Chapter 1 – Introduction

CHAPTER 1 INTRODUCTION 1-1

1.1 HYDRAULIC FRACTURING AND MULTI-WELL PAD DRILLING 1-1
1.1.1 Significant Changes in Proposed Operations Since 2009 1-2
1.1.1.1 Use of Reserve Pits or Centralized Impoundments for Flowback Water 1-2
1.1.1.2 Flowback Water Recycling 1-2

1.2 REGULATORY JURISDICTION 1-3

1.3 STATE ENVIRONMENTAL QUALITY REVIEW ACT 1-3

1.4 PROJECT CHRONOLOGY 1-4
1.4.1 February 2009 Final Scope 1-4
1.4.2 2009 Draft SGEIS 1-4
1.4.2.1 April 2010 Announcement Regarding Communities with Filtration Avoidance Determinations ... 1-5
1.4.2.2 Subsequent Exclusion of Communities with Filtration Avoidance Determinations 1-5
1.4.3 Revised Draft SGEIS 1-5
1.4.4 Next Steps 1-5

1.5 METHODOLOGY 1-5
1.5.1 Information about the Proposed Operations 1-5
1.5.2 Intra-/Inter-agency Coordination 1-6
1.5.3 Comment Review 1-6

1.6 LAYOUT AND ORGANIZATION 1-7
1.6.1 Chapters 1-7
1.6.2 Revisions 1-9
1.6.3 Glossary, Bibliographies and Appendices 1-9

1.7 ENHANCED IMPACT ANALYSES AND MITIGATION MEASURES 1-9
1.7.1 Hydraulic Fracturing Chemical Disclosure 1-9
1.7.2 Water Well Testing 1-10
1.7.3 Water Withdrawal and Consumption 1-10
1.7.3.1 2009 Draft SGEIS 1-10
1.7.3.2 Revised Draft SGEIS 1-10
1.7.4 Well Control and Emergency Response Planning 1-10
1.7.5 Local Planning Documents 1-11
1.7.6 Secondary Containment, Spill Prevention and Stormwater Pollution Prevention 1-11
1.7.7 Well Construction 1-11
1.7.7.1 2009 Draft SGEIS 1-11
1.7.7.2 Revised Draft SGEIS 1-12
1.7.8 Flowback Water Handling On-Site 1-12
1.7.9 Flowback Water Disposal 1-13
1.7.10 Management of Drill Cuttings 1-13
1.7.11 Emissions and Air Quality 1-14
1.7.11.1 2009 Draft SGEIS 1-14
1.7.11.2 Revised Draft SGEIS 1-15
1.7.12 Greenhouse Gas Mitigation 1-16
1.7.13 Habitat Fragmentation 1-16
1.7.14 State Forests, State Wildlife Management Areas and State Parks 1-17
1.7.15 Community and Socioeconomic Impacts 1-17

1.8 ADDITIONAL PRECAUTIONARY MEASURES 1-17

Chapter 2 – Description of Proposed Action

CHAPTER 2 DESCRIPTION OF PROPOSED ACTION 1

2.1 PURPOSE 2

2.2 PUBLIC NEED AND BENEFIT 2

2.3 PROJECT LOCATION 7

2.4 ENVIRONMENTAL SETTING 8
2.4.1 Water Use Classifications 8
2.4.2 Water Quality Standards 12
2.4.3 Drinking Water 13
2.4.3.1 Federal 13
2.4.3.2 New York State 18
2.4.4 Public Water Systems 19
2.4.4.1 Primary and Principal Aquifers 20
2.4.4.2 Public Water Supply Wells 22
2.4.5 Private Water Wells and Domestic-Supply Springs 22
2.4.6 History of Drilling and Hydraulic Fracturing in Water Supply Areas 23
2.4.7 Regulated Drainage Basins 25
2.4.7.1 Delaware River Basin 25
2.4.7.2 Susquehanna River Basin 26
2.4.7.3 Great Lakes-St. Lawrence River Basin 28
2.4.8 Water Resources Replenishment 28
2.4.9 Floodplains 30
2.4.9.1 Analysis of Recent Flood Events 32
2.4.9.2 Flood Zone Mapping 32
2.4.9.3 Seasonal Analysis 33
2.4.10 Freshwater Wetlands 34
2.4.11 Socioeconomic Conditions 35
2.4.11.1 Economy, Employment, and Income 41
2.4.11.2 Population 75
2.4.11.3 Housing 81
2.4.11.4 Government Revenues and Expenditures 91
2.4.11.5 Environmental Justice 103
2.4.12 Visual Resources 116
2.4.12.1 Historic Properties and Cultural Resources 119
2.4.12.2 Parks and Other Recreation Areas 126
2.4.12.3 Natural Areas 132
2.4.12.4 Additional Designated Scenic or Other Areas 141
2.4.13 Noise 150
2.4.13.1 Noise Fundamentals 150
2.4.13.2 Common Noise Effects 151
2.4.13.3 Noise Regulations and Guidance 153
2.4.13.4 Existing Noise Levels 155
2.4.14 Transportation - Existing Environment 156
2.4.14.1 Terminology and Definitions 156
2.4.14.2 Regional Road Systems 161
2.4.14.3 Condition of New York State Roads 167
2.4.14.4 NYSDOT Funding Mechanisms 168
2.4.14.5 Rail and Air Services 171
2.4.15 Community Character 172

FIGURES

Figure 2.1 - Primary and Principal Aquifers in New York State 21
Figure 2.2 - Susquehanna and Delaware River Basins 27
Figure 2.3 - Representative Regions Within the Marcellus Shale Extent (New August 2011) 36
Figure 2.4 - Representative Regions A, B, and C (New August 2011) 38
Figure 2.5 - Region A: Natural Gas Production, 1994 to 2009 (New August 2011) 61
Figure 2.6 - Region C: Natural Gas Production, 1994-2009 (New August 2011) 73
Figure 2.7 - Potential Environmental Justice Areas for Region A (New August 2011) 108
Figure 2.8 - Potential Environmental Justice Areas for Region B (New August 2011) 111
Figure 2.9 - Potential Environmental Justice Areas for Region C (New August 2011) 114
Figure 2.10 - Area of Interest for Visual Resources (New August 2011) 117
Figure 2.11 - Visually Sensitive Areas Associated with Historic Properties and Cultural Resources (New August 2011) 125
Figure 2.12 - Parks and Recreational Resources that May be Visually Sensitive (New August 2011) 130
Figure 2.13 - Natural Areas that May be Visually Sensitive (New August 2011) 133
Figure 2.14 - Additional Designated Scenic or other Areas that May be Visually Sensitive 142
Figure 2.15 - Level of Continuous Noise Causing Speech Interference (New August 2011) 152
Figure 2.16 - FHWA Vehicle Classifications (New August 2011) 159
Figure 2.17 - New York State Department of Transportation Regions (New August 2011) 161
Figure 2.18 - Transportation (New August 2011) 163
Figure 2.19 - Land Cover and Agricultural Districts, Representative Region A (New August 2011) 176
Figure 2.20 - Land Cover and Agricultural Districts, Representative Region B (New August 2011) 184
Figure 2.21 - Land Cover and Agricultural Districts, Representative Region C (New August 2011) 192

