0.2	95	97	0.4	0.4	5	7
Tetrachloroethene							0.2	0.2
Toluene		0.2						

TABLE 3.39 Concentrations of Inorganic Analytes Detected in Interior Well Water

Analyte	Concentration (µg/L) in Samples							
	JCDW4AW	JCDW4BW	JCSW4AW	JCSW4BW	7CSW7AW	7CSW7BW	JCDPWAW	JCDPWBW
Aluminum	2,930	1,250	1,850	5,900	1,060	2,290	70	151
Arsenic	-	-	3.1	3.3	-	-	-	-
Barium	91	72	123	133	108	147	90	94
Beryllium	-	-	-	3.0	-	-	-	-
Cadmium	-	7.0	-	14.0	-	10.0	-	7.0
Calcium	130,000	115,000	120,000	109,000	163,000	151,000	143,000	145,000
Chromium	-	-	38	29	-	5.0	-	-
Copper	-	-	-	14.0	-	8.0	10.0	12.0
Iron	4,200	1,560	2,930	7,390	1,760	4,590	358	547
Lead	2.5	1.3	4.9	4.2	2.1	3.5	-	3.3
Magnesium	31,800	28,900	23,800	22,300	26,700	25,400	27,000	28,600
Manganese	659	528	1,380	795	234	722	452	444
Mercury	-	-	0.1	-	-	-	-	-
Nickel	-	-	-	57	-	-	-	-
Potassium	6,700	10,300	2,860	3,830	4,120	3,960	1,900	1,840
Selenium	-	-	-	-	2.1	1.4	-	-
Silver	-	-	7.0	-	-	-	-	-
Sodium	30,600	33,200	49,500	42,900	50,400	46,000	48,300	48,700
Thallium	1.2	1.4	1.3	-	1.1	-	1.0	-
Zinc	28	-	44	73	64	-	-	72

3.2.8.3 Nature and Extent of Contamination

The only worrisome contaminant associated with the interior wells is TCE in the groundwater, mostly in the Cluster 4 shallow well, but to a lesser degree in the deep production well. Additional monitoring would be required to locate the source and extent of this contaminant.

3.2.9 Outfalls

3.2.9.1 Data Summary

Analyses of sample JCOF1AW indicate that the only organics present in Outfall 001 are three VOCs at very low concentrations: 1,1,1-TCA, 0.6 µg/L; TCE, 0.3 µg/L; and bromoform, 0.4 µg/L (Table 3.14). Among the inorganic analytes (Table 3.15), only sodium exceeds regulatory limits.

Organic analyses of sample JCOF2AW from Outfall 002 show the presence of the VOCs acetone (17 µg/L) and TCE (4 µg/L), as well as low concentrations of three PAHs and bis(2-ethylhexyl) phthalate (Table 3.14). Except for aluminum and iron, inorganics are within New York State regulatory limits (Table 3.15).

Soil sample HA-14 (in the path of Outfall 003), taken at a depth of three feet, was examined by using field-portable instrumentation. It contained no MEM-detectable organics. Of the inorganic constituents determined with EDXRF spectroscopy, silver (3.5 mg/kg) and zinc (225 mg/kg) seemed somewhat high (Table 3.40).

TABLE 3.40 Inorganic Analytes Detected in Hand Auger Sample HA-14, Related to Outfall No. 3 (depth 3 ft)

Analyte	Concentration (mg/kg)	
	Original	Duplicate
Arsenic	26	35
Barium	397	398
Cadmium	3.8	2.0
Chromium	71	62
Copper	39	47
Lead	38	42
Selenium	Not detected	0.82
Silver	3.5	1.3
Vanadium	70	101
Zinc	225	242

3.2.9.2 Definition of the Sources of Contamination

Outfalls 001 and 002 are permitted for the discharge of storm runoff. Sampling point HA-4 is in the path of Outfall 003, which was formerly used for the seasonal discharge of noncontact cooling water. A soil sample from this spot was chosen for assessment of the outfall's impact on environmental quality because no water was flowing there at the time of sampling. Some of the inorganic analytes in sample HA-14 may have originated in the groundwater

source of the cooling water. It is reasonable to believe that some of the contaminants found in the outfall samples originated in previously contaminated soil, but such a rationale is not a likely explanation for the presence of VOCs. The SVOCs in Outfall 002 may be the result of extensive contact by runoff with the pavement, from which low concentrations of asphalt constituents, such as PAHs, have been leached.

3.2.9.3 Nature and Extent of Contamination

As would be expected for permitted outfalls, the water is relatively clean. The discharge from the outfalls is small compared with the flow of the Little Choconut Creek, and dilution is expected to minimize the impact of small concentrations of chemicals on the stream.

Though the extent of any contamination near Outfall 003 cannot be determined from one sample, the flow path from outfall to stream is short and well defined. Although field analysis data are not used for risk assessment, the contamination indicated by sample HA-14 would have little health or environmental significance. The presence of two metals at somewhat elevated levels nonetheless suggests that they be targeted in future monitoring, should the outfall continue or resume discharge.

3.2.10 Creek

3.2.10.1 Data Summary

An assessment of site-related surface water contamination is based upon a single sample of Little Choconut Creek water, JCCW2AW, taken on November 17, 1991. No organics were detected in this sample. All inorganics were below regulatory limits, except for mercury (Table 3.13).

The one sediment sample, JCSD2AS, was reported to contain a single detectable VOC, methylene chloride, at 8 µg/kg. It also contained dibenzofuran, di-n-butyl phthalate and 14 PAHs (Table 3.35). Inorganic analytes appeared to be within the normal ranges (Table 3.36).

3.2.10.2 Definition of the Sources of Contamination

Because mercury, the sole contaminant above regulatory limits identified in the surface water, was absent from the outfalls and the associated sediment sample, it may have come from upstream in the Little Choconut Creek. Perhaps it was the result of a minor discharge of short duration. Its presence must for now be considered an isolated instance and not necessarily attributable to AFP 59.

The presence of PAHs can be attributed to particulates carried to Little Choconut Creek by storm runoff from AFP 59's asphalt-paved parking lot.

3.2.10.3 Nature and Extent of Contamination

Only mercury was found at too high a level in the Little Choconut Creek. Because of the relatively swift movement of stream contaminants, as compared with soil, groundwater, or pond contaminants, one sampling on a single day is merely a snapshot of a rapidly changing situation. Proof of an ongoing presence of mercury would require continuous monitoring.

Contamination in sediment probably consists of numerous relatively water-insoluble petroleum constituents sorbed to organic or clay particles. Because of periods of turbulent flow, it is likely that sediment contaminants persist for some distance downstream.

3.2.11 MEM/EDXRF Screening Locations

3.2.11.1 Data Summary

As summarized in Section 2.2.4 and fully presented in Appendix I, ANL conducted an exploratory screening investigation of soil contaminants at AFP 59 in December 1991. Eighteen samples were collected with soil augers by boring to a depth of up to 3 ft. A Bruker "mobile environmental monitor" (MEM) gas chromatograph/mass spectrometer was used to analyze samples for the presence of organic compounds, and a Spectrace 6000, energy-dispersive X-ray fluorescence (EDXRF) spectrometer was used to analyze samples for the presence of metals. The (EPA) Level II quality data generated by these portable instruments cannot be used for risk analysis. Further, the GC/MS analyses were made at method detection limits of 0.2 ppm for volatiles and 10 ppm for semivolatiles. (The detection limit for metals analyses, by using EDXRF, was 10 ppm.) The results are useful for rapidly determining whether an area of soil is contaminated with low concentrations of metals or organic compounds. Sampling depths, formal and informal site and site-feature associations, and significant results are listed in Table 2.7. The areas sampled for field analysis are described below.

Formally Associated Locations

Field-analyzed samples from three areas have been discussed previously. The sample from location HA-14 is associated with Outfall 003 and was discussed in Section 3.2.9. A sample from location HA-17 was associated with Site A-2 and was discussed in Section 3.2.2. Samples from six locations in the Site A-5 area were discussed in Section 3.2.5.

Parking-Lot Locations

Nine samples were taken from beneath the asphalt surface of the rear parking lot. One was taken from the ridged "watershed" area in the approximate center of the lot (location HA-13). Soil here should represent the contaminant state of the lot's subsurface in that area prior to paving. This sample was taken from 2 ft below surface. The remaining eight samples were taken from locations along edges of the lot where the asphalt dips to form a marginal run-off trench. The asphalt in the trench was generally fissured with age, and standing water could migrate into the subsurface. One of the trench locations was along the south edge of the lot. The remaining trench locations were next to the fence on the north margin of the lot, near potential sources of transient contamination. Except for one sample from 2 ft below surface at location HA-11, the trench samples were all from 3 ft below surface (locations HA-7, 8, 9, 10, 12, 15, and 16). A surface sample (2 in. below surface) was collected near the southeast corner of the Special Programs Wing (location HA-18) in a fill area adjacent to an asphalt driveway.

Samples HA-7 and HA-13 gave positive MEM responses for an unidentified VOC at a sensitivity limit of 200 µg/kg, and the presence in the soil of the SVOCs fluoranthene, pyrene, and anthracene/phenanthrene was qualitatively identified in sample HA-11 at a detection level of about 10 mg/kg.

EDXRF analyses (Table 3.41) revealed the following particularly high analytical values:

- HA-9: 10.5 mg/kg of cadmium.
- HA-10: 446 mg/kg of chromium.
- HA-12: 2.3 mg/kg of mercury.
- HA-13: 82 mg/kg of cadmium; 110 mg/kg of chromium; 547 mg/kg of copper; 50 mg/kg of nickel; 3.9 mg/kg of silver; and 156 mg/kg of zinc.
- HA-15: 2.6 mg/kg of mercury.
- HA-18: 374 mg/kg of arsenic; 4,722 mg/kg of copper; 201 mg/kg of lead; 8.7 mg/kg of selenium; 5.6 mg/kg of silver; and 1,522 mg/kg of zinc.

TABLE 3.41 Concentrations of Inorganic Analytes Detected in Hand Auger Soil Samples under the AFP 59 Parking Lot

Analyte	Concentration (mg/kg) in Samples									
	HA-7 ^a	HA-8 ^a	HA-9 ^a	HA-10 ^a	HA-11 ^b	HA-12 ^a	HA-13 ^b	HA-15 ^a	HA-16 ^a	HA-18 ^c
Arsenic	12.5	17.6	8.6	19.2	20.7	18.9	28.1	38.0	20.1	374
Barium	315	288	321	264	322	259	327	284	426	64.9
Cadmium	-	-	10.5	-	0.92	7.0	82.3	-	6.2	-
Chromium	45.9	48.5	87.9	446	54.4	31.3	110	63.3	39.0	90.5
Copper	48.9	23.2	25.2	71.5	37.3	24.9	547	21.1	25.0	4,722
Lead	37.7	4.6	19.2	47.5	48.3	19.4	82.2	16.9	13.4	201
Mercury	1.4	-	0.79	-	-	2.3	0.14	2.6	-	-
Nickel	-	-	-	-	-	-	49.7	-	-	-
Selenium	0.46	1.9	-	-	-	-	0.88	-	0.79	8.7
Silver	1.04	-	2.3	-	0.48	-	3.9	-	3.4	5.6
Vanadium	85.6	103	90.4	71.1	98.2	91.4	63.3	83.3	87.6	55.8
Zinc	93.3	72.0	73.1	99.5	104	77.4	156	74.9	78.9	1,522

^a Depth of 3 ft.

^b Depth of 2 ft.

^c Depth of 0.16 ft.

3.2.11.2 Definition of the Sources of Contamination

North Edge of Parking Lot

The sampling locations along the northern edge of the rear parking lot were associated by proximity with site features as follows:

- HA-7: aboveground waste-oil storage tank,
- HA-8: toxic storage shed,
- HA-9: plating building,
- HA-10: settling ponds,
- HA-11: range building,
- HA-12: transformer pad, and
- HA-16: aboveground waste-oil storage tank.

It is probably significant that the only notable chromium concentration of this group and the highest chromium concentration detected anywhere on AFP 59 was found at location HA-10, near the settling ponds. During an overflow event observed during ANL field-work, water from the ponds ran across the pavement and pooled in the trench along the fence in the sampling area. Any similar overflows in previous years, when plating wastes were in the ponds, probably followed the same path. Any connection between the cadmium contamination at location HA-9 and the nearby plating building is through a less obvious migration route. Unidentified VOCs detected at HA-7 may or may not relate to the waste-oil storage tank there. Because of, in part, a nearby loading dock and a nearby outdoor storage, a great deal of plant activity has taken place in the general HA-7 area.

Center of Parking Lot

The elevated metal concentrations detected at location HA-13 suggest that the original graveled lot surface and/or material graded prior to paving was contaminated. The extent and the severity of such contamination remain unknown.

South Edge of Parking Lot

The source of the mercury found beneath the trench at the south edge of the parking lot is unknown, as is the source of a similar concentration encountered at location HA-12 on the north edge of the lot.

Building Corner

The results from sample location HA-18 are enigmatic. A corroding wall-mounted pipe in the area could account for some of the high metals readings. A small amount of improperly discarded liquids at HA-18 (which is the nearest graveled area to a garage bay), or past temporary outdoor storage activities in this locked-fence area, might account for the findings there. It is doubtful that HA-18 is extensive. Deeper soil samples from nearby soil bores A3H1 and A1H1 do not reflect the problem indicated at the HA-18 surface.

3.2.11.3 Nature and Extent of Contamination

Because the MEM, as operated, was not well suited for detecting or identifying low-ppb-level concentrations of organic compounds, the information presented here cannot be used to declare the majority of field-analyzed samples as "clean."

The soil beneath portions of the parking lot trench may have absorbed relatively high volumes of recharge water, depending upon the condition of the asphalt. If so, solutes in surface runoff could have concentrated in the soil at these locations. If metals contamination were confined to the relatively permeable ditch areas, it might be argued that the total metal inventory is low. However, the original parking lot surface in the HA-13 area appears to have been contaminated prior to paving. At present, it may only be concluded that metals contamination is present in the rear parking lot area.

3.3 Baseline Risk Assessment for Human Health Effects under a Current-Use Scenario

The purpose of this baseline risk assessment is to evaluate potential adverse health effects on the population in the vicinity of AFP 59 under conditions of current use. Exposures are assumed to occur under conditions of the no-action alternative, which is defined as the absence of any remedial actions to control or mitigate possible exposures or releases of toxic substances.

The procedures used in this risk assessment are consistent with U.S. Environmental Protection Agency (EPA) guidance, such as the Risk Assessment Guidance for Superfund (1989), and with the Air Force risk assessment guidelines (U.S. Air Force 1989); additional technical information and guidance documents have been used where appropriate. In addition, New York State Department of Environmental Conservation health-based standards for surface water and groundwater have been considered.

3.3.1 Scope and Organization

3.3.1.1 Scope

This risk assessment is concerned with potential risks to human populations in Johnson City and surrounding communities that could be exposed to, under conditions of current use, environmental contamination originating at the nearby AFP 59 site. Approximately 128,000 people draw their water from the Clinton Street-Ballpark Valley Aquifer, which may be affected by groundwater flowing beneath the AFP 59 site.

The following exposure scenarios are evaluated quantitatively:

- Ingestion by nearby adult residents of potable water from Johnson City municipal wells.
- Dermal contact by adult residents with potable water from Johnson City municipal wells.
- Inhalation by adult residents of volatile organic compounds emitted by potable water from Johnson City municipal wells.
- Dermal contact with Little Choconut Creek sediments by nearby resident children in the course of wading or recreational fishing. Ages 6 to 21 are considered (children are more likely to engage in these activities than adults).

Sampling data collected from November 1991 to February 1992 are used for quantitative risk estimates. Earlier data, as well as the identities of contaminants from monitoring wells associated with the municipal well field, are presented for comparison.

3.3.1.2 Organization

The format of this report follows the EPA's recommended outline (EPA 1989) and is organized in eight sections, including this introductory section. Section 3.3.2, Selection of Chemicals of Potential Concern, summarizes data collection and the details of the selection of chemicals of potential concern. Section 3.3.3 identifies all potentially exposed populations and evaluates potential exposure pathways. Section 3.3.3 also provides estimates of environmental concentrations of contaminants at exposure points and contaminant intakes for specific pathways. Section 3.3.4 summarizes the noncarcinogenic and carcinogenic health effects related to the chemicals of potential concern. Section 3.3.5 combines the results of the exposure and toxicity assessments to characterize the potential for adverse health effects. Section 3.3.6 evaluates the uncertainties related to this risk assessment. Section 3.3.7 summarizes the risk assessment, and Section 3.3.8 lists the references.

Four appendixes are relevant to the risk assessment. Appendix K provides additional details of the sampling and analytical data. Appendix L provides calculations of Henry's Law constants required to select dermal absorption factors for sediment contaminants. Appendix M presents an estimate of the maximum potential effect of soil contaminants in Well Cluster 9 on the aquifer water quality. Appendix N contains expanded toxicity summaries for chemicals contributing significantly to risk at AFP 59.

3.3.2 Selection of Chemicals of Potential Concern

3.3.2.1 Origin of Contamination

Air Force Plant 59 was designed and built in 1942 by PLANCOR, the Defense Plant Corporation, on the north bank of the Little Choconut Creek, a tributary that discharges to the nearby Susquehanna River. The plant contains 14.3 acres of space covered by buildings in a total land area of 29.6 acres. The half of the area not occupied by buildings was at first bare or vegetated, but much of this area was paved over for parking in 1959.

From 1942 to 1945, the plant was operated by Remington Rand for the manufacture of aluminum aircraft propellers. After that, it was closed for four years. Since reopening in 1949, the plant has been used by the General Electric Company for the production of aircraft controls. In 1974, a water supply well was sited immediately south of the manufacturing building to reduce the plant's demand on Johnson City municipal water supplies. Operations at AFP 59 have generated a variety of waste products, including oils, degreasing solvents, plating acids, caustics, chromium

and cyanide solutions, and paint residues. Past and present waste disposal practices at AFP 59 are summarized below.

- Concentrated plating baths (possibly containing chromium, cyanide, arsenic, lead, cadmium, and barium) were stored from 1952 to 1990 in an aboveground holding tank and removed as hazardous waste by a contractor. Since 1990, 55-gal drums have been used for disposal of the concentrated plating baths.
- Plating rinse water was treated in a settling tank to precipitate metals before the water was discharged to Outfall No. 001 from 1952 to 1969. The plating rinse water was treated in a settling tank for chromium reduction and metal precipitation before the water was discharged to Outfall 001 from 1969 to 1984. From 1984 to 1988, the plating rinse water was treated for reuse with a mixed ion-exchange resin column. From 1988 to the present, the plating rinse water has been discharged into the sanitary sewer.
- Waste oils were primarily recovered, although some of the waste oils were discharged to an oil/water separator upstream of Outfall No. 002 from 1942 to 1953. The waste oils were discharged to two underground waste-oil storage tanks and removed by contractor for disposal from 1953 to 1985. Since 1985, the waste oils have been discharged to an aboveground storage tank and are removed monthly by a private contractor.
- Kerosene-based degreasing solvents were disposed of with the waste oils from 1942 to 1969. Spent solvents were drummed and removed by a contractor until 1990. Since then, halogenated solvents have been used and recycled with the aid of a distilling unit. Trichloroethene, however, has not been used at the plant since 1985 (Schneider 1985). Other organic solvent and solvent-contact wastes (including still bottoms, waste flux, and plant shop waste) have been removed by a contractor.

Six sites (Figure 1.2) have been examined as potential sources of contamination, five of them on the south side of the plant and one on the north:

- Site A-1, the former underground waste-oil storage tanks area, contained two interconnected 1,000-gal underground storage tanks for temporary storage of waste oils from 1953 until their removal in 1985. Spills occurred during monthly collection of the oils for disposal. In the course of tank removal operations, the gravel surrounding both tanks was found to be heavily stained. The stained gravel and soil around the tanks were excavated to a depth of 12 ft (approximately 6 ft below the bottom of the tanks) and removed from the site. The remaining soil was determined to be nonhazardous. The tanks were replaced by a single, double-walled aboveground tank. Information is available

on the waste types associated with this site, but no specific contaminants can be traced to these waste types.