TABLES

Table 2.1 - Economic and Fiscal Impacts of Gas Well Drilling Activities in Broome County, NY Over 10 Years 6
Table 2.2 - New York Water Use Classifications 9
Table 2.3 - Primary Drinking Water Standards 15
Table 2.4 - Secondary Drinking Water Standards 18
Table 2.5 - Public Water System Definition 20
Table 2.6 - New York State: Area Employment by Industry, 2009 (New August 2011) 43
Table 2.7 - New York State: Wages by Industry, 2009 (New August 2011) 44
Table 2.8 - New York State: Labor Force Statistics, 2000 and 2010 (New August 2011) 44
Table 2.9 - New York State: Income Statistics, 1999 and 2009 (New August 2011) 45
Table 2.10 - New York State: Employment in Travel and Tourism, 2009 (New August 2011) 46
Table 2.11 - New York State: Wages in Travel and Tourism, 2009 (New August 2011) 46
Table 2.12 - New York State: Agricultural Data, 2007 (New August 2011) 47
Table 2.13 - New York: Impact of a $1 Million Dollar Increase in the Final Demand in the Output of the Oil and Gas Extraction Industry on the Value of the Output of Other Industries (New August 2011) 48
Table 2.14 - New York State: Employment in the Oil and Gas Extraction Industry, 2000-2010 (New August 2011) 49
Table 2.15 - Most Common Occupations in the U.S. Oil and Gas Extraction Industry, 2008 (New August 2011) 50
Table 2.16 - New York State: Wages in the Oil and Gas Industry, 2009 (New August 2011) 51
Table 2.17 - New York State: Natural Gas Production, 1985-2009 (New August 2011) 52
Table 2.18 - Permits Issued, Wells Completed, and Active Wells, NYS Gas Wells, 1994-2009 (New August 2011) 52
Table 2.19 - Average Wellhead Price for New York State's Natural Gas, 1994-2009 (New August 2011) 54
Table 2.20 - Market Value of New York State's Natural Gas Production, 1994-2009 (New August 2011) 54
Table 2.21 - Region A: Area Employment by Industry, 2009 (New August 2011) 55
Table 2.22 - Region A: Wages by Industry, 2009 (New August 2011) 56
Table 2.23 - Region A: Labor Force Statistics, 2000 and 2010 (New August 2011) 57
Table 2.24 - Region A: Income Statistics, 1999 and 2009 (New August 2011) 57
Table 2.25 - Region A: Employment in Travel and Tourism, 2009 (New August 2011) 59
Table 2.26 - Region A: Wages in Travel and Tourism, 2009 (New August 2011) 59
Table 2.27 - Region A: Agricultural Data, 2007 (New August 2011) 60

Table 2.28 - Region A: Number of Active Natural Gas Wells, 1994-2009 (New August 2011) 61
Table 2.29 – Natural Gas Production and Active Wells by Town within each County in Region A, 2009 (New August 2011).....62
Table 2.30 - Region B: Area Employment, by Industry, 2009 (New August 2011) 63
Table 2.31 - Region B: Wages, by Industry, 2009 (New August 2011).....63
Table 2.32 - Region B: Labor Force Statistics, 2000 and 2010 ((New August 2011)) 64
Table 2.33 - Region B: Income Statistics, 1999 and 2009 (New August 2011) 65
Table 2.34 - Region B: Travel and Tourism, by Industrial Group, 2009 (New August 2011).....66
Table 2.35 - Region B: Wages in Travel and Tourism, 2009 (New August 2011).....66
Table 2.36 - Region B: Agricultural Data, 2007 (New August 2011) 67
Table 2.37 - Region C: Area Employment by Industry, 2009 (New August 2011) 68
Table 2.38 - Region C: Wages, by Industry, 2009 (New August 2011).....68
Table 2.39 - Region C: Labor Force Statistics, 2000 and 2010 (New August 2011) 69
Table 2.40 - Region C: Income Statistics, 1999 and 2009 (New August 2011) 69
Table 2.41 - Region C: Travel and Tourism, by Industrial Group, 2009 (New August 2011).....71
Table 2.42 - Region C: Wages in Travel and Tourism, 2009 (New August 2011).....71
Table 2.43 - Region C: Agricultural Data, 2007 (New August 2011) 72
Table 2.44 - Number of Active Natural Gas Wells in Region C, 1994-2009 (New August 2011) 73
Table 2.45 - Natural Gas Production and the Number of Active Gas Wells by Town within each County in Region C, 2009 (New August 2011) 74
Table 2.46 - New York State: Historical and Current Population, 1990, 2000, 2010 (New August 2011) 76
Table 2.47 - New York State: Projected Population, 2015 to 2030 (New August 2011).....76
Table 2.48 - Region A: Historical and Current Population, 1990, 2000, 2010 (New August 2011).....77
Table 2.49 - Region A: Population Projections, 2015 to 2030 (New August 2011).....78
Table 2.50 - Region B: Historical and Current Population - 1990, 2000, 2010 (New August 2011).....78
Table 2.51 - Region B: Population Projections, 2015 to 2030 (New August 2011).....79
Table 2.52 - Region C: Historical and Current Population - 1990, 2000, 2010 (New August 2011).....80
Table 2.53 - Region C: Population Projections, 2015 to 2030 (New August 2011).....80
Table 2.54 - New York State: Total Housing Units - 1990, 2000, 2010 (New August 2011).....81
Table 2.55 - New York State: Type of Housing Units, 2009[1] (New August 2011) 81
Table 2.56 - New York State: Number of Sales and Annual Median Sale Price of Single-Family Homes Sold, 2008-2010 (New August 2011) 82
Table 2.57 - New York State: Housing Characteristics, 2010 (New August 2011) 82
Table 2.58 - Region A: Total Housing Units - 1990, 2000, 2010 (New August 2011).....83
Table 2.59 - Region A: Total Housing Units by Type of Structure, 2009[1] (New August 2011).....83
Table 2.60 - Region A: Number of Sales and Annual Median Sale Price of Single-Family Homes Sold, 2008-2010 (New August 2011) 84
Table 2.61 - Region A: Housing Characteristics, 2010 (New August 2011).....85
Table 2.62 - Region A: Short-Term Accommodations (Hotels/Motels), 2011 (New August 2011) 85
Table 2.63 - Region B: Total Housing Units - 1990, 2000, 2010 (New August 2011).....86
Table 2.64 - Region B: Total Housing Units by Type of Structure 2009[1] (New August 2011).....86
Table 2.65- Region B: Number of Sales and Annual Median Sale Price of Single-Family Homes Sold, 2008-2010 (New August 2011).....87
Table 2.66 - Region B: Housing Characteristics, 2010 (New August 2011).....88
Table 2.67 - Region B: Short-Term Accommodations (Hotels/Motels) (New August 2011).....88
Table 2.68 - Region C: Total Housing Units - 1990, 2000, 2010 (New August 2011).....89
Table 2.69 - Region C: Total Housing Units by Type of Structure, 2009[1] (New August 2011) 89
Table 2.70 - Region C: Number of Sales and Annual Median Sale Price of Single-Family Homes Sold, 2008-2010 (New August 2011) 90
Table 2.71 - Region C: Housing Characteristics, 2010 (New August 2011).....90
Table 2.72 - Region C: Short-Term Accommodations (Hotels/Motels) (New August 2011).....91
Table 2.73 - New York State Revenues Collected for FY Ending March 31, 2010 (New August 2011).....92

Table 2.74 - New York State: Number of Leases and Acreage of State Land Leased for Oil and Natural Gas Development, 2010 (New August 2011) 93
Table 2.75 - 2000-2010 Leasing Revenue by Payment Type for New York State (New August 2011)....93
Table 2.76 - Region A: Total Revenue for FY Ending December 31, 2009 ($ millions) (New August 2011)....95
Table 2.77 - Region A: Local Tax Revenue for FY Ending December 31, 2009 ($ millions) (New August 2011) 96
Table 2.78 - Gas Economic Profile for Medina Region 3 (New August 2011)....96
Table 2.79 - Region A: Expenditures for FY Ending December 31, 2009 ($ millions) (New August 2011)....97
Table 2.80 - Region B: Total Revenue for FY Ending December 31, 2009 ($ millions) (New August 2011)....98
Table 2.81 - Region B: Local Tax Revenue for FY Ending December 31, 2009 ($ millions) (New August 2011) 99
Table 2.82 - Gas Economic Profile for Medina Region 4 and State Equalization Rates and Millage Rates for Region B (New August 2011) 99
Table 2.83 - Region B: Expenditures for FY Ending December 31, 2009 ($ millions) (New August 2011)....100
Table 2.84 - Region C: Revenues for FY Ending December 31, 2009 ($ millions) (New August 2011)....101
Table 2.85 - Region C: Local Tax Revenue for FY Ending December 31, 2009 ($ millions) (New August 2011) 102
Table 2.86 - Gas Economic Profile for Medina Region 2 and State Equalization Rates and Millage Rates for Region C (New August 2011) 102
Table 2.87 - Region C: Expenditures for FY Ending December 31, 2009 (New August 2011)....103
Table 2.88 - Racial and Ethnicity Characteristics for New York State (New August 2011) 106
Table 2.89 - Region A: Racial and Ethnicity Characteristics (New August 2011) 109
Table 2.90 - Region B: Racial and Ethnicity Characteristics (New August 2011) 112
Table 2.91 - Region C: Racial and Ethnicity Characteristics (New August 2011) 115
Table 2.92 - Number of NRHP-Listed Historic Properties within the Area Underlain by the Marcellus and Utica Shales in New York (New August 2011)....120
Table 2.93 - National Historic Landmarks (NHLs) Located within the Area Underlain by the Marcellus and Utica Shales in New York (New August 2011)....123
Table 2.94 - State Parks Located within the Area Underlain by the Marcellus and Utica Shales in New York (New August 2011)....127
Table 2.95 - Select Trails Located within the Area Underlain by the Marcellus and Utica Shales in New York (New August 2011)....131
Table 2.96 - State Nature and Historic Preserves in Counties Located within the Area Underlain by the Marcellus and Utica Shales in New York (New August 2011) 134
Table 2.97 - National and State Wild, Scenic and Recreational Rivers (designated or potential) Located within the Area Underlain by the Marcellus and Utica Shales in New York (New August 2011) 137
Table 2.98 - State Game Refuges and State Wildlife Management Areas Located within the Area Underlain by the Marcellus and Utica Shales in New York (New August 2011)....139
Table 2.99 - National Natural Landmarks Located within the Area Underlain by the Marcellus and Utica Shales in New York (New August 2011)....140
Table 2.100 - Designated and Proposed National and State Scenic Byways, Highways, and Roads Located within the Area Underlain by the Marcellus and Utica Shales in New York (New August 2011) 143
Table 2.101 - Recommended Open Space Conservation Projects Located in the Area Underlain by the Marcellus and Utica Shales in New York (New August 2011) 146
Table 2.102 - Effects of Noise on People (New August 2011) 153
Table 2.103 - Summary of Noise Levels Identified as Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety (New August 2011)....154
Table 2.104 - Common Noise Levels (New August 2011)....156
Table 2.105 - Guidelines on Extent of Rural Functional Systems (New August 2011)....158
Table 2.106 - Descriptions of the Thirteen FHWA Vehicle Classification Categories (New August 2011)....160
Table 2.107 - Region A: Highway Mileage by County, 2009 (New August 2011) 164
Table 2.108 - Heavy Vehicles as a Percentage of Total Vehicles in Rural Areas in NYSDOT Regions 6 and 9, 2004-2009 (New August 2011) 164
Table 2.109 - Region B: Highway Mileage by County, 2009 (New August 2011)....165
Table 2.110 - Heavy Vehicles as a Percentage of Total Vehicles in Rural Areas in NYSDOT Region 9, 2004-2009 (New August 2011)....166