- At Site A-2, General Electric personnel observed discolored soils while repairing a leak in the underground sprinkler main beneath the plating building. Soil samples from beneath the building and from the test borings immediately south of the building were analyzed for metals; contaminants were found, including arsenic, barium, lead, and chromium. The highest chromium concentration was 67.4 mg/kg at a depth of 8–10 ft. No concentrations exceeded maximum allowable limits for extraction procedure (EP) toxicity, which is 5.0 mg/L.
- Some organic contamination appears to be present at Site A-3, the World War II (WWII) Oil/Water Separator Site. The separator was reportedly filled with sand and capped with concrete during the 1970s.
- Site A-4 is immediately south of the plating building and is the location of storage and settling tanks for plating room liquids. At the time of sampling, the settling tank was open-topped and near the plant buildings. The storage tank for spent plating solution was covered, and the contents were to be removed as hazardous material by a contractor. For about six months in 1991, burnite (an alkaline mixture containing citrate, surfactants, and sequestering agents) was also placed in the storage tank for spent plating solution before removal by the contractor as hazardous material. The storage tank has not been used to hold hazardous waste since June 1991. Plating rinse water and neutralized burnite are run through the settling pond and into the sanitary system. In May 1991, one soil sample was recovered from immediately below each tank by means of angled boreholes. A single composite sample, representing material from 10–12 ft and 13–15 ft below surface, was taken from beneath each tank. Both samples were analyzed for pH, heavy metals, and volatile organics according to the Toxicity Characteristics Leachate Procedure (TCLP, successor to the EP toxicity procedure). The pH levels (8.80 beneath the settling tank and 7.58 beneath the holding tank) were within the accepted range of 5–9. Barium and tetrachloroethene were detected in the samples from beneath both tanks; cadmium and chromium were detected under the holding tank. All detections were well below RCRA TCLP regulatory levels.
- No contaminant data are available for Site A-5, the fluid storage and piping area.
- Polynuclear aromatic hydrocarbons (PAHs) were found in soil at Site A-6, the former gasoline storage tank area. The tank was reportedly removed in 1975.

The overriding environmental concern with respect to the AFP 59 site is the possible pollution of the Johnson City residential water supply. Monitoring wells surrounding the

Johnson City well-field were recently sampled and analyzed (URS 1992). The following analytes exceeded New York State groundwater standards at least once: 1,1,1-trichloroethane, benzene, sec-butylbenzene, chromium, iron, manganese, sodium, zinc, and antimony. The municipal water supply wells were found to have low levels of 1,1,1-trichloroethane, dichlorodifluoromethane, tetrachloroethane, trichloroethene, and trace levels of benzene. However, it should be noted that many of these compounds do not exceed New York State groundwater standards at the AFP 59 site. Possible sources of organic contamination appear to exist north of the well field. The sources of antimony appear to be northwest and southwest of the well field (in the opposite direction from AFP 59). Multiple sources may be responsible for other metals, especially chromium. According to URS Consultants, Inc., "The apparent presence of a groundwater divide between the Camden Street Well Field and potential contaminant sources at AFP 59 provides local flow restriction between the two sites. However, under certain circumstances ..., a transient divide could allow either direct or circuitous groundwater flow from AFP 59 toward discharge at the well field" (URS 1992). The possibility that groundwater from beneath the Site is affecting the Johnson City municipal well field is further discussed in Section 1.2.3 of the Site Inspection Report (ANL 1993).

The soil beneath the plant does contain detectable levels of contaminants. Nevertheless, their link with these contaminants in groundwater beneath the site is, at best, tenuous, as determined by analyses of water from both shallow and deep monitoring wells. Virtually the entire AFP 59 property is occupied by buildings or covered with pavement. Very little precipitation penetrates the soil; thus, almost no water is available to carry contaminants to the aquifer. Because the property is located in the Susquehanna River floodplain, it sometimes experiences rises in the water table, even to the point of basement flooding. Thus, groundwater may occasionally come in contact with the soil contaminants. Despite the presence of contaminants in the soil at Site A4, samples of that soil subjected to the TCLP analysis have shown little tendency for metals or volatile organic compounds to be extracted into water, so the TCLP values have been far below allowable limits.

Samples drawn at the up-gradient edges of the plant property appear to contain enough contaminants to suggest that at least part of the AFP 59 groundwater contamination originates off-site.

The one body of surface water that would be expected to suffer from AFP 59 runoff pollution, Little Choconut Creek, was found to have very few contaminant concentrations above surface water guidelines. This finding is surprising in view of the magnitude of the AFP 59 operation and the level of urban development upstream. The stream sediment, however, was found to have contaminant levels above those found in background sampling locations and is therefore a possible source of risk.

3.3.2.2 Precursors to the Current Effort

Prior Contaminant Identification Efforts. A program records search of AFP 59 (reviewing installation records, touring, and interviewing employees at the site) was completed in October 1984 by CH2M Hill. The contractor identified and prioritized spill sites posing a potential threat to public health or the environment through contaminant migration, in particular the underground waste-oil storage tanks and the drum storage area. The potential for groundwater migration of hazardous contaminants was deemed moderately high in view of the moderate net annual precipitation rate, short distance to groundwater (15 ft), high soil permeability, and the absence of a continuous low-permeability confining stratum in the unsaturated zone. Although no environmental stress was observed, it was recommended that field sampling and laboratory analyses be performed to confirm or disprove the presence of environmental contamination at AFP 59 (CH2M Hill 1984).

A second study of AFP 59 was completed in March 1988 by Fred C. Hart Associates. That study defined and quantified the presence of contamination at AFP 59. The groundwater contaminants of particular concern were lead, cadmium, trans-1,2-dichloroethene, and trichloroethene. It was recommended that additional studies be performed to further define the presence, evaluate the potential sources, and determine the magnitude and extent of the contamination at AFP 59 (Hart 1988).

Analyses performed on soil from beneath the plating room liquid storage and settling tanks have been discussed in Section 3.3.2.1.

Phase II Stage 2 Installation Restoration Program. A 1988 study by EA Engineering, Science and Technology, Inc., laid the groundwork for the current program. It first identified existing data gaps (EA 1988):

- Lack of adequate AFP 59 groundwater quality data because there are too few monitoring wells and they are poorly positioned.
- Lack of up-gradient and down-gradient monitoring wells.
- Lack of analyses of the full range of potentially hazardous constituents used in past AFP 59 operations.
- Effect of clay layers on contaminant migration.
- Impact of Little Choconut Creek on groundwater quality at AFP 59.

- Impact of surface runoff on Little Choconut Creek contamination.
- Off-site source contributions to groundwater contamination at AFP 59.

The report also identified the following important objectives to be achieved by monitoring well installation, the most important initiating activity:

- Determine if AFP 59 is contributing to groundwater contamination in the area.
- Determine and further define the nature of contaminants leaving the area.
- Determine the rate and direction of contaminant migration.
- Provide more precise information on the physical characteristics of the underlying geology and groundwater flow direction and rates.
- Provide analytical data for evaluating potential sources of contaminants present in the deep aquifer.
- Provide site-specific quantitative information upon which recommendations for further actions can be made.

Certain additional objectives that were identified during the formative stages of the present effort are added here:

- Obtain surface water and sediment samples from the Little Choconut Creek for Target Compound List (TCL) samples.
- Install five shallow and five deep aquifer-monitoring wells, obtain soil samples from borings from seven well areas for TCL analysis, and obtain water samples from all wells for TCL analysis.
- Identify populations potentially affected, identify pathways of potential exposure, and perform a baseline health risk assessment.

3.3.2.3 Overview of Stage 2 Sampling and Analysis

Field samples were taken by Argonne National Laboratory (ANL) and analyzed by Galson Laboratories. Data validation was conducted by ECHEM, and data quality was assessed by Gradient Corporation (Wait 1992). The complete data set is presented in Appendix K.

Well-Borehole Soil Samples. Well-borehole sampling consisted of 15 field samples, 3 field replicates, 1 background sample, and 2 field blanks. The "A" series came from shallower depths, while the "B" series (e.g., JCDW1BS) came from lower depths. JCDW1AS stands for "Johnson City deep well, sample 1, A series, soil." Two rinsate blanks were associated with these soil samples. The samples were taken during November and December 1991.

Groundwater Samples. Groundwater sampling comprised 32 field samples, 2 field replicates, 1 background sample, and 1 field blank. The "A" series (first round) samples were taken from January 5 through January 9, 1992. The "B" series (second round) samples were taken from January 29 through February 3, 1992. The bailer blank with which these were compared was taken in November 1991. No pesticides, PCBs, or semivolatiles were found in the groundwater.

Named-Site Test Bore and Hand Soil Samples. Named-site test bore and hand soil sampling consisted of 6 field samples; a seventh sample was collected for volatile and semivolatile organic analysis only.

Creek Sediment Samples. Creek sediment sampling consisted of 2 field samples and 1 background sample collected in November 1991. However, sediment collected from the most upstream field sampling point must be regarded as a local background sample.

Creek Water Samples. Creek water sampling consisted of 2 field samples and 1 background sample collected in November 1991. However, water collected from the most upstream field sampling point must be regarded as a local background sample.

Outfall Samples. Outfall water sampling consisted of 2 field samples collected on November 23, 1991. The field blank for water sampling, a bailer blank, was taken earlier in the same month.

3.3.2.4 Data Criteria and Quality (Wait 1992)

As stated above, the data were validated by ECHEM and reviewed by D. Wait of Gradient Corporation. During this effort, data qualifiers reported by the laboratory and quality control information were reviewed and the usability of the data was evaluated.

Chemicals that were analyzed for, but not detected, were reported with a "U." These sample results, including those qualified with a "UJ," were treated in this risk assessment as non-detects. Concentration values associated with "U" qualifiers were the analytical detection limits. When contaminant concentrations were averaged, half of the associated "U"-qualified value was used for each such non-detect, with two exceptions: (1) if all the values for a contaminant in a given medium were non-detects (i.e., "U"-qualified), the average was considered zero, and (2) if a non-detect value was "UD"-qualified (meaning that the original sample solution had undergone a second dilution), the half-value was not used in calculating an average (i.e., the sample was ignored in the analysis). Whenever a field sample was replicated, the value used for each contaminant was the average of those for the two replicate samples, subject to the preceding rules.

Any concentration values for organics or metals deviating in minor ways from requirements for holding times, analytical spikes, duplicates, or other quality control parameters were considered estimated values and reported with a "J." These values were used in the risk assessment as if they were not qualified (i.e., as if they were fully acceptable). Any inorganic concentration values reported as less than the contract-required detection limit (CRDL), but greater than the instrument detection limit, were qualified with a "B." These values were used in the risk assessment as if they were not qualified. All values qualified with an "R," indicating sample results rejected by the validation personnel, were purged from the data set and were not used in this risk assessment. Decisions made regarding the data are described below.

Well-Borehole Soil Samples. Overall precision and accuracy for metals are good. All data for metals are usable, with the following qualifications: all antimony, arsenic, selenium, and thallium data may be biased low and should be considered estimated; lead concentrations should be considered estimated because of the possibility of a low bias on the basis of inconclusive matrix-spike results; all manganese data are usable but estimated because of a lack of data on accuracy; cyanide data should be considered estimated because of the uncertainty of the results as a result of poor field duplicate precision.

All well-borehole soil pesticide, semivolatile organic, and volatile organic data are usable.

Groundwater Samples. All groundwater data for metals are usable, with the following qualifications: the mercury results reported for samples JCSW4AW and JCSW8AW are likely to be false positives; aluminum, copper, iron, and zinc results are considered estimated because of uncertainty in the quantitation on the basis of field replicate precision. All groundwater pesticide,

PCB, and semivolatile organic data are usable. With the exception of the tentatively identified freons in a few samples, all groundwater volatile organic data are usable.

Named-Site Test Bore and Hand Soil Samples. Overall precision and accuracy for metals are good. All metals data are usable with the following qualifications: all antimony and selenium data may be biased low; lead should be considered estimated because of the possibility of a low bias on the basis of inconclusive matrix-spike results; all manganese data are usable but estimated because of a lack of data on accuracy; calcium and lead data are considered to be estimated results because of the uncertainty of the quantitation on the basis of poor laboratory duplicate precision.

All test-bore soil pesticide/PCB data are usable. All test-bore and hand-semivolatile organic soil data are usable. All test-bore and hand-soil volatile organic data are usable, except for 2-butanone in sample JC1H1CS.

Creek Sediment Samples. Overall laboratory precision for metals is good; however, no field replicate was collected, and therefore sampling precision and sampling homogeneity could not be evaluated. Accuracy was evaluated by using matrix spike information from a well-borehole sample. All metals data are usable, with the following qualifications: all antimony, arsenic, selenium, and thallium data may be biased low; all manganese data are usable, but estimated, because of a lack of data on accuracy. All creek sediment pesticide data, PCB data, semivolatile organic data, and volatile organic data are usable.

Creek Water Samples. All creek water sample data for metals meet quality assurance/quality control (QA/QC) criteria, precision criteria, and accuracy criteria, as indicated by laboratory QC, duplicates, and matrix spikes. Therefore, all metals data are usable, with the caution that no field replicate was collected, and therefore sampling precision and sample heterogeneity could not be evaluated. All creek water pesticide data, PCB data, semivolatile organic data, and volatile organic data are usable.

Outfall Samples. All outfall water sample data for metals meet QA/QC criteria, precision criteria, and accuracy criteria, as indicated by laboratory QC, duplicates, and matrix spikes. Therefore, all metals data are usable, with the caution that no field replicate was collected, and therefore sampling precision and sample heterogeneity could not be evaluated. All outfall water pesticide data, PCB data, semivolatile organic data, and volatile organic data are usable. No outfall sediment samples were taken.

3.3.2.5 Data Selection and Summary of Chemicals of Potential Concern

Chemicals can be eliminated from consideration in a risk assessment for several justifiable reasons. For AFP 59, five rationales for eliminating chemicals from the lists presented in Appendix K were used: (1) nondetection, (2) occurrence below the maximum local background concentration, (3) occurrence in less than 5% of the samples for a given medium (at least 20 samples must have been taken) and then only at comparatively low concentrations (i.e., concentrations that are unlikely to cause any significant risks), (4) unavailability of reference doses (RfDs) or carcinogenic slope factors (SFs) for certain common and relatively harmless elements (many are actually essential elements in the human diet), and (5) occurrence below regulatory values for groundwater, surface water, or drinking water. Each type of elimination decision is discussed below.

Nondetection. Any chemical that was not detected in any medium (i.e., "U"- or "UJ"-qualified) was eliminated as a chemical of potential concern because there was no evidence that the chemical was present at the site. A total of 82 chemicals were eliminated on this basis. These chemicals are listed in Table 3.42. Elimination of these chemicals does, however, introduce some uncertainty into the risk assessment. Chemicals that are not detected are not necessarily absent from the sample, but they may be present at levels just below those at which the analytical laboratory can reliably detect and measure them.

Occurrence below the Maximum Site-Specific Background Concentration. Site-specific background concentrations are summarized in Section 3.1.4. Typical soil background concentrations in the eastern United States and worldwide are also summarized in Table 3.43 for inorganic analytes. When an analyte is found on-site in a given medium at levels below the maximum local background concentration for that particular medium, it may be reasonable to conclude one or more of the following: (1) the "contamination" is widespread, (2) the contaminant is migrating (in the case of groundwater or flowing surface water) into and out of the site and could only be eliminated by a cleanup of much larger proportions than that applicable to the site alone, (3) the "background" samples are not representative of the conditions up-gradient of the site, and the background analyses should therefore be disregarded, or (4) regardless of the origin and ubiquity of the contamination, it represents a problem too serious to be ignored. Within this framework of possibilities, a high background occurrence was used as a criterion to strengthen the elimination of some analytes on other grounds.

Occurrence in Less than 5% of Samples from a Given Medium. The criterion for elimination of a chemical from the risk assessment was the occurrence of the contaminant in <5% of the samples; however, the substance could still be retained as a contaminant of concern if it were present at a high concentration (i.e., a concentration likely to present some human health risk) or in a distribution indicative of a local "hot spot." Exercising this option permitted the early elimination of some of the relatively unimportant contaminants that would have had little impact on the risk assessment if they had been carried through the entire process.

TABLE 3.42 Contaminants^a That Were Not Detected in Any Medium at AFP 59

1,1,2,2-Tetrachloroethane	Benzyl alcohol
1,1,2-Trichloroethane	beta-BHC
1,2,4-Trichlorobenzene	Bis(2-chloroethoxy)ethane
1,2-Dichlorobenzene	Bis(2-chloroisopropyl) ether
1,2-Dichloroethane	Bis(2-chloroethyl) ether
1,2-Dichloroethene	Bromodichloromethane
1,2-Dichloropropane	Bromomethane
1,3-Dichlorobenzene	Butyl benzyl phthalate
1,4-Dichlorobenzene	Carbon disulfide
2,4,5-Trichlorophenol	Carbon tetrachloride
2,4,6-Trichlorophenol	Chlorobenzene
2,4-Dichlorophenol	Chloroethane
2,4-Dinitrophenol	Chloromethane
2,4-Dinitrotoluene	cis-1,3-Dichloropropene
2,6-Dinitrotoluene	delta-BHC
2-Butanone	Di-n-octyl phthalate
2-Chloronaphthalene	Dieldrin
2-Hexanone	Diethyl phthalate
2-Methylphenol	Dimethyl phthalate
2-Nitroaniline	Endosulfan I
3,3'-Dichlorobenzidine	Endosulfan sulfate
3-Nitroaniline	Endrin
2-Nitrophenol	Endrin ketone
4,4'-DDD	Ethylbenzene
4,4'-DDT	gamma-BHC (lindane)
4,6-Dinitro-2-methylphenol	Heptachlor
4-Bromophenyl phenyl ether	Hexachlorobenzene
4-Chloroaniline	Hexachlorobutadiene
4-Chlorophenyl phenyl ether	Hexachlorocyclopentadiene
4-Methyl-2-pentanone	Hexachloroethane
4-Nitroaniline	Isophorone
4-Nitrophenol	Methoxychlor
alpha-BHC	N-Nitrosodi-n-propylamine
alpha-Chlordane	N-Nitrosodiphenylamine
Aroclor-1016	Nitrobenzene
Aroclor-1221	Pentachlorophenol
Aroclor-1232	Toxaphene
Aroclor-1242	trans-1,3-Dichloropropene
Aroclor-1248	Vinyl acetate
Aroclor-1254	Vinyl chloride
Benzene	
Benzoic acid	

^a Total of 82.

TABLE 3.43 Characterization Results for Inorganic Analytes in Soil

Analyte	Detection ^a Frequency	Detection Percentage	Concentration Range (mg/kg)	Detection Limits (mg/kg)	Maximum Background (mg/kg)	Eastern U.S. ^b Range (mg/kg)	Eastern U.S. ^b Estimated Arithmetic Mean (mg/kg)
Aluminum	21/21	100	5,070-16,300	—	9,310	7,000->100,000	57,000
Antimony	1/21	4.8	1.6-1.6	0.31-0.51	0.23 ^c		
Arsenic	21/21	100	2.9-10.2	—	8.2	<0.1-73	7.4
Barium	20/21	95	23.5-109	52.9-53.5	47.8	10-1,500	420
Beryllium	5/21	24	0.77-0.97	0.2-1.3	0.115 ^c	<1-7	0.85
Cadmium	1/21	4.8	7.5-7.5	0.46-2.9	0.34 ^c	01-2 ^d	0.35 ^d
Calcium	21/21	100	307-80,400	—	1,340	700-500,000 ^d	15,000 ^d
Chromium	21/21	100	8.1-428	—	14.3	1-1,000	52
Cobalt	19/21	90	5.2-13.3	5.6-6.4	6.1	<0.3-70	9.2
Copper	21/21	100	11.5-85.9	—	24.8	<1-700	22
Cyanide	3/21	14	2.6-7.9	1-2	0.55 ^c		
Iron	21/21	100	13,200-28,400	—	19,400	2,000-550,000 ^d	40,000 ^d
Lead	21/21	100	5.2-572	—	19.9	<10-300	17
Magnesium	21/21	100	2,760-10,800	—	2,250	400-9,000 ^d	5,000 ^d
Manganese	21/21	100	336-2,110	—	555	<2-7,000	648
Mercury	10/21	48	0.05-0.13	0.04-0.07	0.1	01-3.4	0.12
Nickel	20/21	95	13-124	11.6-11.6	13.4	<5-700	18
Potassium	21/21	100	451-1,520	—	653	80-37,000 ^d	14,000 ^d
Selenium	6/21	29	0.19-0.4	0.15-0.27	0.38	<0.1-3.9	0.45
Silver	1/21	4.8	2.8-2.8	0.62-1	0.455 ^c	0.01-8 ^d	0.05 ^d
Sodium	9/21	43	25.3-578	18.2-180	12.65 ^c	150-25,000 ^d	5,000 ^d
Thallium	1/21	4.8	0.67-0.67	0.31-0.53	0.21 ^c	2.2-23	8.6
Vanadium	19/21	90	8.8-75.2	9.6-12.5	13.2	<7-300	66
Zinc	21/21	100	36.5-109	—	60.5	<5-2,900	52

^a In determining detection frequencies, duplicate samples were only counted once; a detection in any sample, or all samples, was counted as one detection. However, in determining maximum and minimum values, all values were considered, making possible a range of values for only one sample.