Table 2.111 - Region C: Highway Mileage by County, 2009 (New August 2011).....166
Table 2.112 - Heavy Vehicles as a Percentage of Total Vehicles in Rural Areas in NYSDOT Region 5, 2009 (New August 2011).....167
Table 2.113 - Ranking System of Pavement Condition in New York State (New August 2011).....168
Table 2.114 - NYSDOT Total Receipts, 2009-2012 ($ thousands) (New August 2011) 170

Chapter 3 - Proposed SEQRA Review Process

CHAPTER 3 PROPOSED SEQRA REVIEW PROCESS 3-1

3.1 INTRODUCTION – USE OF A GENERIC ENVIRONMENTAL IMPACT STATEMENT 3-1
3.1.1 1992 GEIS and Findings 3-2
3.1.2 Need for a Supplemental GEIS 3-2

3.2 FUTURE SEQRA COMPLIANCE 3-3
3.2.1 Scenarios for Future SEQRA Compliance under the SGEIS 3-4
3.2.2 Review Parameters 3-5
3.2.2.1 SGEIS Applicability - Definition of High-Volume Hydraulic Fracturing 3-6
3.2.2.2 Project Scope 3-6
3.2.2.3 Size of Project 3-7
3.2.2.4 Lead Agency 3-8
3.2.3 EAF Addendum and Additional Informational Requirements 3-8
3.2.3.1 Hydraulic Fracturing Information 3-9
3.2.3.2 Water Source Information 3-9
3.2.3.3 Distances 3-10
3.2.3.4 Water Well Information 3-11
3.2.3.5 Fluid Disposal Plan 3-11
3.2.3.6 Operational Information 3-12
3.2.3.7 Invasive Species Survey and Map 3-13
3.2.3.8 Required Affirmations 3-13
3.2.3.9 Local Planning Documents 3-14
3.2.3.10 Habitat Fragmentation 3-14
3.2.4 Prohibited Locations 3-14
3.2.5 Projects Requiring Site-Specific SEQRA Determinations of Significance 3-15

3.3 REGULATIONS 3-17

Chapter 4 - Geology

CHAPTER 4 - GEOLOGY **4-1**

4.1 INTRODUCTION **4-1**

4.2 BLACK SHALES **4-2**

4.3 UTICA SHALE **4-5**
4.3.1 Total Organic Carbon 4-10
4.3.2 Thermal Maturity and Fairways 4-13
4.3.3 Potential for Gas Production 4-13

4.4 MARCELLUS FORMATION **4-14**
4.4.1 Total Organic Carbon 4-16
4.4.2 Thermal Maturity and Fairways 4-16
4.4.3 Potential for Gas Production 4-17

4.5 SEISMICITY IN NEW YORK STATE **4-23**
4.5.1 Background 4-23
4.5.2 Seismic Risk Zones 4-24
4.5.4 Seismic Events 4-27
4.5.5 Monitoring Systems in New York 4-35

4.6 NATURALLY OCCURRING RADIOACTIVE MATERIALS (NORM) IN MARCELLUS SHALE **4-35**

4.7 NATURALLY-OCCURRING METHANE IN NEW YORK STATE **4-36**

FIGURES

Figure 4.1 - Gas Shale Distribution in the Appalachian Basin 4-4
Figure 4.2 - Stratigraphic Column of Southwestern New York 4-7
Figure 4.3 - East West Cross-Section of New York State. 4-8
Figure 4.4 - Extent of Utica Shale in New York State 4-9
Figure 4.5 - Depth to Base of Utica Shale in New York State 4-11
Figure 4.6 - Thickness of High-Organic Utica Shale in New York State 4-12
Figure 4.7 - Utica Shale Fairway in New York State 4-15
Figure 4.8 - Depth and Extent of Marcellus Shale in New York State 4-18
Figure 4.9 - Marcellus Shale Thickness in New York State 4-19
Figure 4.10 - Total Organic Carbon of Marcellus Shale in New York State 4-20
Figure 4.11 - Marcellus Shale Thermal Maturity 4-21
Figure 4.12 - Marcellus Shale Fairway in New York State 4-22
Figure 4.13 - Mapped Geologic Faults in New York State 4-25
Figure 4.14 - New York State Seismic Hazard Map 4-26
Figure 4.15 - Seismic Events in New York State (1970 to 2009) 4-34

TABLES

Table 4.1 - Modified Mercalli Scale 4-29
Table 4.2 - Summary of Seismic Events in New York State 4-30

Chapter 5 - Natural Gas Development Activities & High-Volume Hydraulic Fracturing

CHAPTER 5 NATURAL GAS DEVELOPMENT ACTIVITIES & HIGH-VOLUME HYDRAULIC FRACTURING 5-5

5.1 LAND DISTURBANCE 5-6
5.1.1 Access Roads 5-6
5.1.2 Well Pads 5-10
5.1.3 Utility Corridors 5-14
5.1.4 Well Pad Density 5-14
5.1.4.1 Historic Well Density 5-14
5.1.4.2 Anticipated Well Pad Density 5-16

5.2 HORIZONTAL DRILLING 5-24
5.2.1 Drilling Rigs 5-25
5.2.2 Multi-Well Pad Development 5-30
5.2.3 Drilling Mud 5-32
5.2.4 Cuttings 5-33
5.2.4.1 Cuttings Volume 5-33
5.2.4.2 NORM in Marcellus Cuttings 5-34
5.2.5 Management of Drilling Fluids and Cuttings 5-37
5.2.5.1 Reserve Pits on Multi-Well Pads 5-37
5.2.5.2 Closed-Loop Tank Systems 5-37

5.3 HYDRAULIC FRACTURING 5-39

5.4 FRACTURING FLUID 5-40
5.4.1 Properties of Fracturing Fluids 5-49
5.4.2 Classes of Additives 5-49
5.4.3 Composition of Fracturing Fluids 5-50
5.4.3.1 Chemical Categories and Health Information 5-63

5.5 TRANSPORT OF HYDRAULIC FRACTURING ADDITIVES 5-79

5.6 ON-SITE STORAGE AND HANDLING OF HYDRAULIC FRACTURING ADDITIVES 5-80
5.6.1 Summary of Additive Container Types 5-81

5.7 SOURCE WATER FOR HIGH-VOLUME HYDRAULIC FRACTURING 5-83
5.7.1 Delivery of Source Water to the Well Pad 5-84
5.7.2 Use of Centralized Impoundments for Fresh Water Storage 5-85

5.8 HYDRAULIC FRACTURING DESIGN 5-88
5.8.1 Fracture Development 5-89
5.8.2 Methods for Limiting Fracture Growth 5-90
5.8.3 Hydraulic Fracturing Design – Summary 5-90

5.9 HYDRAULIC FRACTURING PROCEDURE 5-91

5.10 RE-FRACTURING 5-98

5.11 FLUID RETURN 5-99
5.11.1 Flowback Water Recovery 5-99
5.11.2 Flowback Water Handling at the Wellsite 5-100
5.11.3 Flowback Water Characteristics 5-100
5.11.3.1 Temporal Trends in Flowback Water Composition 5-117
5.11.3.2 NORM in Flowback Water 5-117

5.12 FLOWBACK WATER TREATMENT, RECYCLING AND REUSE 5-118
5.12.1 Physical and Chemical Separation 5-120
5.12.2 Dilution 5-121
5.12.2.1 Reuse 5-122
5.12.3 Other On-Site Treatment Technologies 5-124
5.12.3.1 Membranes / Reverse Osmosis 5-124
5.12.3.2 Thermal Distillation 5-125
5.12.3.3 Ion Exchange 5-126
5.12.3.4 Electrodialysis/Electrodialysis Reversal 5-126
5.12.3.5 Ozone/Ultrasonic/Ultraviolet 5-127
5.12.3.6 Crystallization/Zero Liquid Discharge 5-128
5.12.4 Comparison of Potential On-Site Treatment Technologies 5-128

5.13 WASTE DISPOSAL 5-129
5.13.1 Cuttings from Mud Drilling 5-129
5.13.2 Reserve Pit Liner from Mud Drilling 5-130
5.13.3 Flowback Water 5-130
5.13.3.1 Injection Wells 5-131
5.13.3.2 Municipal Sewage Treatment Facilities 5-132
5.13.3.3 Out-of-State Treatment Plants 5-132
5.13.3.4 Road Spreading 5-133
5.13.3.5 Private In-State Industrial Treatment Plants 5-133
5.13.3.6 Enhanced Oil Recovery 5-134
5.13.4 Solid Residuals from Flowback Water Treatment 5-134

5.14 WELL CLEANUP AND TESTING 5-134

5.15 SUMMARY OF OPERATIONS PRIOR TO PRODUCTION 5-135

5.16 NATURAL GAS PRODUCTION 5-137
5.16.1 Partial Site Reclamation 5-137
5.16.2 Gas Composition 5-137
5.16.2.1 Hydrocarbons 5-137
5.16.2.2 Hydrogen Sulfide 5-138
5.16.3 Production Rate 5-138
5.16.4 Well Pad Production Equipment 5-139
5.16.5 Brine Storage 5-141
5.16.6 Brine Disposal 5-141
5.16.7 NORM in Marcellus Production Brine 5-141
5.16.8 Gas Gathering and Compression 5-142

5.17 WELL PLUGGING 5-143

FIGURES

Figure 5.1 - Well Pad Schematic 5-15
Figure 5.2 - Possible well spacing unit configurations and wellbore paths 5-31
Figure 5.3 - Sample Fracturing Fluid Composition (12 Additives), by Weight, from Fayetteville Shale 5-53
Figure 5.4 - Sample Fracturing Fluid Composition (9 Additives), by Weight, from Marcellus Shale (New July 2011). 5-53
Figure 5.5 - Sample Fracturing Fluid Composition (6 Additives), by Weight, from Marcellus Shale (New July 2011). 5-54
Figure 5.6 - Example Fracturing Fluid Composition Including Recycled Flowback Water (New July 2011)..... 5-123
Figure 5.7 - One configuration of potential on-site treatment technologies. 5-124
Figure 5.8 - Simplified Illustration of Gas Production Process..... 5-140

TABLES

Table 5.1 - Ten square mile area (i.e., 6,400 acres), completely drilled with horizontal wells in multi-well units or vertical wells in single-well units (Updated July 2011) 5-23
Table 5.2 - 2009 Marcellus Radiological Data..... 5-35
Table 5.3 - Gamma Ray Spectroscopy 5-36
Table 5.4 - Fracturing Additive Products – Complete Composition Disclosure Made to the Department (Updated July 2011)..... 5-42
Table 5.5 - Fracturing Additive Products – Partial Composition Disclosure to the Department (Updated July 2011) 5-47
Table 5.6 - Types and Purposes of Additives Proposed for Use in New York State (Updated July 2011)..... 5-50
Table 5.7 - Chemical Constituents in Additives" (Updated July 2011) 5-55
Table 5.8 - Categories based on chemical structure of potential fracturing fluid constituents. (Updated July 2011) 5-64
Table 5.9 - Parameters present in a limited set of flowback analytical results (Updated July 2011) 5-102
Table 5.10 - Typical concentrations of flowback constituents based on limited samples from PA and WV, and regulated in NY' (Revised July 2011) 5-106
Table 5.11 - Typical concentrations of flowback constituents based on limited samples from PA and WV, not regulated in NY(Revised July 2011) 5-108
Table 5.12 - Conventional Analytes In MSC Study (New July 2011) 5-110
Table 5.13 - Total and Dissolved Metals Analyzed In MSC Study (New July 2011)..... 5-110
Table 5.14 - Volatile Organic Compounds Analyzed in MSC Study (New July 2011) 5-111
Table 5.15 - Semi-Volatile Organics Analyzed in MSC Study (New July 2011)..... 5-112
Table 5.16 - Organochlorine Pesticides Analyzed in MSC Study (New July 2011) 5-112
Table 5.17 - PCBs Analyzed in MSC Study (New July 2011) 5-113
Table 5.18 - Organophosphorus Pesticides Analyzed in MSC Study (New July 2011) 5-113
Table 5.19 - Alcohols Analyzed in MSC Study (New July 2011) 5-113
Table 5.20 - Glycols Analyzed in MSC Study (New July 2011)..... 5-113
Table 5.21 - Acids Analyzed in MSC Study (New July 2011) 5-113
Table 5.22 - Parameter Classes Analyzed for in the MSC Study (New July 2011)..... 5-114
Table 5.23 - Parameter Classes Detected in Flowback Analyticals in MSC Study (New July 2011) 5-114
Table 5.24 - Concentrations of NORM constituents based on limited samples from PA and WV (Revised July 2011)5-118
Table 5.25 - Maximum allowable water quality requirements for fracturing fluids, based on input from one expert panel on Barnett Shale (Revised July 2011)..... 5-119
Table 5.26 - Treatment capabilities of EDR and RO Systems..... 5-127
Table 5.27 - Summary of Characteristics of On-Site Flowback Water Treatment Technologies (Updated July 2011) 5-129
Table 5.28 - Out-of-state treatment plants proposed for disposition of NY flowback water..... 5-133
Table 5.29 - Primary Pre-Production Well Pad Operations (Revised July 2011)..... 5-135
Table 5.30 - Marcellus Gas Composition from Bradford County, PA..... 5-137