^b Shacklette and Boerngen (1984).

^c Not detected; reported value is one-half the detection limit.

^d Bodek et al. (1988); mean is a median value.

Nonavailability of Reference Doses or Slope Factors for Certain Common Elements. No noncarcinogenic reference doses or carcinogenic slope factors were found for certain common elements (generally essential elements in the human diet) in either of the authoritative sources for toxicity information: EPA's Integrated Risk Information System (IRIS) and Health Effects Assessment Summary Tables (HEAST) (EPA 1992b,c). These common elements are widespread and generally regarded as either beneficial or nonhazardous. The *Risk Assessment Guidance for Superfund* states: "Chemicals that are (1) essential human nutrients, (2) present at low concentrations (i.e., only slightly elevated above naturally occurring levels), and (3) toxic only at very high doses (i.e., much higher than those that could be associated with contact at the site) need not be considered further in the quantitative risk assessment" (pp. 5-23, EPA 1989a). Essentially harmless elements (such as aluminum, calcium, iron, magnesium, potassium, sodium, and, to a lesser degree, cobalt) are extremely common and are usually no cause for concern. However, judgment was exercised in the use of this criterion. Thus, iron and sodium were not eliminated from the list of contaminants of concern in groundwater on the basis of their levels with respect to applicable regulatory standards, as explained in the next section.

The basis for determining that these elements are relatively harmless, except at very high doses, is discussed below. These brief summaries provide support for their elimination from the list of chemicals of concern.

Aluminum is found in food, and it is widely used in cooking utensils, antacids, and antiperspirants. Exposure to aluminum may be harmful to sensitive subpopulations (such as dialysis patients and pregnant women). Neurological effects are potentially associated with exposure to high levels of aluminum in drinking water; however, the causal link between these effects and exposure is tenuous (ATSDR 1990). Several reports of dialysis encephalopathy link aluminum-contaminated dialysis water with the onset of the disease. Dialysis water containing greater than 50-100 $\mu\text{g Al/L}$ has been implicated. The maximum permissible level of aluminum in dialysis water is 10 $\mu\text{g Al/L}$ (Friberg et al. 1986).

Calcium is vital to bone formation and strength and in muscle and soft tissue operation and maintenance. The recommended daily allowance (RDA) for calcium is 1,200 mg for males and females ages 11 to 24 years and 800 mg for adults older than 24.

Inorganic cobalt is incorporated into vitamin B12 by bacteria. Although cobalt is a vital part of vitamin B12, there is no evidence that cobalt is ever limiting in the human diet. Therefore, no RDA is established for cobalt (NRC 1989). Many cases of cardiac failure, polycythemia, and thyroid lesions attributable to the consumption of large quantities of beer in which cobalt was used as an additive have been reported. Consumption of up to 10l beers/day resulted in as much as 10 mg excess cobalt/day. However, the effects listed above could have been multicausal (resulting from poor nutrition and heavy drinking), not necessarily just from the excess cobalt (Friberg et al. 1986).

Iron is a component of hemoglobin, myoglobin, and many enzymes in the human body and is therefore an essential nutrient. The RDA for iron in adults is 15 mg for women and 10 mg for

men (NRC 1989). Severe poisoning in children may occur after ingestion of greater than 0.5 g iron. Such ingestion can lead to renal failure, hepatic cirrhosis, gastrointestinal ulceration, shock, coma and death. Long-term exposure, from intake of >50–100 mg iron/day, can lead to hemosiderosis, hemochromatosis, and liver cirrhosis (Friberg et al. 1986).

Magnesium is required in many physiological and biochemical processes. The Mg-ATP-2 complex is essential for all biosynthetic processes. The RDA for magnesium for adults ages 19 and older is 280 mg for women and 350 mg for men, or 6 to 10 mg/kg; children, pregnant women, and lactating women require more. Deficiencies in this element can lead to neuromuscular irritation, formation of kidney stones, and cardiac and renal damage. Magnesium compounds (e.g., hydroxide and sulfate) are widely used as antacids, cathartics, anti-inflammation agents, and as central nervous system depressants. Toxic effects of magnesium are most commonly associated with inhalation exposures. High exposure levels to magnesium oxide have resulted in metal fume fever, a syndrome that occurs after exposure to a number of metal compounds (e.g., zinc oxide). Reports of adverse effects following ingestion exposures are rare, but they may occur at high exposure levels. Adverse effects include a sharp drop in blood pressure and respiratory paralysis as a result of central nervous system depression.

Potassium is the primary intracellular cation in the human body. The RDA for potassium for adults is 3,500 mg. Acute intoxication will result from sudden increases in potassium intake at levels of 12.0 g/m²-surface area per day. (This value is equivalent to approximately 18 g/day for an adult.) Acute intoxication (hyperkalemia) can cause cardiac arrest (NRC 1989).

Sodium is the primary extracellular cation in the human body. The RDA of sodium for adults is 2.4 g or less. Sodium deficiency from low dietary intake is very rare and is due primarily to health conditions that produce an inability to retain sodium. High sodium intake has been implicated in the development of hypertension in sensitive individuals.

Conformance with Regulatory Values for Drinking Water. New York State water quality standards and guidelines are among the most stringent in the United States. Therefore, if the maximum or average (estimated by the upper 95% confidence limit of the average) concentration of a contaminant does not exceed the most relevant state regulatory or guidance values for ground or surface water (or, in their absence, EPA regulatory values for drinking water), further risk assessment for that contaminant in the medium in question should not be needed.

Summary and Elimination of Chemicals, by Medium Chemicals in Soil. In total, 21 or 22 soil field samples were taken in each of four categories of chemicals, namely volatile organics, semivolatile organics, pesticides/PCBs, and inorganic analytes. The soil was of three types (i.e., well-borehole, named-site test-bore, and hand-soil samples). The following chemicals were deleted from the lists shown in Tables 3.43 and 3.44 because they occurred in <5% (i.e., only one) of the samples: antimony; cadmium; silver; thallium; 1,1,1-trichloroethane; phenol;

TABLE 3.44 Characterization Results for Organic Compounds in Soil^a

Compound	Detection ^b Frequency	Detection Percentage	Concentration Range (µg/kg)	Detection ^c Limits (µg/kg)	Maximum ^d Background (µg/kg)
1,1,1-Trichloroethane	1/22	4.6	1-1	5-770	3
2,4-Dimethylphenol	1/22	4.6	100-100	700-1,100	375
2-Chlorophenol	1/22	4.6	110-110	700-1,100	375
2-Methylnaphthalene	5/22	23	92-1,400	700-1,100	375
4,4'-DDE	1/21	4.8	6-6	17-27	9
4-Chloro-3-methylphenol	1/22	4.6	100-100	700-1,100	375
4-Methylphenol	1/22	4.6	210-210	700-1,100	375
Acenaphthene	4/22	18	120-1,900	700-1,100	375
Acenaphthylene	2/22	9.1	88-280	700-1,100	375
Acetone	6/22	27	8-37	10-1,500	5.5
Aldrin	1/21	4.8	7.6-9.2	8.3-11	4.5
Anthracene	7/22	32	12-2,800	710-1,100	375
Aroclor-1260	1/21	4.8	130-130	170-270	90
Benzo(a)anthracene	6/22	27	120-5,300	710-1,100	375
Benzo(a)pyrene	8/22	36	75-3,700	710-1,100	375
Benzo(b)fluoranthene	8/22	36	89-5,200	710-1,100	375
Benzo(ghi)perylene	7/22	32	64-1,700	700-1,100	375
Benzo(k)fluoranthene	8/22	36	48-1,900	710-1,100	375
Bis(2-ethylhexyl) phthalate	11/22	50	74-11,000	700-1,100	375
Chrysene	8/22	36	68-4,900	710-1,100	375
Di-n-butyl phthalate	7/22	32	110-410	700-870	375
Dibenzo(a,h)anthracene	3/22	14	140-440	700-1,100	375
Dibenzofuran	4/22	18	43-2,100	700-1,100	375
Endosulfan II	1/21	4.8	84-84	17-27	9
Fluoranthene	11/22	50	65-9,900	710-900	375
Fluorene	4/22	18	120-2,900	700-1,100	375
gamma-Chlordane	1/21	4.8	24-24	83-130	45
Heptachlor epoxide	2/21	9.5	62-84	8.3-13	4.5
Indeno(1,2,3-cd)pyrene	6/22	27	62-1,600	710-1,100	375
Methylene chloride	4/22	18	3-10	5-770	3
Naphthalene	6/22	27	35-4,200	700-1,100	375
Phenanthrene	10/22	45	33-9,800	710-1,100	375
Phenol	1/22	4.6	250-250	700-1,100	375
Pyrene	11/22	50	52-9,100	710-900	375
Trichloroethene	2/22	9.1	6-14	5-770	3

^a R-qualified data were not used.

^b In determining detection frequencies, duplicate samples were only counted once; a detection in any sample, or all samples, was counted as one detection. However, in determining maximum and minimum values, all values were considered, making possible a range of values for only one sample.

^c Doubly diluted samples were not used to establish detection limit ranges.

^d None of these compounds were detected in background samples; reported value is one-half the detection limit.

2-chlorophenol; 4-chloro-3-methylphenol; 4-methylphenol; 2,4-dimethylphenol; aldrin; 4,4'-DDE; Arochlor 1260; endosulfan II; and gamma-chlordane. Heptachlor epoxide was detected twice, but it was eliminated as a chemical of concern because it is unlikely that this chemical is related to past site uses. Although some of these chemicals were detected at levels higher than background, the low number of detects suggests that these detects may be anomalous. The essentially harmless common elements that were eliminated for lack of RfDs or SFs were aluminum, calcium, cobalt, iron, magnesium, potassium, and sodium. Therefore, the number of soil chemicals of potential concern was reduced in comparison with those listed in Tables 3.45 and 3.46.

Chemicals in Creek Sediment. Two field samples of sediment were taken from the Little Choconut Creek near the AFP 59 site, and a background sample was taken considerably upstream. The first field sample, No. JCSD1AS, was just upstream of the upstream outfall (OF-2) and was therefore essentially a background sample. Sample No. JCSD1AS had far fewer semivolatile contaminants than the downstream sediment sample (No. JCSD2AS), but this sample was similar in its distribution of metals. Detected analytes/compounds are listed in Tables 3.47 and 3.48. Neither of the field samples contained more of the following elements than the local background sample, and so these elements were deleted from the list of contaminants of potential concern: aluminum, barium, chromium, cobalt, iron, manganese, and nickel. The essential common elements that were also eliminated because they lacked RfDs or SFs were calcium, magnesium, potassium, and sodium. The number of inorganic sediment chemicals of potential concern was thus reduced in comparison with those listed in Table 3.49. No organic chemicals were screened out because none of the elimination criteria were met; all chemicals were detected in at least one of two samples and at concentrations higher than background. Therefore, Table 3.48 is the final list of organic contaminants of concern in creek sediments.

Chemicals in Groundwater. Thirty-two groundwater samples were analyzed (see Tables 3.50 and 3.51). Each contaminant was found at concentrations above background concentration in at least one of the samples. The following chemicals occurred at low levels and appeared in <5% (i.e., only one) of the samples: styrene, 1,1-dichloroethene, chloroform, and

TABLE 3.45 Inorganic Soil Analytes Remaining after Screening

Arsenic	Copper	Nickel
Barium	Lead	Selenium
Beryllium	Manganese	Vanadium
Chromium	Mercury	Zinc
		Cyanide

TABLE 3.46 Organic Soil Analytes Remaining after Screening

Acenaphthene	Dibenzofuran
Acenaphthylene	Di-n-butyl phthalate
Acetone	Di-n-octyl phthalate
Anthracene	Fluoranthene
Benzo[a]anthracene	Fluorene
Benzo[b]fluoranthene	Indeno[1,2,3-cd]pyrene
Benzo[k]fluoranthene	Methylene chloride
Benzo[ghi]perylene	2-Methylnaphthalene
Benzo[a]pyrene	Naphthalene
Bis(2-ethylhexyl)	Phenanthrene
Phthalate	Pyrene
Chrysene	Trichloroethene
Dibenzo[a,h]anthracene	

TABLE 3.47 Characterization Results for Inorganic Analytes in Creek Sediment

Analyte	Detection Frequency	Concentration Range (mg/kg)	Detection Limits (mg/kg)	Maximum Background (mg/kg)
Aluminum	2 / 2	9,240-9,260	-	10,500
Arsenic	2 / 2	5.4-5.6	-	4.3
Barium	2 / 2	46.3-49.3	-	58.9
Beryllium	2 / 2	0.94-1	-	0.5 ^a
Calcium	2 / 2	7,450-12,200	-	1,210
Chromium	2 / 2	16-16.5	-	16.5
Cobalt	2 / 2	10-10.3	-	13.4
Copper	2 / 2	16.5-20.5	-	16.3
Iron	2 / 2	26,100-27,000	-	30,500
Lead	2 / 2	22.2-92.1	-	13.4
Magnesium	2 / 2	3,410-4,430	-	3,330
Manganese	2 / 2	461-464	-	584
Mercury	2 / 2	0.07-0.08	-	0.03 ^a
Nickel	2 / 2	19.7-20.5	-	22.2
Potassium	2 / 2	834-851	-	602
Selenium	1 / 2	0.29-0.29	0.21	0.105 ^a
Sodium	2 / 2	72.4-82	-	45.6 ^a
Vanadium	2 / 2	13.4-14.1	-	13.7
Zinc	2 / 2	119-134	-	66.4

^a Not detected; reported value is one-half the detection limit.

acetone. Tables 3.50 and 3.51 show that the highest concentrations of the following do not exceed the relevant regulatory values: arsenic, barium, beryllium, copper, lead, mercury (where the two detections reported were probably false positives), selenium, silver, thallium, zinc, 1,1-dichloroethane, 1,1-dichloroethene, bromoform, dibromochloromethane, methylene chloride, tetrachloroethene, toluene, and xylenes. Five additional groundwater contaminants were eliminated on the basis of a comparison of their average concentrations (estimated by the upper 95% confidence limit of the average concentrations) with regulatory values (see Table 3.58); these contaminants included cadmium, chromium, nickel, vanadium, and 1,1,1-trichloroethane. The essential common elements that were eliminated for lack of RfDs or SFs were aluminum, calcium, cobalt, magnesium, and potassium.

The essentially harmless metallic elements iron and sodium were retained on the list of chemicals of possible concern because their concentrations in Johnson City well field samples, as well as in many AFP 59 groundwater samples, exceeded regulatory values, although these are not necessarily toxic concentrations. Therefore, the number of groundwater chemicals of potential concern was reduced in number to those listed in Table 3.52.

TABLE 3.48 Characterization Results for Organic Compounds in Creek Sediment

Compound	Detection Frequency	Concentration Range (µg/kg)	Detection Limits (µg/kg)	Maximum ^a Background (µg/kg)
2-Methylnaphthalene	1/2	110-110	880-880	445
Acenaphthene	1/2	380-380	880-880	445
Aldrin	2/2	8.8-18	10-10 ^b	5
Anthracene	1/2	520-520	880-880	445
Benzo(a)pyrene	1/2	610-610	880-880	445
Benzo(b)fluoranthene	1/2	830-830	880-880	445
Benzo(ghi)perylene	1/2	190-190	880-880	445
Benzo(k)fluoranthene	1/2	330-330	880-880	445
Bis(2-ethylhexyl) phthalate	1/2	210-210	860-860	445
Chrysene	1/2	790-790	880-880	445
Di-n-butyl phthalate	2/2	270-300	890-890 ^b	445
Dibenzofuran	1/2	230-230	880-880	445
Fluoranthene	2/2	150-2,200	890-890 ^b	445
Fluorene	1/2	430-430	880-880	445
Indeno(1,2,3-cd)pyrene	1/2	190-190	880-880	445
Methylene chloride	1/2	8-8	6-6	3
Naphthalene	1/2	270-270	880-880	445
Phenanthrene	1/2	2,300-2,300	880-880	445
Pyrene	1/2	1,800-1,800	880-880	445

^a None of these compounds were detected in background samples; the reported value is one-half the detection limit.

^b On the basis of detection limits for background samples.

Chemicals in Creek Water. Two field samples of creek water were taken from the Little Choconut Creek near the AFP 59 site, and a background sample was taken upstream. The first field sample, No. JCCW1AW, was taken just upstream of the upstream outfall (OF-2) and could be considered a background sample like its sediment counterpart. (Analytical results are provided in Tables 3.53 and 3.54.) No volatile organic compounds, semivolatile organic compounds, pesticides, or PCBs were found in the two field samples from the Little Choconut Creek. The following eight metals were the only ones detected: aluminum, calcium, iron, magnesium, manganese, mercury, potassium, and sodium. Three of these metals (aluminum, iron, and manganese) occurred at levels below the local

TABLE 3.49 Inorganic Sediment Analytes Remaining after Screening

Arsenic	Lead	Vanadium
Beryllium	Mercury	Zinc
Copper	Selenium	

TABLE 3.50 Characterization Results for Inorganic Analytes in Groundwater

Analyte	Detection ^a Frequency	Detection Percentage	Concentration Range (µg/L)	Detection Limits (µg/L)	Maximum Background (µg/L)	New York State Groundwater Standards ^b (µg/L)
Aluminum	32/32	100	70-19,800	-	23.5 ^c	100
Antimony	3/32	9.4	3.7-28.5	3-3	1.5 ^c	3
Arsenic	17/32	53	2.4-6.7	2-2	1 ^c	25
Barium	32/32	100	30-211	-	170	1,000
Beryllium	3/32	9.4	1-3	1-1	0.5 ^c	3
Cadmium	14/32	44	4-14	4-4	2 ^c	10
Calcium	32/32	100	30,200-186,000	-	123,000	-
Chromium	23/32	72	5-63	5-5	2.5 ^c	50
Cobalt	2/32	6.3	10-24	5-13	2.5 ^c	5
Copper	21/32	66	3-35	3-19	1.5 ^c	200
Iron	32/32	100	151-26,700	-	10.5 ^c	300 ^d
Lead	30/32	94	1-14.6	1-1	0.5 ^c	25
Magnesium	32/32	100	9,370-36,600	-	25,800	35,000
Manganese	32/32	100	33-4,400	-	3	300 ^d
Mercury	3/32	9.4	0.1-0.11	0.1-0.1	0.05 ^c	2
Nickel	5/32	16	39-115	4-36	4 ^c	100 ^e
Potassium	32/32	100	1,840-50,300	-	2,390	-
Selenium	4/32	13	1.1-2.1	1-1	0.5 ^c	10
Silver	3/32	9.4	7-9	7-7	3.5 ^c	50
Sodium	32/32	100	20,700-301,000	-	70,600	20,000
Thallium	8/32	25	1-1.4	1-5	0.5 ^c	4
Vanadium	2/32	6.3	8-35	3-37	1.5 ^c	14
Zinc	23/32	72	26-195	17-60	25	300

^a In determining detection frequencies, duplicate samples were only counted once, and a detection in any sample, or all samples, was counted as one detection. However, in determining maximum and minimum values, all values were considered, making possible a range of values for only one sample.

^b Source: Cleanup Standards Task Force (1991).

^c Not detected; reported value is one-half the detection limit.

^d The total concentration of iron and manganese cannot exceed 500 µg/L.

^e EPA (1991c).