PHOTOS

Photo 5.1 - Access Road and Erosion/Sedimentation Controls, Salo 1, Barton, Tioga County NY 5-8
Photo 5.2 - Access Road, Nornew Smyrna Hillbillies 2H, Smyrna, Madison County NY 5-8
Photo 5.3 - In-Service Access Road to Horizontal Marcellus well in Bradford County PA 5-9
Photo 5.4 - Access Road and Sedimentation Controls, Moss 1, Corning, Steuben County NY..... 5-9
Photo 5.5 - Chesapeake Energy Marcellus Well Drilling, Bradford County, PA 5-12
Photo 5.6 - Hydraulic fracturing operation, Horizontal Marcellus Well, Upshur County, WV 5-12
Photo 5.7 - Hydraulic Fracturing Operation, Horizontal Marcellus Well, Bradford County, PA 5-13
Photo 5.8 - Locations of Over 44,000 Natural Gas Wells Targeting the Medina Formation, Chautauqua County NY 5-18
Photo 5.9 - Locations of 48 Natural Gas Wells Targeting the Medina Formation, Chautauqua County NY..... 5-19
Photo 5.10 - Locations of 28 Wells in the Town of Poland, Chautauqua County NY..... 5-20
Photo 5.11 - Locations of 77 Wells in the Town of Sheridan, Chautauqua County NY..... 5-21
Photo 5.12 - Double Drilling Rig, Union Drilling Rig 54, Olsen 1B, Town of Fenton, Broome County NY..... 5-28
Photo 5.13 - Double Drilling Rig, Union Drilling Rig 48, Salo 1, Town of Barton, Tioga County NY 5-28
Photo 5.14 - Triple Drilling Rig, Precision Drilling Rig 26, Ruger 1, Horseheads, Chemung County NY 5-29
Photo 5.15 - Top Drive Single Drilling Rig, Barber and DeLine Rig, Sheckells 1, Town of Cherry Valley, Otsego County NY 5-29
Photo 5.16 - Drilling rig mud system (blue tanks) 5-33
Photo 5.17 - Sand used as proppant in hydraulic fracturing operation in Bradford County, PA..... 5-51
Photo 5.18 - Transport trucks with totes..... 5-82
Photo 5.19 - Fortuna SRBC-Approved Chemung River Water Withdrawal Facility, Towanda PA 5-86
Photo 5.20 - Fresh Water Supply Pond..... 5-86
Photo 5.21 - Water Pipeline from Fortuna Centralized Freshwater Impoundments, Troy PA..... 5-86
Photo 5.22 - Construction of Freshwater Impoundment, Upshur County WV..... 5-87
Photo 5.23 - Personnel monitoring a hydraulic fracturing procedure. Source: Fortuna Energy. 5-91
Photo 5.24 - Three Fortuna Energy wells being prepared for hydraulic fracturing, with 10,000 psi well head and goat head attached to lines. Troy PA. Source: New York State Department of Environmental Conservation 20095-93
Photo 5.25 - Hydraulic Fracturing Operation Equipment at a Fortuna Energy Multi-Well Site, Troy PA 5-96
Photo 5.26 - Fortuna Energy Multi-Well Site in Troy PA After Removal of Most Hydraulic Fracturing Equipment 5-97
Photo 5.27 - Wellhead and Fracturing Equipment 5-97
Photo 5.28 - Pipeline Compressor in New York. Source: Fortuna Energy 5-143

Chapter 6 – Potential Environmental Impacts

CHAPTER 6 POTENTIAL ENVIRONMENTAL IMPACTS 6-1

6.1 WATER RESOURCES 6-1
6.1.1 Water Withdrawals 6-2
6.1.1.1 Reduced Stream Flow 6-2
6.1.1.2 Degradation of a Stream's Best Use 6-2
6.1.1.3 Impacts to Aquatic Habitat 6-3
6.1.1.4 Impacts to Aquatic Ecosystems 6-3
6.1.1.5 Impacts to Wetlands 6-5
6.1.1.6 Aquifer Depletion 6-5
6.1.1.7 Cumulative Water Withdrawal Impacts 6-6
6.1.2 Stormwater Runoff 6-14
6.1.3 Surface Spills and Releases at the Well Pad 6-15
6.1.3.1 Drilling 6-16
6.1.3.2 Hydraulic Fracturing Additives 6-16
6.1.3.3 Flowback Water and Production Brine 6-17
6.1.3.4 Potential Impacts to Primary and Principal Aquifers 6-36
6.1.4 Groundwater Impacts Associated With Well Drilling and Construction 6-40
6.1.4.1 Turbidity 6-40
6.1.4.2 Fluids Pumped Into the Well 6-41
6.1.4.3 Natural Gas Migration 6-41
6.1.5 Unfiltered Surface Drinking Water Supplies: NYC and Syracuse 6-42
6.1.5.1 Pollutants of Critical Concern in Unfiltered Drinking Water Supplies 6-45
6.1.5.2 Regulatory and Programmatic Framework for Filtration Avoidance 6-48
6.1.5.3 Adverse Impacts to Unfiltered Drinking Waters from High-Volume Hydraulic Fracturing 6-50
6.1.5.4 Conclusion 6-52
6.1.6 Hydraulic Fracturing Procedure 6-52
6.1.6.1 Wellbore Failure 6-53
6.1.6.2 Subsurface Pathways 6-53
6.1.7 Waste Transport 6-56
6.1.8 Fluid Discharges 6-57
6.1.8.1 POTWs 6-57
6.1.8.2 Private Off-site Wastewater Treatment and/or Reuse Facilities 6-63
6.1.8.3 Private On-site Wastewater Treatment and/or Reuse Facilities 6-64
6.1.8.4 Disposal Wells 6-64
6.1.8.5 Other Means of Wastewater Disposal 6-64
6.1.9 Solids Disposal 6-65
6.1.9.1 NORM Considerations - Cuttings 6-65
6.1.9.2 Cuttings Volume 6-65
6.1.9.3 Cuttings and Liner Associated With Mud-Drilling 6-66