TABLE 3.51 Characterization Results for Organic Compounds in Groundwater^a

Compound	Detection ^b Frequency	Detection Percentage	Concentration Range (µg/L)	Detection Limits (µg/L)	Maximum Background (µg/L)	New York State ^c Groundwater Standards (µg/L)
1,1,1-Trichloroethane	24/32	75	0.2-15.2	1-6	3	5
1,1-Dichloroethane	10/32	31	0.2-5	1-1	0.5 ^d	5
1,1-Dichloroethene	1/32	3.1	0.3-0.3	1-1	0.5 ^d	5
Acetone	1/32	3.1	35-35	2-2	1 ^d	50
Bromoform	4/32	13	0.2-0.6	1-1	0.5 ^d	50
Chloroform	1/32	3.1	0.3-0.3	1-1	0.5 ^d	100
Dibromochloromethane	3/32	9.4	0.2-0.3	1-1	0.5 ^d	50
Methylene chloride	5/32	16	0.7-4	0.6-6	0.5 ^d	5
Styrene	1/32	3.1	0.1-0.1	1-1	0.5 ^d	5
Tetrachloroethene	2/32	6.3	0.2-0.2	1-1	0.5 ^d	5
Toluene	5/32	16	0.2-0.3	1-1	0.5 ^d	5
Trichloroethene	15/32	47	0.2-97	1-1	0.7	5
Xylenes	3/32	9.4	0.2-0.4	1-1	0.5 ^d	5 ^e

^a R-qualified data were not used.

^b In determining detection frequencies, duplicate samples were only counted once, and a detection in any sample, or all samples, was counted as one detection. However, in determining maximum and minimum values, all values were considered, making possible a range of values for only one sample.

^c Source: Cleanup Standards Task Force (1991).

^d Not detected; reported value is one-half the detection limit.

^e Each isomer.

background concentration. The essential common elements that were eliminated for lack of RfDs or SFs were calcium, magnesium, potassium, and sodium. The only remaining contaminant, mercury, was detected at 4.9 mg/L in the downstream sample, No. JCCW2AW, which is clearly above the New York State water quality standard of 2.0 mg/L. However, this finding must be viewed in the context of the outfall water analyses, where no mercury was detected. Because it appears that this detection of mercury is an isolated detection, this element was not included as a chemical of concern.

Outfall Samples. Two outfalls to the Little Choconut Creek were sampled for surface water; no sediment samples were taken from outfalls. Among the 13 metals detected (Table 3.53), iron and zinc levels were below those found in the creek water background sample. The following common elements were eliminated for lack of RfDs or SFs: aluminum, calcium, magnesium and potassium. Barium, chromium, lead, manganese, selenium, silver, and zinc concentrations fell below health-based New York State surface water standards. Sodium, which is considered an essential element, was detected at a level close to the New York State surface water standard of 20,000 µg/L. Therefore, all metals in surface waters of these two outfalls were eliminated from consideration as contaminants of potential concern. Among the organic chemicals analyzed, there were four volatiles and four semivolatiles detected; their concentrations were all below 20 µg/L (Table 3.54). Of these, acetone, 1,1,1-trichloroethane, bromoform, pyrene, and fluoranthene fell below New York State health guidance values for surface waters. The organic contaminants that were not eliminated were trichloroethene, bis(2-ethylhexyl) phthalate, and chrysene.

Potential Air Pollutants. No air analyses were conducted at the AFP 59 site, nor does it appear likely that vapor emissions from the soil or emission of fugitive dust could constitute any sort of threat to public health under the existing use of the property. Potential exposures to volatile organic compounds found in groundwater are evaluated.

Blanks. Blanks associated with both metallic and organic contaminants are listed in Table 3.55.

TABLE 3.52 Groundwater Contaminants of Potential Concern Remaining after Screening and Their Permeability Coefficients

Contaminant	K _p (cm/h)
Antimony	10 ^{-3a}
Iron	10 ^{-3a}
Manganese	10 ^{-3a}
Sodium	10 ^{-3a}
Trichloroethene	1.6 x 10 ^{-2b}

^a Default value in EPA (1992a) pp. 5-38.

^b Table 5-7 in EPA (1992a).

TABLE 3.53 Characterization Results for Inorganic Analytes in Outfall Water and Creek Waters

Analyte	Detection Frequency	Concentration Range (µg/L)	Detection Limits ^a (µg/L)	Maximum Background (µg/L)	Health-based Surface Water Standard ^b (µg/L)
Outfall Waters					
Aluminum	2/2	72-399	-	317	100 ^c
Barium	1/2	94-94	25-34	12.5 ^d	1,000
Calcium	2/2	32,600-99,100	-	18,400	-
Chromium	1/2	6-6	4	2 ^d	50
Iron	2/2	134-310	-	362	300
Lead	2/2	1.6-5.3	-	1.3	50
Magnesium	2/2	6,190-21,400	-	4,530	35,000
Manganese	2/2	36-168	-	83	300
Potassium	2/2	795-2,010	-	1,090	-
Selenium	1/2	1.1-1.1	1	0.5 ^d	10
Silver	1/2	5-5	4	2 ^d	50
Sodium	2/2	19,300-57,200	-	10,800	20,000 ^e
Zinc	1/2	93-93	10-37	418	300
Creek Water					
Aluminum	2/2	122-136	-	317	100 ^c
Calcium	2/2	33,400-35,400	-	18,400	-
Iron	2/2	145-183	-	362	300
Magnesium	2/2	6,470-6,590	-	4,530	35,000
Manganese	2/2	13-40	-	83	300
Mercury	1/2	4.9-4.9	0.1	0.05 ^d	2
Potassium	2/2	1,680-1,950	-	1,090	-
Sodium	2/2	19,200-23,400	-	10,800	20,000

^a Detection limits were derived from the results reported for samples in which the contaminant was not detected.

^b Source: Cleanup Standards Task Force (1991).

^c Aquatic life.

^d Not detected; reported value is one-half the detection limit.

^e Groundwater.

TABLE 3.54 Characterization Results for Organic Compounds in Outfall Waters

Compound	Detection Frequency	Concentration Range (µg/L)	Detection Limits (µg/L)	Maximum ^a Background (µg/L)	Health-based Surface Water Standard ^b (µg/L)
1,1,1-Trichloroethane	1 / 2	0.6-0.6	1-1	0.5	5
Acetone	1 / 2	17-17	2-2	1	50 ^c
Bis(2-ethylhexyl) phthalate	1 / 2	8-8	12-12	5	4
Bromoform	1 / 2	0.4-0.4	1-1	0.5	50
Chrysene	1 / 2	2-2	12-12	5	0.002
Fluoranthene	1 / 2	4-4	12-12	5	50
Pyrene	1 / 2	3-3	12-12	5	50
Trichloroethene	2 / 2	0.3-4	-	0.5	3

^a Compounds were not detected in background samples; reported value is one-half the detection limit.

^b Source: Cleanup Standards Task Force (1991).

^c Source: New York State Department of Environmental Conservation (1992).

Summary of Chemicals of Potential Concern. Undetected chemicals, chemicals below the maximum site-specific background concentration, contaminants that occurred in <5% of the samples in soil and groundwater, certain common elements for which RfDs and SFs were not available, and contaminants found below regulatory values for groundwater, surface water, or drinking water have been excluded. The chemicals remaining were considered contaminants of potential concern for the AFP 59 site or its environs. These chemicals are listed in Table 3.56.

3.3.3 Exposure Assessment

Exposure is defined as the contact between an individual and a chemical of potential concern. The magnitude of this contact is determined by estimating how much of the chemical is available for absorption during a specified period at one of the body's three exchange boundaries (i.e., the intestinal tract, the lungs, and the skin). Determining the type and magnitude of exposure of this type to the chemicals of potential concern is the objective of an exposure assessment. This section identifies potential exposure routes at the AFP 59 site and quantifies the magnitudes, durations, and frequencies for those routes.

TABLE 3.55 Characterization Results for Blanks

Contaminant	Detection Frequency	Concentration Range (µg/L)	Detection Limits ^a (µg/L)
Inorganic Analytes			
Beryllium	3 / 3	3-3	-
Calcium	1 / 3	8.5-494	17-17
Iron	3 / 3	10-948	-
Lead	2 / 3	1.6-2.5	1-1
Manganese	1 / 3	0.5-8	1-1
Potassium	3 / 3	308-1,510	-
Sodium	3 / 3	157-1,250	-
Zinc	3 / 3	5-15	-
Organic Compounds			
1,1,1-Trichloroethane	6 / 39	2-7	1-5
Acetone	4 / 39	5-12	2-10
Benzene	1 / 39	1-1	1-5
Chloroform	1 / 39	0.6-0.6	1-5
Methylene chloride	11 / 39	0.2-3	0.3-5
Toluene	3 / 39	0.2-0.2	1-5
Xylene	2 / 39	0.1-0.1	1-5

^a Detection limits were derived from the results reported for samples in which the contaminant was not detected.

3.3.3.1 Characterization of the Exposure Setting

This section summarizes information regarding the physical setting of the site and the populations potentially influenced by the site (abstracted from the Phase II Stage 2 RI/FS work plan by EA Engineering, Science and Technology, Inc. [EA 1988]).

Air Force Plant 59 is located in Broome County, New York, in the village of Johnson City, about three miles west-northwest of Binghamton. The 29.6-acre plant is occupied by 14.3 acres of buildings, and nearly all of the remaining area is paved. It is situated in the Susquehanna River floodplain within the Appalachian Plateau physiographic province. The geography of the area is characterized by relatively undisturbed, nearly horizontal sedimentary rocks bisected by streams. Surface runoff from AFP 59 drains to the Little Choconut Creek, a tributary to the nearby Susquehanna River.

The plant is bordered on the north side by Main Street (New York State Route 17C) and on the east and south by Little Choconut Creek. A residential area is located immediately west of the site. The site topography is fairly flat, varying in elevation from 830 to 840 ft above mean sea level. The nonresidential land around the plant is used for transportation, commercial enterprises, forest land/recreation, and industrial activity.

Climate and Meteorology. The climate near AFP 59 is humid, maritime with mild summers and long, cold winters. The prevailing wind direction is west-southwest. The weather is usually warm and humid when the air flow is from the south or southwest and cold and less humid when the air flow is from the north or northwest.

The average annual temperature for nearby Binghamton is 46°F. Monthly mean temperatures vary from 20°F in January to 69°F in July. The average daily minimum temperature in January is 13°F, and the lowest recorded temperature is -20°F. The average daily maximum temperature in July is 78°F, and the highest temperature recorded in Binghamton is 96°F in September. Freezing temperatures occur at Binghamton an average of 147 days per year.

Mean annual precipitation recorded in the vicinity of AFP 59 is about 37 in. The greatest precipitation occurs in June and the least in February. For the most part, precipitation is evenly distributed through the year. Snowfall accounts for a large proportion of the total precipitation during the winter months, with an average of about 85 in. at the Broome County Airport. Snowfall greater than 1.0 in. occurs approximately 24 days per year. Mean

TABLE 3.56 Summary of Contaminants of Potential Concern (after screening) at AFP 59

Contaminants	Media ^a
Acenaphthene	S, Sed
Acenaphthylene	S
Acetone	S
Aldrin	Sed
Anthracene	S, Sed
Antimony	GW
Arsenic	S, Sed
Barium	S
Benzo[a]anthracene	S
Benzo[b]fluoranthene	S, Sed
Benzo[k]fluoranthene	S, Sed
Benzo[ghi]perylene	S, Sed
Benzo[a]pyrene	S, Sed
Beryllium	S, Sed
Bis(2-ethylhexyl) phthalate	S, Sed, OF
Chromium	S
Chrysene	S, Sed, OF
Copper	S, Sed
Cyanide	S
Dibenzo[a,h]anthracene	S
Dibenzofuran	S, Sed
Di-n-butyl phthalate	S, Sed
Di-n-octyl phthalate	S
Fluoranthene	S, Sed
Fluorene	S, Sed
Indeno[1,2,3-cd]pyrene	S, Sed
Iron	GW
Lead	S, Sed
Manganese	S, GW
Mercury	Sed, S
Methylene chloride	S, Sed
2-Methylnaphthalene	S, Sed
Naphthalene	S, Sed
Nickel	S
Phenanthrene	S, Sed
Pyrene	S, Sed
Selenium	S, Sed
Sodium	GW
Trichloroethene	S, GW, OF
Vanadium	S, Sed
Zinc	S, Sed

^a S = soil; Sed = sediment; GW = ground-water; OF = outfall water.

annual lake evaporation, commonly used to estimate the mean annual evapotranspiration rate, is estimated to be 28 in., so that the annual groundwater recharge rate is estimated at about 9 in. (or less).

Soil Types. The site surface consists of cut-and-fill soils, including silty soils of alluvial origin that do not support heavy loads well and are subject to erosion. The western edge is covered by loamy materials of glacial origin that have been disturbed or reworked because of human activity.

Geologic Setting. The geology of the Susquehanna River Basin and vicinity consists of glacial valley fill Pleistocene sediments. The glacial deposits of the basin contain clay, silt, sand, and gravel. The bedrock underlying the glacial deposits consists of shales and minor siltstones. The plant site is underlain by unconsolidated alluvial and glacial sediments. These sediments consist of permeable brown sand and silt, with occasional lenses of gravel and trace amounts of clay. Bedrock is present at a depth of 94 ft.

Hydrogeology. The part of the Susquehanna River Basin in which AFP 59 is located consists of broad sediment valleys with 70–500 ft of stratified glacial drift atop bedrock. The Clinton Street-Ballpark Valley Aquifer, which supplies water to 128,000 residents, is a "stratified aquifer." This aquifer extends from the western part of Binghamton through the central part of Johnson City, underlying 3 mi² of urban land in the Susquehanna River Valley. In 1985 it was designated as a sole-source aquifer by the EPA under the Safe Drinking Water Act (EPA 1985). This classification was made because the aquifer is the principal source of drinking water for 128,000 residents in Broome and Tioga Counties. Because the aquifer is overlain by permeable, unconsolidated glacial and alluvial deposits, it is highly susceptible to contamination through surface recharge.

Installation Restoration Program Phase II Stage 1 hydrogeologic investigations concentrated on the shallow, water-bearing zone of the Clinton Street-Ballpark Valley Aquifer. Beneath the AFP 59 site, water table elevations range from 808 to 812 ft above mean sea level (about 20 ft below grade). The direction of groundwater flow was initially believed to be southwest, toward three municipal supply wells and the Susquehanna River (CH2M Hill 1984). Data from monitoring wells, however, indicate that the direction of groundwater flow is northwest, consistent with the regional flow direction determined by the U.S. Geological Survey in 1981.

Approximately 3.3×10^6 gal (2,290 gpm) of ground-water is pumped daily from Johnson City's municipal wells (about 1,000 ft west-southwest of AFP 59). This pumping creates a groundwater gradient of 0.0044 across the southern portion of AFP 59. Pumping the AFP 59 on-site production well at a normal rate of 350 gal/min (gpm) causes the groundwater gradient to decrease to about 0.0022. The transmissivity of the aquifer in the vicinity of AFP 59 generally ranges from 10,000 ft²/d to 50,000 ft²/d. The combination of high transmissivity,

recharge from streams, and infiltration of precipitation permits well yields of 400 gal/min to be sustained for long periods.

Ecology. AFP 59 is in the Johnson City urban area. The site has been raised and leveled with silty materials by means of cut-and-fill techniques and is now almost completely covered with buildings or pavement. No natural plant or animal communities are present on the site. Small stands of second-growth hardwood forest are nearby, consisting mainly of sycamore, elm, and willow trees. No endangered or threatened terrestrial wildlife or plant species are known to be in the vicinity. During studies in 1976–1977, 36 species of fish and 177 species of benthic macroinvertebrates were collected in the Susquehanna River near Johnson City. (Presumably, many of these species are present in the Little Choconut Creek as well.) Reduced macroinvertebrate populations were noted downstream from the confluence of Little Choconut Creek with the Susquehanna (1,000 ft west of the southwest corner of the plant), probably in response to the thermal discharge from the Goudey Station power plant. The most abundant fish species were smallmouth bass, white sucker, carp, northern hog sucker, walleye, and spotfin shiner. No endangered or threatened fish species are believed to exist in the vicinity of AFP 59.

Potentially Exposed Populations. AFP 59 has a work force of approximately 2,300 people. The population served by the nearby Johnson City municipal wells is approximately 128,000. Exposure pathways from AFP 59 that could potentially cause human health risks are described in Section 3.3.3.2.

3.3.3.2 Identification and Analysis of Complete Exposure Pathways

An exposure pathway describes the movement of a chemical from a source to the point where an individual (the "receptor") comes in contact with that chemical. A complete exposure pathway consists of the following:

- A source and mechanism of chemical release.
- A transport medium.
- A point of potential contact with the contaminated medium and a potentially exposed population.
- An exposure route at the contact point.

In some instances, the source is also the exposure point, and there is no release or transport involved. If a pathway is not complete, there is no exposure and, therefore, no risk.

The information available for the AFP 59 site was evaluated to determine which exposure pathways were (or would be) complete. To illustrate the exposure pathways from sources to receptors, a conceptual site model was developed. The components of this model are described in more detail below. All possible and reasonable exposure pathways were first identified and evaluated for completeness; exposure pathways were then selected for quantification.

Identifying complete exposure pathways involves not only characterizing site features, but also considering relevant physicochemical properties of the site contaminants. Forty-three chemicals were selected in Section 3.3.2.5 as contaminants of potential concern at this site (Table 3.56). Predicting their fate and transport from their source at a site to receptors at an exposure point on a case-by-case basis can be difficult, involving estimates of properties or use of default values of questionable accuracy. Certain assumptions regarding fate and transport processes have been made in the following pathway analyses. These have been explained carefully; they have also been examined in the section on uncertainty (Section 3.3.6).

Identification of Exposure Pathways: Sources, Release Mechanisms, and Transport Media. Manufacturing activities have been carried out at AFP 59 since 1942. They have entailed the use of petroleum products and chlorinated solvents, as well as highly toxic heavy metals and cyanide, in the electroplating operations. During storage and transfer, these materials sometimes leaked or spilled, thus contaminating surrounding soils. It is difficult to determine the extent to which these substances may have been transferred to the groundwater or to the adjacent Little Choconut Creek. Some leaching may have occurred through precipitation recharge of the aquifer, but leaching should have nearly stopped after the parking lot was paved in 1959. Once dissolved in the groundwater, the contaminants of chief concern (volatile organic compounds and heavy metals) would not be significantly retarded by adsorption on soil and would move fairly rapidly in the open-pored sandy aquifer. There is considerable uncertainty as to the origin of groundwater contaminants and their role, if any, in Johnson City well field contamination. Nevertheless, for risk assessment purposes, contaminants identified in groundwater from AFP 59 production or monitoring wells have been treated in this risk assessment as if they were the consequence of AFP 59 operations and might result in consumer exposures.

Although the half of AFP 59 not covered by buildings is almost all paved over, two small portions are not. Grassy soil surrounds Well Cluster 9, and Sites A1/A3 are covered with gravel. A rough estimate has been made (Appendix M) of the maximum possible incremental organic contaminant contribution of the first of these permeable plots to the Johnson City water supply in the course of a single year. This estimate confirmed that Well Cluster 9 could not have a large impact. Inorganics were not included in the calculation because the EP toxicity values for metals at AFP 59 had all been well within regulatory limits in a previous survey (Hart 1988). No similar calculation was conducted for Sites A1/A3 because the low solubilities of most of the organic contaminants precluded any significant impact on groundwater quality. Furthermore, except for volatile organic compounds (VOCs), no organic pollutants were found in the groundwater.

Exposure Points. An exposure point is defined as the point at which a human receptor can come in contact with a contaminated medium. The contaminated source, transport medium, or

release point itself can also be an exposure point (e.g., contaminated sediment). Potential current exposure points identified for the AFP 59 site include the following:

- Little Choconut Creek sediment and surface water,
- Little Choconut Creek fish,
- Outfall water and sediment,
- On-site soils,
- AFP 59 groundwater (treated as if the concentrations of the contaminants in the Johnson City well field were the same as the upper bound estimate of average AFP 59 groundwater concentrations), and
- Air containing emissions from AFP 59 groundwater (treated as if the concentrations of the volatiles in the Johnson City well field were the same as the upper bound estimate of the average AFP 59 groundwater concentrations).

Exposure Routes. Human populations may be exposed to contaminants by the following three routes: (1) ingestion of contaminated media, (2) inhalation of contaminated media, and (3) dermal contact with contaminated media.

Sediments that have collected in Little Choconut Creek over a period could be a source of contamination by dermal contact for barefoot waders and people engaged in episodic recreational fishing. Adolescents are more likely than adults to visit the creek. The depth of the stream (several inches) is such that inadvertent ingestion of the sediments is unlikely.

Surface water in Little Choconut Creek was clear of contaminants at hazardous levels when it was sampled, with the possible exception of mercury, which exceeded the drinking water standard by a factor of less than 3 in one sample of two. Because of the doubt surrounding the significance or consistency of this exception, and because exposure to this water would be extremely infrequent, the potential exposure pathways of dermal contact with surface water and incidental ingestion of creek water during recreational activities were judged incomplete.

Although fishing does take place in Little Choconut Creek, the frequency with which individuals would actually consume fish caught in the creek is likely to be small. In addition, it is unlikely that any subsistence fishing occurs at this location.

The outfalls to Little Choconut Creek are slightly contaminated, but they are not considered exposure points because individuals are not likely to visit the outfalls frequently. The outfall pathway was therefore not quantified.

Although the contamination of AFP 59 soil has been confirmed at several points on the site, the samples were taken from beneath the surface, and the surface is almost completely covered by pavement or structures. Therefore, no complete exposure pathway for direct contact exists for workers or for residents from on-site soils, such as dermal contact, incidental ingestion, or inhalation of volatiles or suspended particulates. Additionally, it is unlikely that indirect pathways from on-site soils exist (such as ingestion of garden crops).

As previously discussed, approximately 128,000 individuals use water from the Johnson City well fields, which may be affected by the AFP 59 site. Therefore, the exposure pathways of ingestion of groundwater, dermal contact with groundwater, and inhalation of volatiles from groundwater are considered complete exposure pathways.

Exposed Populations. Potentially exposed populations at the AFP 59 site include workers on the site and nearby residents. Workers on the site are unlikely to be exposed to contaminants, because the entire site is paved or covered with buildings. Nearby residents could potentially be exposed to contaminants in groundwater or to contaminants in Little Choconut Creek during recreational activities.

Summary. On the basis of the nature of contamination and the anticipated activities at the exposure points, complete exposure pathways identified for the AFP 59 site include the following:

- Dermal contact with sediment in Little Choconut Creek.
- Ingestion of and dermal contact with groundwater in the water supply.
- Inhalation of volatile emissions from groundwater in the water supply.

Complete Exposure Pathway Analysis. The potential exposure pathways under current land use are listed in Table 3.57, as are the rationales for including or excluding these pathways. Potential pathways that are judged to be incomplete (e.g., no exposure point and/or route by which contact could occur) are not quantified. For the exposure pathway of dermal contact with sediment, risks related to dermal uptake of inorganic contaminants are not quantified, because the contribution of these contaminants to overall risk would be minimal. This statement is supported by the fact that dermal absorption of inorganic contaminants is slowed by their low lipid solubility and by experimental evidence of their low rates of uptake through the skin (EPA 1992a).

TABLE 3.57 Complete and Incomplete Exposure Pathways for Current Land Use

Potentially Exposed Population	Exposure Route, Medium and Exposure Point	Pathway Selected for Quantitative Evaluation?	Reason for Selection or Exclusion
Workers on site	Ingestion and dermal contact with soil	No	Site is covered by buildings and pavement.
Workers on site	Inhalation of volatiles or suspended particulates	No	Site is covered by buildings and pavement.
Residents near site	Inhalation of volatiles or suspended particulates	No	Site is covered by buildings and pavement.
Residents near site	Ingestion of garden crops	No	Site is covered by buildings and pavement.
Residents near site	Ingestion of groundwater, dermal exposure to groundwater, inhalation of volatiles from groundwater when showering	Yes	Water from under site may contaminate existing well field.
Recreational visitors	Ingestion of sediments	No	Depth of stream does not allow exposure.
Recreational visitors	Exposure to outfall waters or sediments	No	Exposure is likely to be an infrequent occurrence.
Recreational visitors	Ingestion of fish	No	Fishing is unlikely to occur on a regular basis.
Recreational visitors	Dermal exposure of feet to sediment during wading	Yes	Anglers and children have access to Choconut Creek, though observed use is low.
Recreational visitors	Ingestion of surface water or dermal contact	No	Except for one suspect detection of mercury, Choconut Creek was clean.

3.3.3.3 Quantification of Exposure

The last step in the exposure-assessment process is to calculate an average daily intake of the chemicals of potential concern. This intake is an approximation of the exposure expressed in terms of the contaminant mass at the body exchange boundary per unit body weight per day (mg/kg·d). To calculate intakes, the following general equation is used:

$$DI = C \times HIF = C \times (CR \times EFD/BW)(1/AT) \quad (3.1)$$

where:

DI = daily intake — the average amount of the chemical at the body's exchange boundary (mg/kg·d).

C = chemical concentration — the concentration that comes in contact with the body during the exposure period (e.g., mg/kg in soil or µg/L in water).

HIF = human intake factor, i.e., $CR \times EFD/(BW \times AT)$.

CR = contact rate — the amount of contaminated medium contacted per unit time or event (e.g., L/d for drinking water).

EFD = exposure frequency and duration — how long and how often exposure occurs. The EFD term is usually calculated from two terms, the exposure frequency, EF (usually expressed in days/year), and the exposure duration, ED (usually expressed in years). A third term, exposure time per event (ET), is used for inhalation and dermal exposure to water.

BW = body weight — the average body weight over the exposure period (kg).

AT = averaging time — the period over which exposure is averaged (days).

The variables used in this equation were those recommended by the EPA and were selected by the EPA to achieve an estimate of the reasonable maximum exposure for each pathway (EPA 1989a, 1991a). The reasonable maximum exposure is defined by the EPA as the maximum exposure that is reasonably expected to occur (EPA 1989a). However, the reasonable maximum exposure, as defined by the EPA, is quite conservative. In fact, many of the variables recommended by the EPA are 90th or 95th percentile values; multiplication of these values in the intake equation results in an estimate that is highly conservative and does not actually represent an average exposure or even a 90th or 95th percentile exposure.

The average daily intake calculation was undertaken in two stages: (1) estimation of exposure concentrations (the "C" term in the equation) and (2) calculation of HIF (the combined "CR," "EFD," "BW," and "AT" terms in the equation).

Estimation of Exposure Point Concentrations

An exposure point concentration is the arithmetic mean concentration of a chemical in a medium, averaged over the area in which exposure is expected to occur (EPA 1989a). Although this concentration is not the maximum that could potentially be contacted at any one time (with the exception noted below), it is regarded as a reasonable estimate of the concentration that is likely to be contacted over time. Because of the uncertainty associated with estimating the true arithmetic mean from a limited number of samples, a degree of conservatism is needed in calculating exposure point concentrations (EPA 1989a). This conservatism is provided by using the 95 percent upper confidence limit (UL₉₅) on the arithmetic average, or by using the maximum detected value when the number of samples is so small that the upper confidence limit exceeds the maximum detected value.

Calculation of exposure point concentrations involves (1) selecting samples from locations that represent exposure points and (2) analyzing available sampling data to estimate the mean concentration of each chemical at each exposure point.

Selection of Sampling Data. Sampling data used in exposure point concentration calculations are summarized in Tables 3.48 (Organic Compounds in Creek Sediment) and 3.58 (Groundwater Sampling Data).

Because only two sediment samples were taken for analysis, the higher detected contaminant value was chosen for each contaminant (Table 3.48). This approach is highly conservative. Note that only one contaminant, bis(2-ethylhexyl)phthalate, was found at a higher level in the sediment of sample JCSD1AS (essentially a background sample) than in that of sample JCSD2AS (field sample). The physicochemical characteristics of sediment were presumed to be those of soil. As is usually true for estimates of dermal exposure to soil, only exposure to organic contaminants in creek sediments (Table 3.48) were considered. Percutaneous absorption of inorganic contaminants is not evaluated because there is little evidence on which to base estimates of skin absorption efficiency from soil and because the low lipid solubility of metallic salts can reasonably be expected to retard their transdermal migration (EPA 1992a).

For groundwater contaminants, UL₉₅ values were used because the groundwater taken at various sampling points would be well mixed by the time it reached the consumer via the Johnson City well field. As previously mentioned, comparison of the UL₉₅ concentrations with applicable water quality standards (Table 3.58) led to the elimination of five additional groundwater contaminants of potential concern (cadmium, chromium, nickel, vanadium, and 1,1,1-trichloroethane).

TABLE 3.58 Groundwater Sampling Data of Potential Use for Exposure Calculations

Analytes	UL ₉₅ Average (µg/L)	Regulatory Limit ^a (µg/L)	Comment
Inorganic			
Antimony	4.6	3	
Cadmium	5.9	10	Eliminated ^b
Chromium	24.5	50	Aquatic criterion for Class A surface water; eliminated ^b
Iron	6,533	300 ^c	No RfD or SF available
Manganese	1,172	300 ^c	
Nickel	26.6	100	Eliminated ^b
Sodium	89,443	20,000	No RfD or SF available
Vanadium	10.3	14	Surface water criterion; eliminated ^b
Organic			
1,1,1-Trichloroethane	3.6	5	Eliminated ^b
Trichloroethene	16.2	5	

^a Except for nickel, which follows the EPA criteria, these are all New York State regulatory values.

^b These contaminants are not considered to be of concern because their UL₉₅ concentrations fell below regulatory levels.

^c The combined concentrations of iron and manganese must not exceed 500 µg/L.

Exposure Point Calculations. Some adjustments to the data set were necessary before the exposure point calculations; these adjustments are summarized below. Many of the chemicals were not found in all media. For example, a few chemicals of potential concern were detected only in soil; they were not detected in groundwater. Inclusion of these chemicals in risk quantification for media in which they had not been detected might have overestimated risk. Therefore, a chemical not detected in any sample in a particular medium was not quantified for that medium.

The highest detected concentrations of organic sediment contaminants were used as exposure point concentrations for the pathway of dermal contact with creek sediment.

The UL₉₅ groundwater concentrations were used for calculation of dermal and ingestion exposures. Chemicals that were analyzed for, but not detected, are qualified as "U" or "UJ" and are the analytical detection limits. For the calculation of UL₉₅ concentrations, half of the detect limit was used (if a non-detect value was "UD"-qualified, meaning that the original sample solution

had undergone a second dilution, the sample was ignored in the analysis). Data validation and qualifiers are discussed further in Section 3.3.2.4.

The maximum exposure point concentration value for trichloroethene vapor emanating from shower water was obtained by multiplying the UL_{95} concentration in water by a factor developed by McKone (1987), namely 0.026:

$$C_{air} = C_w \times 0.026. \quad (3.2)$$

Substitution of 16.15 mg/m^3 , derived from the UL_{95} concentration of trichloroethene in Table 3.58, into Equation 3.2 gives a value for C_{air} of 0.420 mg/m^3 . Note that the exposure point concentrations for groundwater and for volatiles in air emitted from groundwater during showering are made on the basis of the assumption that the contaminant concentrations do not change as groundwater travels from the AFP 59 site to the Johnson City wells. This extremely conservative position ignores the possibilities of dilution by cleaner water, adsorption of organic chemicals to soil particles, and chemical and biological degradation of the organic contaminants.

Calculation of Human Intake Factors

In the general equation for calculating human intake (Equation 3.1), the HIF incorporates the terms that describe exposure as related to human activity. The value of the HIF in calculating chemical intakes depends on the specific exposure scenario being evaluated. An HIF value is calculated individually for each exposed population, for each medium, for each exposure route, and for each exposure duration. In general, an HIF value consists of three terms:

- A contact rate term that describes the quantitative intake of a medium (e.g., milligrams of soil or liters of water) by a person on a day when exposure occurs.
- A body weight term.
- A series of time correction factors that account for the fact that exposure may not occur every day during the period of interest. These variables include exposure frequency (days or events per year) and exposure duration (years) and may also include exposure time (hours per day or per event). Such factors are divided by the period (in days) over which the exposure is averaged.

Activity Patterns of Potentially Exposed Populations

Human intake factors are derived for two assumed populations: adolescent recreational anglers/waders and adult residential consumers of water from the Johnson City potable water supply. A brief description of the assumed activity patterns of these two populations is presented below.

Anglers/Waders. Members of this small local subpopulation are assumed to be between 6 and 21 years old. They visit the Little Choconut Creek occasionally to fish or wade and may come in contact with the sediment. Smaller children would not usually engage in unsupervised play in such an area. Adults are less likely to engage in recreational activities in this area. The activity is confined to warm weather; much of the year the water is too cold to entice barefoot waders. The sediment is normally covered to a depth of several inches by water. Therefore, the assumption that sediment clings to the feet long enough for significant transdermal contaminant transfer to the receptor represents a very conservative approach.

Local Residents. Individuals living and working in the area served by the Johnson City water supply are potentially exposed individuals. They may be exposed to chemicals of concern in groundwater by drinking and by dermal contact while bathing. They may also inhale volatile emissions from shower water. However, it should be kept in mind that the groundwater concentrations used in this risk assessment were those detected beneath or close to the site; actual groundwater concentrations in the municipal wells are likely to be much lower.

Quantitative Evaluations

The values used in the pathway-specific exposure calculations are presented below, unless otherwise specified in the individual exposure scenarios.

Body Weight (BW). An average human body weight of 70 kg (154 lb) was assumed for the adult population exposed to groundwater (EPA 1991a). Adolescent waders were assumed to weigh 50 kg (EPA 1989b).

Area of Exposed Skin (SA). On the basis of available data from the *Exposure Factors Handbook* (EPA 1989b), the adolescent (13–14 years old) wader's lower leg skin area exposed to sediment was estimated as 1,880 cm². The whole-body skin area adopted for a resident exposed to water during bathing was 20,000 cm² (EPA 1992a).

Exposure Frequency (EF). Residential EF is based on full-time residence with 15 d/yr spent away from home, resulting in a residential exposure frequency of 350 d/yr (EPA 1991a). In consideration of the location and climate of the site, it was assumed that dermal contact by waders with sediment would occur 10 d/yr as a reasonable maximum. (In view of the small degree to which the local population engages in fishing in the Little Choconut Creek near the AFP 59 site, this activity would have to be considered recreational. There is no evidence that the creek supports subsistence fishing.) (EPA 1991a).

Exposure Duration (ED). On the basis of EPA default values (1991a), all human exposures to groundwater or air containing groundwater emissions have been assumed to be to adults over a period of 30 years. Human exposures to sediment are assumed to be to those people between ages 6 and 21.

Exposure Time (ET). The only ET assumption was 12 min daily for showering and bathing.

Averaging Time (AT). The AT was expressed in days and assumed equal to the ED for chronic (noncarcinogenic) hazards and 25,550 d (70 yr) for lifetime (carcinogenic) risks (EPA 1991a).

Contact Rate Terms

Ingestion of Water. The EPA-recommended adult drinking water ingestion rate of 2 L/d was used (EPA 1989a, 1991a). This is a 90th percentile value, which assumes that all liquid intake during a day is tap water. Thus, this assumption is a conservative estimate of daily residential water intake.

Dermal Contact with Sediment. One parameter needed to calculate dermal contact with sediment is the soil-to-skin adherence factor. Consideration of a number of sources led the EPA to adopt the factor $AF = 1 \text{ mg/cm}^2$ as a reasonable upper value (EPA 1992a). Adherence factors may vary, depending on the type of soil found at a particular site. Another parameter needed to calculate dermal intake is the fraction of the chemical that is absorbed from soil (ABS). This is a chemical-specific value. In general, metals in soils have low dermal absorption rates; because of these low dermal absorption rates, and because of a lack of data, absorption of metals from sediments was not quantified. An approach developed by McKone (1990) was cited by the EPA for organic contaminants in soil (EPA 1992a): for organic compounds of $\log K_{ow}$ of 6 or less and a dimensionless Henry's Law constant (K_H) less than 0.001, assume 100% uptake in 12 h; for compounds with K_H of 0.01–0.1, assume 40% uptake in 12 h (well below this for $K_{ow} > 10$); for compounds with K_H of 0.1 or above, assume 3% uptake in 12 h. Values of K_H and K_{ow} used

to select percent uptake of organics are given in Appendix L. The values selected for percentage uptake of these contaminants from sediment are presented in Table 3.59.

Dermal Contact with Water. When an individual bathes, solutes enter the body via the skin. Several parameters help to determine the HIF. The adult total SA is 20,000 cm²; the ET for a shower, also adopted here for bathing, is 0.2 h (90th percentile); the annual EF is 350 events/yr; and the permeability coefficient (K_p) is compound-specific (EPA 1992a). The BW is 70 kg for an adult, the ED is 30 yr, and the AT is 10,950 d for noncarcinogens and 25,550 d for carcinogens (EPA 1989a). In the present study, some specified values of K_p and other default values were obtained from an EPA reference document (EPA 1992a). Values of K_p are shown in Table 3.52.

Inhalation Rate for Volatiles. Recent guidance has indicated that the average indoor inhalation rate for an adult is 15 m³/d, or 0.625 m³/h (EPA 1991a). Therefore, the volume of air inhaled in 12 min (0.2 h) was estimated at 0.125 m³.

Summary. Tables 3.60 through 3.63 present calculations of individual HIF values. The resulting HIF values are summarized in Table 3.64.

Calculation of Average Daily Intakes

Average DIs were calculated by using the exposure point concentrations and HIF terms as described above. Chronic intakes (for noncarcinogens) and lifetime intakes (for carcinogens) were calculated according to Equation 3.1. These calculations are summarized in Tables 3.65–3.67, except for inhalation of trichloroethene, which was calculated (see Equation 3.2 and Table 3.63) as:

$$DI = C_{\text{air}} \times \text{HIF} = 3.1 \times 10^{-4} \text{ mg/kg}\cdot\text{d}. \quad (3.3)$$

3.3.4 Toxicity Assessment

Toxicity values for quantifying the potential health effects associated with exposure to the contaminants of concern at the AFP 59 site are identified in this section. Toxicity values for assessing the noncarcinogenic and carcinogenic effects of chemical contaminants of potential concern and their major toxicological effects are described in the next two sections.

TABLE 3.59 Estimate of Percent Dermal Absorption of Contaminants from Sediment over 12 h at a Soil Loading of 1 mg/cm²

Compound	K_H (Dimensionless) ^a	Log K_{ow} ^a	Estimated 12-h Percent Absorption
Methylene chloride	8.30×10^{-2}	1.25	10 ^b
Naphthalene	1.90×10^{-2}	3.30	10 ^c
2-Methylnaphthalene	5.24×10^{-2}	3.97	20 ^d
Acenaphthene	3.76×10^{-3}	4.07	50 ^d
Dibenzofuran	e	e	—
Fluorene	2.62×10^{-3}	4.18	50 ^d
Anthracene	4.17×10^{-2}	4.45	20 ^f
Phenanthrene	6.50×10^{-3}	4.46	20 ^c
Di-n-butyl phthalate	1.15×10^{-5}	4.11	100 ^g
Fluoranthene	2.64×10^{-4}	4.95	90 ^c
Pyrene	2.06×10^{-4}	4.88	100 ^g
Bis(2-ethylhexyl) phthalate	4.52×10^{-4}	9.64	20 ^d
Chrysene	4.29×10^{-5}	5.66	100 ^g
Benzo[b]fluoranthene	4.86×10^{-4}	6.12	50 ^d
Benzo[k]fluoranthene	1.61×10^{-3}	6.84	50 ^d
Benzo[a]pyrene	6.33×10^{-5}	6.10	50 ^c
Indeno[1,2,3-cd]pyrene	2.80×10^{-6}	6.58	20 ^c
Benzo[ghi]perylene	2.18×10^{-6}	6.51	80 ^d
Aldrin	6.54×10^{-4}	3.01	100 ^g

^a The origins of values of K_H and log K_{ow} are provided in Appendix M.

^b Based on McKone (1990), Figure 5.

^c Based on Burmaster and Maxwell (1991), Figure 8 (authors applied McKone's approach).

^d Authors' judgment, based on McKone (1990).

^e No data.

^f Assumed to be similar to behavior of phenanthrene, as in Burmaster and Maxwell (1991).

^g According to rules in McKone (1990).