6.2 FLOODPLAINS 6-66

6.3 FRESHWATER WETLANDS 6-66

6.4 ECOSYSTEMS AND WILDLIFE 6-66
6.4.1 Impacts of Fragmentation to Terrestrial Habitats and Wildlife 6-67
6.4.1.1 Impacts of Grassland Fragmentation 6-72
6.4.1.2 Impacts of Forest Fragmentation 6-74
6.4.2 Invasive Species 6-84

6.4.2.1 Terrestrial 6-84
6.4.2.2 Aquatic 6-86
6.4.3 Impacts to Endangered and Threatened Species 6-88
6.4.4 Impacts to State-Owned Lands 6-90

6.5 AIR QUALITY 6-93
6.5.1 Regulatory Overview 6-93
6.5.1.1 Emission Analysis NO_x - Internal Combustion Engine Emissions 6-99
6.5.1.2 Natural Gas Production Facilities NESHAP 40 CFR Part 63, Subpart HH (Glycol Dehydrators) ... 6-102
6.5.1.3 Flaring Versus Venting of Wellsite Air Emissions 6-103
6.5.1.4 Number of Wells Per Pad Site 6-104
6.5.1.5 Natural Gas Condensate Tanks 6-104
6.5.1.6 Emissions Tables 6-105
6.5.1.7 Offsite Gas Gathering Station Engine 6-107
6.5.1.8 Department Determinations on the Air Permitting Process Relative to Marcellus Shale High-Volume Hydraulic Fracturing Development Activities. 6-108
6.5.2 Air Quality Impact Assessment 6-110
6.5.2.1 Introduction 6-110
6.5.2.2 Sources of Air Emissions and Operational Scenarios 6-113
6.5.2.3 Modeling Procedures 6-117
6.5.2.4 Results of the Modeling Analysis 6-132
6.5.2.5 Supplemental Modeling Assessment for Short Term PM2.5, SO_2 and NO_2 Impacts and Mitigation Measures Necessary to Meet NAAQS. 6-140
6.5.2.6 The Practicality of Mitigation Measures on the Completion Equipment and Drilling Engines. 6-153
6.5.2.7 Conclusions from the Modeling Analysis 6-157
6.5.3 Regional Emissions of O_3 Precursors and Their Effects on Attainment Status in the SIP 6-168
6.5.4 Air Quality Monitoring Requirements for Marcellus Shale Activities 6-180
6.5.5 Permitting Approach to the Well Pad and Compressor Station Operations 6-185

6.6 GREENHOUSE GAS EMISSIONS 6-186
6.6.1 Greenhouse Gases 6-187
6.6.2 Emissions from Oil and Gas Operations 6-187
6.6.2.1 Vented Emissions 6-188
6.6.2.2 Combustion Emissions 6-188
6.6.2.3 Fugitive Emissions 6-189
6.6.3 Emissions Source Characterization 6-189
6.6.4 Emission Rates 6-193
6.6.5 Drilling Rig Mobilization, Site Preparation and Demobilization 6-194
6.6.6 Completion Rig Mobilization and Demobilization 6-195
6.6.7 Well Drilling 6-195
6.6.8 Well Completion 6-196
6.6.9 Well Production 6-198
6.6.10 Summary of GHG Emissions 6-200

6.7 NATURALLY OCCURRING RADIOACTIVE MATERIALS IN THE MARCELLUS SHALE 6-205

6.8 SOCIOECONOMIC IMPACTS 6-207
6.8.1 Economy, Employment, and Income 6-211
6.8.1.1 New York State 6-211
6.8.1.2 Representative Regions 6-217
6.8.2 Population 6-231
6.8.2.1 New York State 6-233
6.8.2.2 Representative Regions 6-238
6.8.3 Housing 6-242

6.8.3.1 New York State 6-242
6.8.3.2 Representative Regions 6-245
6.8.3.3 Cyclical Nature of the Natural Gas Industry 6-250
6.8.3.4 Property Values 6-250
6.8.4 Government Revenue and Expenditures 6-254
6.8.4.1 New York State 6-254
6.8.4.2 Representative Regions 6-257
6.8.5 Environmental Justice 6-263

6.9 VISUAL IMPACTS 6-263
6.9.1 Changes since Publication of the 1992 GEIS that Affect the Assessment of Visual Impacts 6-264
6.9.1.1 Equipment and Drilling Techniques 6-264
6.9.1.2 Changes in Well Pad Size and the Number of Water Storage Sites 6-265
6.9.1.3 Duration and Nature of Drilling and Hydraulic-Fracturing Activities 6-265
6.9.2 New Landscape Features Associated with the Different Phases of Horizontal Drilling and Hydraulic Fracturing 6-266
6.9.2.1 New Landscape Features Associated with the Construction of Well Pads 6-266
6.9.2.2 New Landscape Features Associated with Drilling Activities at Well Pads 6-270
6.9.2.3 New Landscape Features Associated with Hydraulic Fracturing Activities at Well Pads 6-270
6.9.2.4 New Landscape Features Associated with Production at Viable Well Sites 6-272
6.9.2.5 New Landscape Features Associated with the Reclamation of Well Sites 6-272
6.9.3 Visual Impacts Associated with the Different Phases of Horizontal Drilling and Hydraulic Fracturing 6-272
6.9.3.1 Visual Impacts Associated with Construction of Well Pads 6-273
6.9.3.2 Visual Impacts Associated with Drilling Activities on Well Pads 6-274
6.9.3.3 Visual Impacts Associated with Hydraulic Fracturing Activities at Well Sites 6-275
6.9.3.4 Visual Impacts Associated with Production at Well Sites 6-275
6.9.3.5 Visual Impacts Associated with the Reclamation of Well Sites 6-276
6.9.4 Visual Impacts of Off-site Activities Associated with Horizontal Drilling and Hydraulic Fracturing 6-277
6.9.5 Previous Evaluations of Visual Impacts from Horizontal Drilling and Hydraulic Fracturing 6-279
6.9.6 Assessment of Visual Impacts using NYSDEC Policy and Guidance 6-283
6.9.7 Summary of Visual Impacts 6-284

6.10 NOISE 6-289
6.10.1 Access Road Construction 6-291
6.10.2 Well Site Preparation 6-292
6.10.3 High-Volume Hydraulic Fracturing – Drilling 6-293
6.10.4 High-Volume Hydraulic Fracturing – Fracturing 6-296
6.10.5 Transportation 6-299
6.10.6 Gas Well Production 6-300