TABLE 3.60 Human Intake Factor Calculations^a for Percutaneous Absorption of Organic Contaminants from Sediment by Adolescents

Symbol	Variable	Unit	Value of Factor	
			Noncarcinogens	Carcinogens
SA	Surface area	cm ² /event	1,880	1,880
EF	Exposure frequency	events/yr	10	10
ED	Exposure duration	yr	15	15
AF	Adherence factor	mg/cm ²	1	1
CF	Conversion factor ^b	kg/mg	10 ⁻⁶	10 ⁻⁶
BW	Body weight	kg	50	50
AT	Averaging time	d	5,475 ^c	25,550 ^d
ABS	Absorption factor	(unitless)	e	e
HIF	Human intake factor	d ⁻¹	1.03 x 10 ⁻⁶ ABS	2.21 x 10 ⁻⁷ ABS

^a Basic equation for human intake factor (HIF):

$$\text{HIF (d}^{-1}\text{)} = \text{SA} \times \text{EF} \times \text{ED} \times \text{AF} \times \text{CF} \times \text{ABS}/(\text{BW} \times \text{AT})$$

^b The conversion factor is required is required to reconcile the units in the equation.

^c Equivalent to 15 yr.

^d Equivalent to 70 yr.

^e The contaminant-specific absorption factor is from Table 3.59.

TABLE 3.61 Human Intake Factor Calculations^a for Ingestion of Groundwater Contaminants by Adults

Symbol	Variable	Units	Value of Factor	
			Noncarcinogens	Carcinogens
IR	Intake rate	L/d	2	2
EF	Exposure frequency	d/yr	350	350
ED	Exposure duration	yr	30	30
BW	Body weight	kg	70	70
AT	Averaging time	d	10,950 ^b	25,550 ^c
HIF	Human intake factor	L/kg-d	0.0274	0.0117

^a Basic equation for HIF calculation:

$$\text{HIF (L/kg-d)} = \text{IR} \times \text{EF} \times \text{ED}/(\text{BW} \times \text{AT})$$

^b Equivalent to 30 yr.

^c Equivalent to 70 yr.

TABLE 3.62 Human Intake Factor Calculations^a for Percutaneous Absorption of Organic Contaminants through Bathing

Symbol	Variable	Units	Value of Factor	
			Noncarcinogens	Carcinogens
SA	Surface area	cm ² /event	20,000	20,000
K _p	Permeability coefficient	cm/hr	^b	^b
CF	Conversion factor ^c	L/cm ³	10 ⁻³	10 ⁻³
ET	Exposure time	hr/event	0.2	0.2
EF	Exposure frequency	events/yr	350	350
ED	Exposure duration	yr	30	30
BW	Body weight	kg	70	70
AT	Averaging time	d	10,950 ^d	25,550 ^e
HIF	Human intake factor	L/kg·d	0.0548 K _p	0.0235 K _p

^a Basic equation for HIF calculation:

$$\text{HIF (L/kg·d)} = \text{SA} \times \text{K}_p \times \text{CF} \times \text{ET} \times \text{EF} \times \text{ED} / (\text{BW} \times \text{AT})$$

^b The contaminant-specific permeability coefficient is found in Table 3.52.

^c The conversion factor is required to reconcile the units in the equation.

^d Equivalent to 30 yr.

^e Equivalent to 70 yr.

TABLE 3.63 Human Intake Factor Calculations^a for Inhalation Exposure to a Volatile Carcinogenic Contaminant of Groundwater during Showering

Symbol	Variable	Units	Value of Factor
IR	Inhalation rate	m ³ /h	0.625
ET	Exposure time	h/event	0.2
EF	Exposure frequency	events/yr	350
ED	Exposure duration	yr	30
BW	Body weight	kg	50
AT	Averaging time	d	25,550 ^b
HIF	Human intake factor	m ³ /kg·d	7.34 × 10 ⁻⁴

^a Basic equation for HIF calculation:

$$\text{HIF (m}^3\text{/kg·d)} = \text{IR} \times \text{ET} \times \text{EF} \times \text{ED} / (\text{BW} \times \text{AT})$$

^b Equivalent to 70 yr.

TABLE 3.64 Summary of Human Intake Factor Values

Exposure Pathway	Units	HIF Values	
		Noncarcinogens	Carcinogens
Percutaneous absorption of organic contaminants from sediment	d ⁻¹	1.03 x 10 ⁻⁶ ABS ^a	2.21 x 10 ⁻⁷ ABS ^a
Ingestion of groundwater	L/kg-d	0.0274	0.0117
Percutaneous absorption of contaminants from groundwater while bathing	L/kg-d	0.0548 K _p ^b	0.0235 K _p ^b
Inhalation of a volatile carcinogenic contaminant of groundwater while showering	m ³ /kg-d	—	7.34 x 10 ⁻⁴

^a ABS is unitless.

^b K_p is in units of cm/h.

3.3.4.1 Toxicity Values for the Assessment of Noncarcinogenic Effects of Chemical Contaminants

The potential for noncarcinogenic health effects resulting from exposure to chemical contaminants is assessed by comparing an exposure estimate (intake) to a reference dose (RfD). The EPA (1989a) defines a chronic RfD as "an estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime." An RfD is specific to the chemical, the route of exposure, and the duration over which the exposure occurs. Reference doses have been derived for oral and inhalation exposures but are not available for dermal exposure. As explained below, oral RfDs were adjusted to allow their use for the dermal route. Chronic RfDs are used to evaluate exposures occurring over periods of more than seven years, and subchronic RfDs are used to evaluate exposures over shorter periods (from two weeks to seven years). For this risk assessment, only chronic RfDs are considered because the individuals involved are assumed to be exposed for more than seven years.

Official RfDs are derived by EPA work groups. For each compound, all relevant human and animal studies are reviewed, and the studies pertinent to the derivation of the RfD are selected. Each study is then evaluated to determine the no observed adverse-effect level (NOAEL). If the data are inadequate for such a determination, the lowest observed adverse-effect level (LOAEL) is determined.

TABLE 3.65 Calculated Daily Intakes of Organic Compounds of Concern from Sediment through Dermal Absorption

Contaminant	ABS ^b (%)	Daily Intake (DI) ^a (mg/kg·d)	
		As a Noncarcinogen	As a Carcinogen
Acenaphthene	50	1.96×10^{-7}	—
Aldrin	100	1.85×10^{-8}	3.98×10^{-9}
Anthracene	20	1.07×10^{-7}	—
Benzo[b]fluoranthene	50	4.27×10^{-7}	9.13×10^{-8}
Benzo[k]fluoranthene	50	1.70×10^{-7}	3.63×10^{-8}
Benzo[ghi]perylene	80	1.48×10^{-7}	—
Benzo[a]pyrene	50	3.14×10^{-7}	6.71×10^{-8}
Bis(2-ethylhexyl) phthalate	20	4.33×10^{-8}	9.21×10^{-9}
Chrysene	100	8.14×10^{-7}	1.75×10^{-7}
Dibenzofuran	—	—	—
Di-n-butyl phthalate	100	3.09×10^{-7}	—
Fluoranthene	90	2.04×10^{-6}	—
Fluorene	50	2.21×10^{-7}	—
Indeno[1,2,3-cd]pyrene	20	3.91×10^{-8}	8.40×10^{-9}
Methylene chloride	10	8.24×10^{-10}	1.77×10^{-10}
2-Methylnaphthalene	20	2.27×10^{-8}	—
Naphthalene	10	2.78×10^{-8}	—
Phenanthrene	20	4.73×10^{-7}	—
Pyrene	100	1.85×10^{-6}	—

^a $DI = C_{\text{sediment}} \text{ (mg/kg)} \times HIF$. $HIF = 1.03 \times 10^{-6} \text{ d}^{-1} \times ABS$ for noncarcinogens and $2.21 \times 10^{-7} \text{ d}^{-1} \times ABS$ for carcinogens.

^b See Table 3.59 for ABS values.

The LOAEL corresponds to the lowest daily dose administered over a lifetime that induces an observable adverse effect. The toxic effect characterized by the LOAEL is called the "critical effect." The NOAEL corresponds to the highest determined dose, in milligrams per kilogram body weight per day, that can be administered over a lifetime without inducing observable adverse effects.

Both LOAELs and NOAELs are most often based on data from experimental studies in animals. Both the experimental parameters and the extrapolation of animal data to humans are potential sources of uncertainty. Therefore, in the derivation of an RfD, the NOAEL (or the LOAEL) is divided by uncertainty factors to ensure that the RfD is protective of human health. Uncertainty factors are applied to account for (1) extrapolation of data from experimental animals to humans (interspecies extrapolation), (2) variation in human sensitivity to the toxic effects of a

compound, (3) derivation of a chronic RfD based on a subchronic rather than a chronic study, and (4) derivation of an RfD from the LOAEL rather than the NOAEL. In addition to these uncertainty factors, modifying factors between 0 and 10 may be applied to reflect additional qualitative considerations in evaluating the data. For most compounds, the modifying factor is 1.

Reference doses verified by the EPA are available from the EPA's IRIS, an on-line data base that contains current health risk and regulatory information for many chemicals (EPA 1992c). RfDs not included in IRIS are sometimes tabulated in the EPA's annual HEAST (EPA 1992b). Most RfDs used in this risk assessment were obtained from IRIS; HEAST values were only used for a few compounds not listed in IRIS. Chronic oral RfDs were available directly or indirectly from IRIS or HEAST for 14 of the 24 chemical contaminants of potential concern in sediment and groundwater (exclusive of the 8 metals in sediment, which were not evaluated for the percutaneous route). Reference dose values (not found in IRIS or HEAST) were estimated for two organic compounds for which toxicity data were available, as described below. The available oral RfDs and corresponding critical effects for AFP 59 compounds of potential concern are listed in Table 3.68. For compounds in Table 3.68 that have been identified as carcinogenic, and for which SFs have been found, the word "carcinogenicity" has been inserted in the "critical effects" column to direct the reader to the appropriate information (Table 3.69). These PAHs are not known to have noncarcinogenic health effects and therefore are not quantified in the calculation of noncarcinogenic risks. The key study used to derive the RfD for each contaminant of concern is summarized in Appendix N.

There were four organic contaminants for which RfDs could not be obtained from the EPA sources and for which there were no carcinogenic SFs: 2-methylnaphthalene, phenanthrene, benzo[ghi]perylene, and dibenzofuran. RfDs for 2-methylnaphthalene and phenanthrene were estimated (Table 3.68) according to Layton et al. (1987) from the acute oral LD₅₀s for rats, 1,630 mg/kg for 2-methylnaphthalene and 700 mg/kg for phenanthrene (Sweet 1986). Such estimates, at the 95-percentile level, are obtained by multiplying the oral LD₅₀s for rats (or mice) by the factor 1.5×10^{-6} d/L.* (LD₅₀ is the acute dose that will kill 50% of a group of similar test animals under a particular set of experimental conditions.) No LD₅₀s were found from which to estimate RfD values for benzo[ghi]perylene or dibenzofuran.

* Obtained from a statistical plot of allowable daily intakes against LD₅₀s.

TABLE 3.66 Calculated Daily Intake of Groundwater Contaminants of Concern through Ingestion

Contaminant ^a	Daily Intake (DI) ^b (mg/kg-d)
Antimony ^c	1.26×10^{-4}
Iron ^c	1.80×10^{-1}
Manganese ^c	3.21×10^{-2}
Sodium ^c	2.45
Trichloroethene ^d	1.90×10^{-4}

^a See Table 3.58.

^b $DI = C_{\text{Groundwater}} \times HIF$. HIF = 0.0274 L/kg-d for noncarcinogens and 0.0117 L/kg-d for carcinogens, where HIF is the human intake factor developed in Table 3.61.

^c Noncarcinogen.

^d Carcinogen.

TABLE 3.67 Calculated Daily Intake of Groundwater Contaminants of Concern through Bathing

Contaminant ^a	K _p (cm/h)	Daily Intake (DI) ^b (mg/kg-d)
Antimony ^c	10 ⁻³	2.52 x 10 ⁻⁷
Iron ^c	10 ⁻³	3.59 x 10 ⁻⁴
Manganese ^c	10 ⁻³	6.42 x 10 ⁻⁵
Sodium ^c	10 ⁻³	4.88 x 10 ⁻³
Trichloroethene ^d	1.6 x 10 ⁻²	6.09 x 10 ⁻⁶

^a See Table 3.58.

^b DI = C_{Groundwater} x HIF. HIF = 0.0548 K_p L/kg-d for noncarcinogens and 0.0235 K_p L/kg-d for carcinogens, where HIF is the human intake factor developed in Table 3.62.

^c Noncarcinogen.

^d Carcinogen.

Dermal contact with contaminated sediment is a potential route of exposure at the AFP 59 site. Exposure estimates for the dermal route are expressed as the absorbed dose (i.e., the amount of contaminant penetrating the skin). Dermal RfDs were converted into dermal RfDs by multiplying them by the appropriate oral absorption factors (Table 3.70), as discussed in Appendix A of the *Risk Assessment Guidance for Superfund* (EPA 1989a).

For this risk assessment, the RfDs presented in Table 3.68 and in Table 3.70 were used with the exposure estimates developed in Section 3.3.3 to quantify the potential for noncarcinogenic health effects associated with exposures at the site. This assessment is presented in Section 3.3.5.

3.3.4.2 Toxicity Values for the Assessment of Carcinogenic Effects of Chemical Contaminants

The toxicity information considered in the assessment of potential carcinogenic risks includes (1) a weight-of-evidence classification and (2) a slope factor (SF). The weight-of-evidence classification qualitatively describes the likelihood that an agent is a human carcinogen and is based on an evaluation of the available data from human and animal studies. An agent may

TABLE 3.68 Chronic Oral Reference Doses (RfDs) and Critical Effects of Contaminants of Concern at AFP 59^a

Contaminant	RfD (mg/kg-d) ^b	Critical Effects
Acenaphthene	6.0×10^{-2}	Hepatotoxicity
Aldrin	3.0×10^{-5}	Liver lesions, carcinogenicity
Anthracene	3.0×10^{-1}	No treatment-related effects
Antimony	4.0×10^{-4}	Reduced lifespan, altered blood chemistry
Benzo[b]fluoranthene	c	Carcinogenicity
Benzo[k]fluoranthene	c	Carcinogenicity
Benzo[ghi]perylene	c	No information
Benzo[a]pyrene	c	Carcinogenicity
Bis(2-ethylhexyl) phthalate	2.0×10^{-2}	Liver enlargement, carcinogenicity
Chrysene	c	Carcinogenicity
Dibenzofuran	—	No information
Di-n-butyl phthalate	1.0×10^{-1}	Increased mortality
Fluoranthene	4.0×10^{-2}	Nephropathy, liver weight changes, hematological changes
Fluorene	4.0×10^{-2}	Decrease erythrocyte counts
Indeno[1,2,3-cd]pyrene	c	Carcinogenicity
Iron	—	No information
Manganese ^d	5×10^{-3}	Central nervous system effects
Methylene chloride	6.0×10^{-2}	Liver toxicity, carcinogenicity
2-Methylnaphthalene ^e	2.4×10^{-3}	No information
Naphthalene	4.0×10^{-2}	Decreased body weight
Phenanthrene ^e	1.1×10^{-3}	No information
Pyrene	3.0×10^{-2}	Kidney damage
Sodium	—	No information
Trichloroethene	—	Carcinogenicity

^a Information in this table was drawn from the IRIS database (EPA 1992c) or HEAST (EPA 1992b), except as noted. The inorganic contaminants of sediment have been omitted here because their rates of percutaneous absorption are probably small.

^b Oral RfDs in Table 3.70 are adjusted for the dermal route.

^c Carcinogenic PAHs with no RfDs listed in IRIS or HEAST; it is assumed that no noncarcinogenic effects are associated with these chemicals.

^d Oral RfD for manganese in water.

^e Estimated value; see text.

TABLE 3.69 Slope Factors and Carcinogenic Characteristics for Contaminants of Concern at AFP 59^a

Contaminant ^b	Oral Slope Factor (kg-d/mg)	TEF (unitless)	Adjusted Oral Slope Factor (carcinogenic PAHs)	Oral Slope Factor Source	Tumor Type/Route
Aldrin	17.0			IRIS	Mouse liver/oral
Benzo(b)fluoranthene ^c	7.3	0.1	7.3×10^{-1}		
Benzo(k)fluoranthene ^c	7.3	0.1	7.3×10^{-1}		
Benzo[a]pyrene ^c	7.3	1	7.3	IRIS	Rat forestomach/oral
Bis(2-ethylhexyl) Phthalate	1.4×10^{-2}			IRIS	Liver/ingestion
Chrysene ^c	7.3	0.01	7.3×10^{-2}		
Indeno(1,2,3-cd)pyrene ^c	7.3	0.1	7.3×10^{-1}		
Methylene chloride	7.5×10^{-3}			IRIS	Liver/inhalation and drinking water
Trichloroethene ^d	1.1×10^{-2}			d	Liver/oral

^a Oral slope factors were adjusted for the dermal route by dividing by an oral absorption factor (see Table 3.71).

^b For all of these compounds, the weight-of-evidence classification is B2 (i.e., probable human carcinogen with sufficient evidence of carcinogenicity in animals but inadequate or lack of evidence in humans).

^c Other carcinogenic polynuclear aromatic hydrocarbons (PAHs) evaluated by using the benzo[a]pyrene slope factor (SF), in combination with toxicity equivalence factors (TEFs) and with a B2 weight of evidence, are the following: benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene and indeno[1,2,3-cd]pyrene.

^d The inhalation slope factor for trichloroethene (the only inhalation SF required in the present risk assessment) is 6.0×10^{-3} (EPA 1992d). Although this oral slope factor has been withdrawn from IRIS, it is used in this risk assessment.

TABLE 3.70 Calculated Dermal Reference Doses (RfDs) for Noncarcinogenic Effects of Contaminants of Concern at AFP 59^a

Contaminant	Chronic Oral Reference Dose (RfD) (mg/kg-d)	Chronic Oral RfD Source	Oral Absorption Factor (unitless)	Absorption Factor Source	Adjusted Dermal RfD Value (mg/kg-d)
Acenaphthene	6.0×10^{-2}	IRIS	1.00	c	6.0×10^{-2}
Aldrin	3.0×10^{-5}	IRIS	0.50	d	1.5×10^{-5}
Anthracene	3.0×10^{-1}	IRIS	0.50	c	1.5×10^{-1}
Antimony	4.0×10^{-4}	IRIS	0.01	e	4.0×10^{-6}
Bis(2-ethylhexyl) phthalate	2.0×10^{-2}	IRIS	0.25	f	5.0×10^{-3}
Dibenzofuran	-				
Di-n-butyl phthalate	1.0×10^{-1}	IRIS	0.90	g	9.0×10^{-2}
Fluoranthene	4.0×10^{-2}	IRIS	0.50	d	2.0×10^{-2}
Fluorene	4.0×10^{-2}	IRIS	0.50	d	2.0×10^{-2}
Iron	-				
Manganese	5.0×10^{-3}	IRIS ^b	0.03	e	1.5×10^{-4}
Methylene chloride	6.0×10^{-2}	IRIS	0.98	h	5.88×10^{-2}
2-Methylnaphthalene	2.4×10^{-3}	calculated	0.50	d	1.2×10^{-3}
Naphthalene	4.0×10^{-2}	HEAST	1.00	i	4.0×10^{-2}
Phenanthrene	1.1×10^{-3}	calculated	1.00	c	1.1×10^{-3}
Pyrene	3.0×10^{-2}	IRIS	0.60	j	1.8×10^{-2}
Sodium	-				

^a Dermal RfD = oral RfD x oral absorption factor.

^b Oral RfD for water ingestion.

^c EPA (1991).

^d 50% oral absorption is a default value and is based on a chemical's similarity to benzo(a)pyrene.

^e Not evaluated for the dermal route.

^f Schmid and Schlatter (1985).

^g Williams and Blanchfield (1975).

^h ATSDR (1991).

ⁱ NTP (1992).

^j Withey et al. (1991).

be placed in one of three groups to indicate its potential for carcinogenic effects: Group A, a human carcinogen; Group B1 or B2, a probable human carcinogen; and Group C, a possible human carcinogen. Agents that cannot be classified as human carcinogens are categorized as Group D, and those for which there is evidence of noncarcinogenicity in humans are categorized as Group E.

According to the EPA (1989a), the SF is the "plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime." It is used to determine the upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a carcinogen. Slope factors are derived from studies of carcinogenicity in humans and/or experimental animals and are typically calculated for compounds in Groups A, B1, and B2. As in the case of RfDs, the SFs are specific to a chemical and route of exposure, and they are available for both the oral and inhalation exposure routes. Dermal SFs can be calculated from oral slope factors by dividing the oral SF by the fraction orally absorbed, as discussed in Appendix A of the *Risk Assessment Guidance for Superfund* (EPA 1989a).

Of the 20 organic contaminants of concern for sediment or groundwater identified at the site, the 10 for which SFs could be obtained or derived have been classified as Group B2 carcinogens. The available oral SFs (and one inhalation SF, in a footnote) for these compounds are listed in Table 3.69. A method that takes into account the scientific evidence that other PAHs are not as potent carcinogens as benzo(a)pyrene was developed by ICF-Clement (1988) under contract to the EPA Office of Health and Environmental Assessment. This method uses toxicity equivalence factors (TEFs), which relate the potency of other carcinogenic PAHs to that of benzo[a]pyrene. EPA is currently evaluating this report and is developing potency factors. The TEF approach has been used in at least four EPA regions (Regions III, IV, VI, and VIII). The key studies used to derive the SFs for carcinogenic contaminants of concern are summarized in Appendix N. Oral SFs are adjusted for the dermal route by dividing by oral absorption values and are listed in Table 3.71.

In this risk assessment, the SFs presented in Table 3.69 and in Table 3.71 were used with the exposure estimates developed in Section 3.3.3 to quantify the carcinogenic risks associated with potential exposures at the site. The assessment of potential carcinogenic risk is presented in Section 3.3.5.

TABLE 3.71 Calculated Dermal Slope Factors (SFs) for Carcinogenic Effects of Contaminants of Concern at AFP 59^a

Compound	Oral Slope Factor (kg·d/mg)	TEF (unitless)	Adjusted Oral Slope Factor (carcinogenic PAHs)	Oral Absorption Fraction (unitless)	Oral Absorption Fraction Source	Adjusted Dermal SF (mg/kg·d)
Aldrin	17.0			0.5	b	34
Benzo[b]fluoranthene	7.3	0.1	7.3×10^{-1}	0.5	c	1.46
Benzo[k]fluoranthene	7.3	0.1	7.3×10^{-1}	0.5	c	1.46
Benzo[a]pyrene	7.3	1	7.3	0.5	d	14.6
Bis(2-ethylhexyl) phthalate	1.4×10^{-2}			0.25	e	5.6×10^{-2}
Chrysene	7.3	0.01	7.3×10^{-2}	0.5	c	1.46×10^{-1}
Indeno(1,2,3-cd)pyrene	7.3	0.1	7.3×10^{-1}	0.5	c	1.46
Methylene chloride	7.5×10^{-3}			0.98	f	7.65×10^{-3}
Trichloroethene	1.1×10^{-2}			0.98	g	1.12×10^{-2}

^a Dermal SF = oral SF/oral absorption factor.

^b Assumed oral absorption of 50%.

^c Default value of 50% based on chemical's similarity to benzo(a)pyrene.

^d Brainard and Beck (1992).

^e Schmid and Schlatter (1975).

^f ATSDR (1991), Toxicological Profile for Methylene Chloride.

^g ATSDR (1991), Toxicological Profile for Trichloroethene.

3.3.5 Risk Characterization

3.3.5.1 Hazard Quotients and Chemical Risks

Hazard Quotients and Hazard Indexes

A hazard quotient (HQ) provides a measure of the potential for adverse health effects in humans other than cancer. For an individual contaminant, the DI averaged over the exposure period is divided by the RfD to derive the HQ, i.e.,

$$HQ = DI/RfD. \quad (3.4)$$

The RfD is the average daily dose that can be incurred without an appreciable risk of deleterious health effects during a lifetime. The EPA has derived RfDs for both chronic (greater than seven years) and subchronic (less than seven years) exposure periods. Because the potential exposures considered in this risk assessment are for periods of more than seven years, only chronic RfDs are considered. The estimated average DIs resulting from exposure to the contaminants of concern at the site have been presented in Section 3.3.3.4, and the RfDs for these contaminants were identified in Section 3.3.4.1. For an individual contaminant, an HQ of less than 1 is considered to indicate a nonhazardous situation; conversely, an HQ of 1 or greater is considered to indicate a potential for adverse health effects. The HQs for all contaminants are summed to determine a hazard index (HI), namely,

$$HI = HQ_1 + HQ_2 + HQ_3 + \dots + HQ_n. \quad (3.5)$$

If there had been instances where each contaminant-specific HQ was less than 1, but their sum was greater than 1, the major toxicological effects of the individual contaminants would have been examined to determine the potential hazard associated with exposure to multiple contaminants.

Reference doses are specific to the contaminants and the routes of exposure. For the oral route, EPA-promulgated RfDs were available for most of the contaminants of concern. The RfDs for 2-methylnaphthalene and phenanthrene were unofficial estimates calculated for this risk assessment. In contrast to oral RfDs, few inhalation RfDs and no dermal RfDs were available. The oral RfDs in Table 3.68 were multiplied by appropriate oral absorption factors to obtain RfDs, which could be used to assess dermal risks (Table 3.70). The uncertainties in this assessment resulting from the lack of RfDs for some compounds are discussed in Section 3.3.6.

Dermal HQs (in the case of exposure to sediment, for organic compounds only) were estimated by dividing the absorbed doses by the dermal RfDs (using oral RfDs adjusted for the dermal route). The HIs estimated for exposure to groundwater via the dermal pathway were considerably lower than those for the oral pathway of ingestion of groundwater.

Carcinogenic Risks

The risk to an individual resulting from exposure to chemical carcinogens is expressed as the increased probability of a cancer occurring over the course of a lifetime. To calculate the excess cancer risk (R) for a carcinogen, the DI averaged over a lifetime (DIL) is multiplied by the chemical-specific SF:

$$R_i = DI_{Li} \times SF_i. \quad (3.6)$$

The total cancer risk is the sum of the individual cancer risks. Slope factors have been derived by the EPA for a number of carcinogens, and each represents the incremental lifetime cancer risk per milligram of carcinogen per kilogram of body weight, assuming that the exposure occurs over a lifetime of 70 years. The DIs (averaged over a lifetime) resulting from exposure to the chemical carcinogens of concern were estimated in Section 3.3.3, and the SFs for these carcinogens were provided in Section 3.3.4. An SF is specific to the chemical and to the route of exposure (i.e., inhalation or ingestion).

Oral SFs for the organic compounds of concern were adjusted for use in the dermal exposure route by dividing the oral SFs listed in Table 3.69 by the oral absorption values listed in Table 3.71 so that an SF applicable to an absorbed dose could be determined. In contrast to risk estimates for oral and inhalation exposures, which are multiplied by the administered dose, the dermal SF is multiplied by the absorbed dose so that the risks associated with dermal exposures can be estimated.

3.3.5.2 Evaluation of Noncarcinogenic Site-Related Risks

In the angler/wader scenario, contact with sediment would involve dermal exposure to the following compounds for which RfDs are available (Table 3.68): acenaphthene, aldrin, anthracene, antimony, bis(2-ethylhexyl) phthalate, di-n-butyl phthalate, fluoranthene, fluorene, manganese, methylene chloride, naphthalene, and pyrene. Two compounds for which unofficial RfDs have been estimated have been added to this list: 2-methylnaphthalene and phenanthrene. Hazard quotients and a hazard index for sediment exposure are provided in Table 3.72.

Two of the contaminants that occurred consistently, iron and sodium, could not be evaluated because RfDs were not available. Both of these elements are quite common and are apparently not associated with AFP 59 operations. Iron, in particular, can be troublesome because of its taste and appearance in water and because it stains materials with which it comes in contact. However, these chemicals only cause adverse health effects at extremely high intake levels, and there are no means for evaluating their possible health effects quantitatively. In addition, dibenzofuran does not have an RfD established by EPA, nor does it have sufficient published toxicity information to develop an RfD. The potential underestimation of risk due to the lack of an RfD value for dibenzofuran is discussed in the uncertainty section.

TABLE 3.72 Hazard Quotients and Hazard Index for Dermal Exposure to Sediment Contaminants of Concern at AFP 59

Contaminant	Adjusted Dermal RfD Value (mg/kg-d)	Daily Intake ^a (mg/kg-d)	Hazard Quotient
Acenaphthene	6.0×10^{-2}	1.96×10^{-7}	3.27×10^{-6}
Aldrin	1.5×10^{-5}	1.85×10^{-8}	1.23×10^{-3}
Anthracene	1.5×10^{-1}	1.07×10^{-7}	7.13×10^{-7}
Bis(2-ethylhexyl) phthalate	5.0×10^{-3}	4.33×10^{-8}	8.66×10^{-6}
Di-n-butyl phthalate	9.0×10^{-2}	3.09×10^{-7}	3.43×10^{-6}
Fluoranthene	2.0×10^{-2}	2.04×10^{-6}	1.02×10^{-4}
Fluorene	2.0×10^{-2}	2.21×10^{-7}	1.11×10^{-5}
Methylene chloride	5.88×10^{-2}	8.24×10^{-10}	1.40×10^{-8}
2-Methylnaphthalene	1.2×10^{-3}	2.27×10^{-8}	1.89×10^{-5}
Naphthalene	4.0×10^{-2}	2.78×10^{-8}	6.95×10^{-7}
Phenanthrene	1.1×10^{-3}	4.73×10^{-7}	4.30×10^{-4}
Pyrene	1.8×10^{-2}	1.85×10^{-6}	1.03×10^{-4}
Hazard Index			1.91×10^{-3}

^a Daily intake values come from Table 3.65.

Hazard quotients and hazard indices are listed in Tables 3.72–3.74 for the pathways of dermal contact with sediment, ingestion of groundwater, and dermal absorption of groundwater.

3.3.5.3 Evaluation of Carcinogenic Site-Related Risks

Exposure risks attributable to dermal contact with sediment by the angler/wader target population were calculated for the following carcinogens of concern (Table 3.75): aldrin, bis(2-ethylhexyl) phthalate, methylene chloride, and five carcinogenic PAHs (benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, chrysene, and indeno[1,2,3-cd]pyrene).

Only one carcinogen, trichloroethene, was found above regulatory values in the groundwater. Carcinogenic risks were calculated for this compound for three pathways: (1) ingestion, (2) dermal exposure during bathing, and (3) inhalation of vapors during showering (see Table 3.76). The risks from inhalation of shower emissions and from ingestion of drinking water were about the same, while the risk from dermal exposure was negligible (<2% of the total).

TABLE 3.73 Hazard Quotients and Hazard Index for Groundwater Exposures via Ingestion near AFP 59

Contaminant	Chronic Oral Reference Dose (mg/kg-d)	Daily Intake (mg/kg-d)	Hazard Quotient
Antimony	4.0×10^{-4}	1.26×10^{-4}	0.32
Iron	—	1.80×10^{-1}	—
Manganese	5.0×10^{-3}	3.21×10^{-2}	6.42
Sodium	—	2.45	—
Trichloroethene	—	1.90×10^{-4}	—
Hazard Index			6.74

TABLE 3.74 Hazard Quotients and Hazard Index for Groundwater Exposures via Bathing near AFP 59

Contaminant	Chronic Dermal Reference Dose (mg/kg-d)	Daily Intake (mg/kg-d)	Hazard Quotient
Antimony	4×10^{-6}	2.52×10^{-7}	6.3×10^{-2}
Iron	—	3.59×10^{-4}	—
Manganese	1.5×10^{-4}	6.42×10^{-5}	4.28×10^{-1}
Sodium	—	4.88×10^{-3}	—
Trichloroethene	—	6.09×10^{-6}	—
Hazard Index			0.49

3.3.5.4 Summary of Risk Characterization

Noncarcinogenic risks associated with present conditions at Little Choconut Creek, expressed as HQs and HIs, were below a hazard index of 1.0, indicating that adverse noncarcinogenic effects due to dermal contact with creek sediment are unlikely. The highest HQ estimates were 0.00123 for aldrin and 0.00043 for phenanthrene; the total HI was only 0.0019.

For exposure pathways to groundwater, it must be kept in mind that concentrations of chemicals in groundwater from under the AFP 59 site were used, and that these concentrations are not representative of actual current exposures to groundwater from area wells. The HI for groundwater ingestion was 6.74, with an HQ of 6.42 for manganese ingestion. This value

TABLE 3.75 Cancer Risk from Dermal Exposure to Sediment at AFP 59

Contaminant ^a	Slope Factor (mg/kg-d) ⁻¹	Daily Intake (mg/kg-d)	Cancer Risk
Aldrin	34	3.98×10^{-9}	1.35×10^{-7}
Benzo[b]fluoranthene	1.46	9.13×10^{-8}	1.33×10^{-7}
Benzo[k]fluoranthene	1.46	3.63×10^{-8}	5.30×10^{-8}
Benzo[a]pyrene	14.6	6.71×10^{-8}	9.80×10^{-7}
Bis(2-ethylhexyl) phthalate	5.6×10^{-2}	4.33×10^{-8}	2.42×10^{-9}
Chrysene	1.46×10^{-1}	1.75×10^{-7}	2.56×10^{-8}
Indeno[1,2,3-cd]pyrene	1.46	8.40×10^{-8}	1.23×10^{-7}
Methylene chloride	7.65×10^{-3}	1.77×10^{-10}	1.35×10^{-12}
Total Cancer Risk			1.45×10^{-6}

^a See Table 3.69.

TABLE 3.76 Cancer Risk from Trichloroethene via Groundwater

Route	Exposure Point Concentration	Human Intake Factor	Daily Intake (mg/kg-d)	Slope Factor (mg/kg-d) ⁻¹	Risk
Ingestion	0.0162 mg/L	0.0117 L/kg-d	1.90×10^{-4}	1.1×10^{-2}	2.09×10^{-6}
Dermal	0.0162 mg/L	$0.0235 \times 1.6 \times 10^{-2}$ L/kg-d	6.09×10^{-6}	1.12×10^{-2}	6.82×10^{-8}
Inhalation	0.42 mg/m ³	7.34×10^{-4} m ³ /kg-d	3.08×10^{-4}	6.0×10^{-3}	1.85×10^{-6}
Total Cancer Risk					4.01×10^{-6}

indicates that a potential exists for adverse effects due to groundwater ingestion. The oral RfD for manganese in groundwater is based on one study in which neurological effects were seen in a Greek population. The EPA's confidence in the study was medium to low. Problems with the interpretation of the study on which the RfD was based are that differences between U.S. and Greek populations, especially with regard to regular dietary intake, were not taken into account and that neurological effects are very difficult to quantify. In addition, a daily intake of 2 L of drinking water was used in the derivation of the RfD for manganese, as well as in the exposure estimate for this site, which is likely to overestimate exposure due to the ingestion of drinking water (for a further discussion about assumptions regarding the drinking water intake, see Section 3.3.6.5). The HI for bathing in groundwater was 0.49, indicating that adverse effects attributable to dermal exposure to groundwater are not expected (at concentrations measured at the AFP 59 site).

The total carcinogenic risk from contact with sediment associated with present conditions at AFP 59 was estimated at 1.45×10^{-6} , which is attributable principally to benzo(a)pyrene and other carcinogenic PAHs. This risk is within the carcinogenic risk range of 10^{-7} to 10^{-4} for which the U.S. EPA requires remedial alternatives (EPA 1986) and is close to the target risk level of 10^{-6} (EPA 1991b). The no-action alternative is acceptable for this degree of risk (Paustenbach 1989).

The estimated carcinogenic risk from groundwater exposures (4×10^{-6}) is entirely attributable to trichloroethene, with almost equal risks from ingestion and vapor inhalation. The contribution calculated for bathing is less than 2% of the total (Table 3.76). Although the risk exceeds the target risk level of 10^{-6} , the no-action alternative is considered acceptable.

3.3.6 Assessment of Uncertainties

A number of factors can introduce uncertainty into any exposure and risk assessment. This section identifies key factors and assumptions that contribute uncertainty to the evaluation of risks at the AFP 59 site.

3.3.6.1 Selection of Contaminants of Potential Concern

Lists of target "analytes" (inorganic) and "compounds" (organic) have been developed by the EPA for use by analytical laboratories. These lists cover the great majority of pollutants found throughout the United States, but they may not include all of the contaminants historically associated with a particular site. Careful review of past and current site operations may suggest chemical species not on the lists of targeted substances. According to Graselli (1992), it has been estimated that 99% of the organic compounds in most environmental samples are ignored. Furthermore, she cited a study of the performance of 20 contract laboratories using EPA Method 8020 to determine purgeable organics in groundwater. Most of these purgeable organics met the precision criteria, but at concentrations below 20 µg/L, the overall precision estimated by the EPA method could not be achieved.

Under some exposure conditions, risk may be associated with contaminant levels that are lower than the detection limits attainable by using current analytical methods. To compensate for the uncertainty, a contaminant that has not been detected in a given sample, but has been detected elsewhere in the medium (e.g., soil), is considered to occur at half its detection limit. Where a contaminant is found in only a few samples and at low concentrations, this assumption leads to unrealistically high estimates of the average concentration in the medium. On the other hand, a completely undetected target compound could occur widely, although at less than the detection limit. This phenomenon contributes to uncertainty because it implies that risk is underestimated, but the contribution is usually small.

Moving media, such as flowing water, are susceptible to transient pollution events. Thus, the single occurrence of mercury above New York State regulatory limits in Little Choconut Creek water may not have been typical. Remedial action should not be taken on the basis of results from the small number of samples taken from that stream. Rather, a time profile should be established by periodic monitoring of the creek for mercury, or perhaps for a broader list of contaminants, at the site where mercury was found, upstream of AFP 59, and in the outfalls at the plant. Uncertainty about the cleanliness of the stream cannot be completely resolved cost-effectively, but it can be reduced to an acceptable degree.

In stationary media, such as soil, the distribution of contaminants tends to be heterogeneous. Even in a small sampling area, average concentrations are difficult to define. More samples tend to be drawn near "hot spots" than from cleaner locations; thus, "mean" values are usually high. In this risk assessment, because the maximum detected sediment concentration was used, the risks related to dermal contact with sediment in Little Choconut Creek are biased high. The degree to which a sample actually represents the medium from which it is taken is probably more uncertain when the number of samples is extremely small, as is true when samples are taken from sediment. It is uncertain whether the two samples are representative of the creek during all seasons of the year (or from year to year). Nevertheless, these two samples are used to characterize risk for the duration of childhood exposure (15 years). The use of the maximum site concentrations to estimate the upper bound risk for sediment contact is a very conservative approach. No one is likely to be exposed continuously to the maximum concentrations. Thus, risk calculations made on the basis of average exposures, as was done for groundwater exposure pathways, are much more likely to yield values that are representative of actual risks related to the site.

In the case of groundwater (where UL₉₅ averaging was employed), averaging was done without weighting for the volume of water that each analytical sample represented. The groundwater data from under the site are assumed to correctly characterize a lifetime (70 years) exposure to residents using the Johnson City well field. However, current concentrations are likely to decrease over time. Thus, this approach may overestimate risks related to the consumption of groundwater from this area in the future.

The qualification of analytical values as "estimates" (J) or, for inorganic analytes, as below detection limits (B) sometimes introduces a degree of uncertainty without any indication of whether the values are biased toward higher or lower levels.

The AFP 59 data, as reviewed by Gradient Corporation (Wait 1992), were screened for contamination by certain organic compounds common to analytical laboratories. Nevertheless, as suggested by the values for some volatile organic compounds (VOCs) in field blanks, equipment rinsates, trip blanks, and hold blanks, laboratory contamination could account for some of the low-level positive results recorded for acetone, methylene chloride, 1,1,1-trichloroethane, and others.

Duplicate analytical values, either for supposedly identical replicates or for dilutions of given samples, sometimes differed from each other to a considerable degree. On occasion, the half-detection-level values for a given pollutant assigned to non-detects were higher than J-qualified values for the same pollutant. This difference introduces a level of uncertainty for the analytical samples.

In this risk assessment, substances of little public health concern have been eliminated by the five screening procedures described in Section 3.3.2.5. The small number of background samples taken may not yield results that are truly representative of the background concentrations in the area. The deletion of contaminants detected in <5% of the medium samples is likely to add only slightly more uncertainty (per contaminant) than the elimination of undetected target compounds. The elimination of common essential elements with no published RfDs or SFs may add to uncertainty. However, as described in Section 3.3.2.5, these are essential elements in the human diet and are usually well tolerated, except at very high doses. Finally, the deletion of substances that fall below applicable regulatory values may further reduce the site's estimated risks. Nevertheless, because New York State regulatory values are stringent and are usually human-health-based, the occurrence of contaminants below regulatory levels is unlikely to contribute to estimated site risks.

3.3.6.2 Exposure Assessment

Exposure Scenarios. Not all conceivable exposure scenarios at the AFP 59 site are listed in Table 3.57; only the more plausible ones with reasonably high EFs and contaminant concentrations. Among the omitted scenarios are (1) contact with contaminated soil by workmen doing repairs, (2) inhalation by employees of vapors originating in contaminated soil beneath AFP 59 buildings, (3) exposure of children to outfall water or sediments, (4) ingestion of sediment from Little Choconut Creek by waders and anglers, (5) ingestion of or dermal contact with surface water in Little Choconut Creek, (6) ingestion of fish from Little Choconut Creek or adjacent Susquehanna River waters, (7) ingestion of garden crops influenced by suspended particulates from the site, (8) inhalation of other-than-shower indoor vapors of groundwater contaminants by way of the Johnson City well field, and (9) exposure of children and adolescents to residential groundwater. On the basis of the reasons for eliminating these exposure scenarios (outlined in Table 3.57), these exposure scenarios are unlikely to represent significant potential risks.

Among the exposure scenarios selected for evaluation, contact with Choconut Creek sediment by barefoot waders is physically feasible, but it is not likely to apply to many people. For the few who might be involved in this way, the hypothetical degree of contact (see the discussion below on dermal contact) is overestimated to cover the worst reasonable case. The scenario involving the use of groundwater could involve the approximately 128,000 people who use the Johnson City water system.

Contaminant Concentrations. The greatest uncertainty surrounding groundwater exposure estimates is the degree to which groundwater from beneath the AFP 59 site, regardless of the sources of contamination, contributes to the Johnson City well field. In this assessment, risk estimates for exposure via groundwater assumed that residents were exposed to UL95 concentrations of contaminants in groundwater underlying AFP 59, probably overestimating risks. There is no conclusive evidence that groundwater from beneath the site has entered the Johnson City well fields; if it is reaching Johnson City consumers, dilution by groundwater would significantly reduce contaminant concentrations. Moreover, some contaminants might precipitate or be degraded to less hazardous chemical species during the water's transit to the point of consumption. If significant amounts of AFP 59 groundwater are reaching the Johnson City well field, the travel time would be approximately 18 months (Tomasko 1992). Howard et al. (1991) have provided estimated half-life (t) ranges in groundwater for the two organics of greatest interest, 1,1,1-tetrachloroethane and trichloroethene. With a t-range of 20–78 weeks, 1,1,1-tetrachloroethane would be at least half decomposed by the time it reached the well field. Trichloroethene, with a t-range between 46 and 234 weeks, would be at least 20% decomposed in the same period. The possible ranges of these half-lives are four- to five-fold, and the uncertainties are derived on the basis of these figures. Clearly, trichloroethene would persist longer.

Except for small areas covered with grass or gravel, one cannot calculate the concentrations of contaminants in groundwater beneath the AFP 59 property from nearby soil concentrations. With (1) very little recharge to the aquifer from rainwater that falls on the site and (2) low EP toxicity values (Hart 1988), soils covered by buildings or pavement should not readily yield their contaminants to the groundwater. In particular, there is no evidence that AFP 59 is the source of such groundwater pollutants as trichloroethene, nor has an upgradient off-site source been identified. The use of trichloroethene was discontinued over six years before the most recent sampling (Schneider 1985).

Rises in groundwater level during river flooding could provide a mechanism for seasonal groundwater contamination, especially by metals. Unless this means of contamination is thoroughly investigated, uncertainty about cyclical changes in groundwater pollutant concentrations will be considerable.

Exposure Assumptions. Parameters describing human characteristics and activities can represent population means, but they often are the 90th or 95th upper percentile values for a population. In this risk assessment, for simplicity, parameter values chosen for the 30-yr Johnson City resident are those most closely associated with 70-kg male adults, even though a

majority of female residents and all young children would weigh less. Uncertainty due to population diversity can be minimized by a good choice of values for the scenario-related subpopulations (e.g., 50-kg waders in Little Choconut Creek). Nevertheless, the inherent diversity of human populations and their behaviors impose a considerable degree of uncertainty on population-based risk assessments when these assessments are applied to individuals.

Dermal exposure calculations for sediment are among the least satisfactory types of exposure estimates. Whether Little Choconut Creek sediment would adhere to a wader's skin is open to question; there is no evidence that the sediment is tarry enough to stick, and the chances that movement through the creek would wash it off are great. Therefore, the real contact time must be far less than the 12 h assumed in the derivation of absorption factors and the bioavailability of the contaminants must be far lower than portrayed in this risk assessment. In addition, the assumed 12-h percent-absorption values for organic contaminants may be in considerable error; they are based largely on theoretical calculations that have not been validated. No attempt was made to estimate the absorption of inorganics from sediment.

Dermal absorption of contaminants from bath water is also based on some rather uncertain assumptions. In particular, the permeability coefficients are mostly default values. Fortunately, this pathway makes a relatively small risk contribution, so the consequences of inaccuracy in the permeability coefficients are minor.

In this risk assessment, users of groundwater (via the Johnson City well field) are assumed to be showering and bathing daily. Such a dual treatment provides for comparison of the two modes of exposure and probably compensates for not addressing dermal absorption during showering or inhalation of vapors while bathing.

3.3.6.3 Toxicity Assessment

Uncertainties arise with respect to several points in the characterization of health risk. First, the extrapolation of dose-response relationships derived in animal studies to human populations involves several uncertainties. Toxicity values derived from animal studies are based on dose-response relationships developed in high-dosage animal studies. The estimated human intakes associated with the site are, proportionally, many times lower than those that would cause any observable effects in laboratory studies.

RfDs incorporate uncertainty factors that reflect the EPA's doubts (and conservatism) as to the reliability of these "acceptable doses" for human populations of concern. These uncertainties arise from the nature of the extrapolations used to derive RfDs: high- to low-dose levels, short- to long-term exposure, animal to human exposure, less sensitive to more sensitive human subpopulations, and LOAEL to NOAEL. The incorporation of uncertainty factors may lead to an overestimation of RfDs.

For cancer slope factor derivation, there are species differences in uptake, metabolism, and distribution of carcinogens, as well as differences in target site susceptibility. The way in which carcinogenic potency values are developed and used have come under considerable criticism. A recent article by Harris (1992) points out that chemicals are rarely tested below half the maximum tolerated dose and that even the most credible extrapolations to lower doses should be restricted to about one order of magnitude outside the observable range. The author thinks quantitative dose-to-risk conversions should not be attempted beyond that. Instead, he favors including explicitly stated safety factors for regulatory purposes. Extrapolation to risks of one-in-a-million, Harris believes, is bad science, which "should not be used to meet objectives concerning good public policy." The use of the upper 95% confidence limit slope from these studies as the SF results in an estimate of the uppermost bounds of the potential risk. In fact, the lower limit of cancer risk may be as low as zero. Therefore, in general, the uncertainties inherent in developing cancer SFs may lead to overestimates of carcinogenic risk.

In addition, the time frame of carcinogenicity leads to uncertainty in estimates of cancer risk. The experimental concept on which carcinogenicity is built normally entails feeding an animal constant doses of a chemical over a major part of its lifetime. However, exposure both to carcinogens and to noncarcinogens is bound to be uneven. To the degree that the actual exposure pattern deviates from the ideal of constant long-term or lifetime exposure, the uncertainty of the risk prediction would increase.

A second source of uncertainty in risk characterization is the lack of health criteria for every chemical of concern and for every route of exposure. Reference dose values were estimated for 2-methylnaphthalene and phenanthrene from oral lethal doses. No RfD (or RfD surrogate) values could be found or derived for the following contaminants of concern: benzo(g,h,i)perylene, dibenzofuran, iron, or sodium.

Benzo(g,h,i)perylene is a polycyclic aromatic hydrocarbon (PAH). PAHs are found in coal tars, creosote oils, and pitches from distillation of coal tars. Almost no data are available regarding the toxicity or carcinogenicity specifically of benzo(g,h,i)perylene, but there is some information regarding PAHs in general. PAHs can be absorbed via ingestion, dermal exposure, and through inhalation. PAHs have reportedly produced skin disorders and potential immunosuppressive effects (EPA 1989). The EPA has classified benzo(g,h,i)perylene as a Group D carcinogen, not classifiable as to human carcinogenicity. There are no data regarding the carcinogenic or noncarcinogenic effects of benzo(g,h,i)perylene in humans.

No data exist regarding the toxicity and/or carcinogenicity of unsubstituted dibenzofuran, but biological effects are known for chlorinated dibenzofurans (PCDFS). Systemic effects from PCDF mixtures include chloroacne, hyperpigmentation of the skin and mucous membranes, eye discharge, liver toxicity, and abnormal burning or prickling of the skin. Infants may exhibit fluid accumulation in the face and premature eruption of the teeth; these effects occurred in an incident in Japan, where some pregnant women ingested rice oil contaminated with high levels of PCDFs, PCBs, and dioxins (WHO 1988).

Iron is a component of hemoglobin, myoglobin, and many enzymes in the human body and is therefore an essential nutrient. The RDA for iron in adults is 15 mg for women and 10 mg for men. Severe lesions in the gastrointestinal tract, metabolic acidosis, shock, and toxic hepatitis can result in children ingesting soluble iron salts in doses that exceed 0.5 g of iron (Friberg et al. 1986). Chronic ingestion of excessive doses of iron causes hemochromatosis, which eventually causes cirrhosis of the liver (Friberg et al. 1986). An increased mortality in lung cancer has been reported for workers in hematite mines and iron foundries. Data from animal experiments suggest that iron oxide dust may be a cocarcinogenic substance (Friberg et al. 1986).

Sodium is the primary extracellular cation in the human body. The RDA for sodium for adults is 2.4 g or less (NRC 1989). Sodium deficiency from low dietary intake is very rare and is due primarily to health conditions that produce an inability to retain sodium. High sodium intake has been implicated in the development of hypertension in sensitive individuals. Acute toxicity from dietary sodium is usually of no concern, because the kidney can excrete the excess sodium as long as water needs are met (NRC 1989).

3.3.6.4 Risk Characterization

The interactive effects of exposure to a multiplicity of chemicals may be synergistic, antagonistic, or additive. For both carcinogenic and noncarcinogenic risk estimates, there is an assumption of dose additivity. This assumption is most properly applied to compounds that induce the same effect by the same mechanisms of action (EPA 1989). This assumption of dose additivity for the contaminants of concern adds to the overall toxicological uncertainty, which is likely to be overestimated.

3.3.6.5 Summary of Uncertainty

In summary, the selection process for contaminants of concern, the estimation of exposure, the derivation of toxicity values, and the characterization of risk are subject to a number of uncertainties that may lead either overestimates or underestimates of risk.

Assumptions made in this risk assessment that are likely to overestimate risk include the following:

- Techniques for averaging environmental concentrations to provide concentration estimates.
- Common laboratory contaminants (e.g., VOCs) are really present in field samples.
- Organic contaminants in groundwater do not biodegrade.

- Barefoot waders maintain contact with Little Choconut Creek sediment for 10 days every year for 15 yr.
- Johnson City residents use only AFP 59 groundwater for ingestion, bathing, and showering.
- Water users shower and bathe once daily.
- The U.S. EPA's chronic RfDs represent intakes close to the levels at which effects would be observed under constant chronic exposure conditions.
- Cancer slope factors are equal to the UL_{95} of the best estimate of the slope of the dose-response curve for animals and can be extrapolated to human carcinogenicity at risk levels from 10^{-7} to 10^{-4} .
- The sum of all HQs gives a valid hazard index.

Factors in this risk assessment that are likely to underestimate risk include the following:

- Chemicals not detected in a given medium were deleted from consideration for that medium.
- Not all exposure pathways for all detected chemicals were quantified.
- Risks for chemicals not analyzed for, but possibly present, were not evaluated.
- Exposure levels were averaged as if they occurred evenly over the pertinent averaging times.
- Chemicals with no published toxicity values were not evaluated.

Factors for which the direction of the uncertainty cannot be determined include the following:

- Inadequate analytical sensitivity or precision.
- Use of one-half detection limits for calculating UL_{95} values.
- Transience of contamination in flowing media.

- Use of "J" qualified data (estimated values) and "B" qualified data (inorganic values reported as less than the contract-required detection limit, but greater than the instrument detection limit).
- Lack of clear indications of sources for AFP 59 groundwater contaminants.
- Effect of periodic river water rise on mobilization of soil pollutants.
- Additional uncertainty entailed by use of non-EPA estimates of RfDs.
- Lack of information on toxicity interactions among chemicals contributing to risk.
- All modeling assumptions and input parameters (in view of human diversity), especially those related to dermal absorption.

3.3.7 Summary

This baseline risk assessment is an analysis of the potential adverse health effects resulting from exposure to contaminants originating at AFP 59, an active plant for the manufacture of aircraft controls for the U.S. Air Force. Site contaminants consist mainly of metals, petroleum constituents, and solvents, with small amounts of other common contaminants.

The basic methodology used in this risk assessment was developed by the U.S. EPA specifically for the evaluation of risk at hazardous waste sites. A baseline risk assessment considers conditions in the absence of any remedial actions to control or mitigate releases (namely, the "no-action alternative"). Overall, the methodology used is intentionally conservative, meaning that the true risks from the site are unlikely to be higher than the derived estimates and are most likely to be lower. The major elements in this risk assessment are summarized below.

3.3.7.1 Selection of Chemicals of Concern

Analytical data on chemical concentrations in soil, groundwater, sediment, and surface water from the Little Choconut Creek, and water from AFP 59 outfalls that empty into the creek, were evaluated to identify the chemicals that would form the focus of the quantitative risk assessment.

Chemicals were eliminated from the quantitative risk assessment for a given medium if they were not detected in that medium. They were also eliminated (medium-by-medium) for the following reasons: occurrence below the maximum local background concentration, occurrence in

less than 5% of the samples for a given medium (and then only at comparatively low concentrations), nonavailability of RfDs or carcinogenic SFs for certain essential elements, and conformance (where the matrix was water) with regulatory values for groundwater or surface water. In this manner, 41 contaminants of potential concern were identified (Table 3.56). Subsequently, those found only in soil and/or outfall water were deleted because potential pathways between these media and human receptors are unlikely to occur. Mercury was eliminated because it occurred in only one sample of otherwise clean surface water (and not in outfalls feeding that stream), and five groundwater contaminants were eliminated because their UL₉₅ average concentrations in that medium were below New York State regulatory limits. The 24 contaminants of concern that remained after these deletions are listed in Table 3.68.

3.3.7.2 Exposure Assessment

An analysis of the more plausible exposure scenarios and pathways under current conditions was conducted to determine complete exposure pathways that would be quantified. This analysis led to the selection of the following scenarios:

- Adolescents wading or fishing in Little Choconut Creek, with a single potential pathway:

Dermal contact with sediment.

- Adult residents exposed to groundwater by three possible pathways:

Ingestion,

Percutaneous absorption from bath water, and

Inhalation of volatile emissions from shower water.

Each pathway was quantified by:

- Estimating an exposure point concentration.
- Estimating a human intake factor (HIF) that combined all the variables involved in exposure to a contaminant.

3.3.7.3 Toxicity Assessment

Reference doses and carcinogenic slope factors verified by the EPA were obtained, if available, from the EPA's IRIS (EPA 1992a) or from HEAST (EPA 1992b). The most up-to-date SFs for trichloroethene were provided by the EPA's Environmental Criteria and Assessment Office (EPA 1992c). Values incorporating toxicity equivalence factors (TEFs) were used for those carcinogenic PAHs for which there were no SFs. Reference dose values were estimated for two organic compounds. No toxicity values of any sort were obtainable for benzo(g,h,i)perylene, dibenzofuran, iron, or sodium.

3.3.7.4 Risk Characterization

The risk for each pathway was quantified by comparing the daily intake (namely, the product of exposure point concentration and HIF) with an appropriate toxicity value. For noncarcinogens, a hazard quotient (ratio of the daily intake to the RfD) was used; for carcinogens, risk was calculated as the product of the daily intake and the cancer slope factor.

3.3.7.5 Risk Summary

The estimated noncarcinogenic risks associated with present conditions at AFP 59, expressed as HQs and HIs, added up to less than one for the exposure pathways of dermal exposure to sediment and dermal exposure to groundwater in the home. However, the pathway of ingestion of groundwater had a calculated hazard index of 6.7 (due almost entirely to manganese), indicating that adverse health effects could potentially occur if individuals ingested two liters per day of the groundwater under the AFP 59 site for 30 years.

The total carcinogenic risk associated with present conditions at AFP 59 was estimated at 1.5×10^{-6} for dermal exposure to creek sediments and is 4×10^{-6} for potential exposures to groundwater (due almost entirely to trichloroethene). These values are reasonably close to the target risk level of 10^{-6} (EPA 1991b). In view of the extremely conservative assumptions made in this risk assessment, actual risks associated with the site are likely to be considerably less than estimated risks.

3.3.8 References

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4 Conclusions and Recommendations

4.1 Categorization of Sites

According to Air Force guidance, sites may be categorized as belonging to one of the following action categories:

- Category 1: No further action is required because no significant impact to human health or the environment exists.
- Category 2: Further study is required to categorize the site.
- Category 3: Remedial action is required.

Contamination is present at AFP 59, but according to the baseline risk assessment performed, and subject to the discussion below, the contaminants pose no significant impact to human health or the environment. If one accepts this broad conclusion, all named sites (Sites A-1, -2, -3, -4, -5 and -6) and AFP 59 as a whole belong to Category 1. If, however, regulators do not accept that extant data adequately characterize the AFP 59 site, and that contamination as known poses no significant impact to human health or the environment, then further study will be required. Thus, the sites investigated could fall into AF Categories 1 or 2, depending upon the results of regulatory reviews and of any additional studies that may be requested by regulatory bodies.

4.2 Future Studies

This subsection raises or highlights problematic issues that, pending the results of regulatory review, could relate to reclassifications to Category 2 for the specified site areas.

- Manganese

As discussed in Section 3.3.5.4, groundwater ingestion had a calculated hazard index of 6.74, which is due largely to manganese with a hazard quotient of 6.42. Adverse health effects might result from the ingestion of two liters per day for 30 years of groundwater from beneath the AFP 59 site. The oral RfD for manganese is based upon a study that is itself problematic. Nonetheless, manganese is generally high in AFP 59 groundwater and is especially high in groundwater in the area of well cluster 8, located in the southeastern corner of the rear parking lot. Particle tracking indicates a contaminant migration route from that area to the Camden well field.

- Trichloroethene (TCE)

The total carcinogenic risk associated with potential exposure to groundwater from beneath AFP 59 was calculated as 4×10^{-6} (compared with a target value of 10^{-6}). This risk was due primarily to TCE. Relatively high concentrations of TCE were found in the shallow well (SW-4) near the plating building, and elevated concentrations were found in shallow well 9 in the southwest corner of the site. Lesser concentrations of TCE were also detected in the soil in both of these areas. Excluding a single, low, estimated trace value obtained in the cluster 4 area, the only TCE found in water in the deep aquifer was from the deep production well. These facts suggest that shallow-aquifer TCE contamination in the southwestern portion of the plant property and/or TCE contamination near the plating building is entering the deep aquifer under the influence of on-site pumping.

- Semivolatile Compounds (SVOCs) in Soil

Although SVOCs in soil were found scattered across the plant property, and although concentrations were not alarming, some areas contained relatively large numbers and/or concentrations of SVOCs. Comments are made below for several of them.

Soil from site A-1, site A-3, and borehole SW-8 contained similar quantities and kinds of SVOCs, and, unlike anywhere else on the site, contamination in all three locations could be seen and/or smelled by field personnel. Given their close proximity, it seems probable that the subsurface between the site A-1/A-3 and the SW-8 sampling locations is also similarly contaminated.

Soil from borehole SW-6, located on the west central side of the site, contained a relatively high number of SVOCs, perhaps suggesting that the general area contains a contaminant source that predates paving of the parking lot.

- Parking Lot Metals

As discussed in Section 3.2.11, relatively high contaminant screening values for metals in the center of the south parking lot (location HA-13) may indicate a pre-pavement source of contaminants.

- Creek Sediment

The carcinogenic risk associated with potential dermal exposures to creek sediment was slightly above the EPA target risk level. The risk assessment treated Little Choconut Creek as part of AFP 59. It should be noted that the stream is not on plant property.