6.11 TRANSPORTATION IMPACTS 6-300
6.11.1 Estimated Truck Traffic 6-301
6.11.1.1 Total Number of Trucks per Well 6-301
6.11.1.2 Temporal Distribution of Truck Traffic per Well 6-304
6.11.1.3 Temporal Distribution of Truck Traffic for Multi-Well Pads 6-304
6.11.2 Increased Traffic on Roadways 6-307
6.11.3 Damage to Local Roads, Bridges, and other Infrastructure 6-310
6.11.4 Damage to State Roads, Bridges, and other Infrastructure 6-312
6.11.5 Operational and Safety Impacts on Road Systems 6-314
6.11.6 Transportation of Hazardous Materials 6-315
6.11.7 Impacts on Rail and Air Travel 6-316

6.12 COMMUNITY CHARACTER IMPACTS 6-316

6.13 SEISMICITY 6-319
6.13.1 Hydraulic Fracturing-Induced Seismicity 6-319
6.13.1.1 Background 6-320
6.13.1.2 Recent Investigations and Studies 6-323
6.13.1.3 Correlations between New York and Texas 6-325
6.13.1.4 Affects of Seismicity on Wellbore Integrity 6-326
6.13.2 Summary of Potential Seismicity Impacts 6-327

FIGURES

Figure 6.1 - Water Withdrawals in the United States 6-11
Figure 6.2 - Fresh Water Use in NY (millions of gallons per day) with Projected Peak Water Use for High-Volume Hydraulic Fracturing (New July 2011) 6-12
Figure 6.3 - Daily Water Withdrawals, Exports, and Consumptive Uses in the Delaware River Basin 6-13
Figure 6.4- NYSDOH Regulated Groundwater Supplies within Mapped Primary and Principal Aquifers in NY, Where the Marcellus Shale is Greater than 2,000 Feet below Ground Surface 6-38
Figure 6.5 - Average Spatial Disturbance for Marcellus Shale Well Pads in Forested Context (New July 2011) 6-77
Figure 6.6 – Interior Forest Habitat Before & After Development of a Marcellus Gas Well Pad, Elk County PA (New July 2011) 6-80
Figure 6.7 - Total Forest Areas Converted (New July 2011) 6-81
Figure 6.8 - New York's Forest Matrix Blocks and State Connectivity (New July 2011) 6-83
Figure 6.9-Areas of Concern for Endangered and Threatened Animal Species within the Area Underlain by the Marcellus Shale in New York, March 31, 2011 (New July 2011) 6-90
Figure 6.10 - Location of Well Pad Sources of Air Pollution Used in Modeling 6-167
Figure 6.11 - Barnett Shale Natural Gas Production Trend, 1998-2007 6-173
Figure 6.12 – Projected Direct Employment in New York State Resulting from Each Development Scenario (New August 2011) 6-214
Figure 6.13 - Projected Total Employment in New York State Resulting from Each Development Scenario (New August 2011) 6-215
Figure 6.14 - Projected Direct Employment in Region A Resulting from Each Development Scenario (New August 2011) 6-221
Figure 6.15 - Projected Direct Employment in Region B Resulting from Each Development Scenario (New August 2011) 6-222
Figure 6.16 - Projected Direct Employment in Region C Resulting from Each Development Scenario (New August 2011) 6-223
Figure 6.17 – Projected Total Employment in Region A Under Each Development Scenario (New August 2011) 6-225
Figure 6.18 - Projected Total Employment in Region B Under Each Development Scenario (New August 2011) 6-226
Figure 6.19 - Projected Total Employment in Region C Under Each Development Scenario (New August 2011) 6-227
Figure 6.20 - A-Weighted Noise Emissions: Cruise Throttle, Average Pavement (New August 2011) 6-299
Figure 6.21 - Estimated Round-Trip Daily Heavy and Light Truck Traffic, by Well Type - Single Well (New August 2011) 6-304
Figure 6.22 - Estimated Daily Round-Trips of Heavy and Light Truck Traffic - Multi Horizontal Wells (New August 2011) 6-306
Figure 6.23 - Estimated Round-Trip Daily Heavy and Light Truck Traffic - Multi Vertical Wells (New August 2011) .. 6-306

TABLES

Table 6.1 - Comparison of additives used or proposed for use in NY, parameters detected in analytical results of flowback from the Marcellus operations in PA and WV and parameters regulated via primary and secondary drinking water standards, SPDES or TOGS111 (Revised August 2011)' 6-19
Table 6.2 - Grassland Bird Population Trends at Three Scales from 1966 to 2005. (New July 2011) 6-73

Table 6.3 - Terrestrial Invasive Plant Species In New York State (Interim List)' 6-85
Table 6.4 - Aquatic, Wetland & Littoral Invasive Plant Species in New York State (Interim List)' 6-87
Table 6.5 - Endangered & Threatened Animal Species within the Area Underlain by the Marcellus Shale (New July 2011) 6-89
Table 6.6 - EPA AP-42 Emissions Factors Tables 6-100
Table 6.7 - Estimated Wellsite Emissions (Dry Gas) - Flowback Gas Flaring (Tpy)(Updated July 2011) 6-106
Table 6.8 - Estimated Wellsite Emissions (Dry Gas) - Flowback Gas Venting (Tpy)(Updated July 2011) 6-106
Table 6.9 - Estimated Wellsite Emissions (Wet Gas) - Flowback Gas Flaring (Tpy) (Updated July 2011) 6-106
Table 6.10 - Estimated Wellsite Emissions (Wet Gas) - Flowback Gas Venting (Tpy) (Updated July 2011) 6-106
Table 6.11 - Estimated Off-Site Compressor Station Emissions (Tpy) 6-107
Table 6.12 - Sources and Pollutants Modeled for Short-Term Simultaneous Operations 6-159
Table 6.13 - National Weather Service Data Sites Used in the Modeling 6-159
Table 6.14 - National Ambient Air Quality Standards (NAAQS), PSD Increments & Significant Impact Levels (SILs) for Criteria Pollutants ($\mu g/m^3$) 6-160
Table 6.15 - Maximum Background Concentration from Department Monitor Sites 6-161
Table 6.16 - Maximum Impacts of Criteria Pollutants for Each Meteorological Data Set 6-162
Table 6.17 - Maximum Project Impacts of Criteria Pollutants and Comparison to SILs, PSD Increments and Ambient Standards 6-163
Table 6.18 - Maximum Impacts of Non-Criteria Pollutants and Comparisons to SGC/AGC and New York State AAQS 6-164
Table 6.19 - Modeling Results for Short Term PM10, PM2.5 and NO_2 (New July 2011) 6-165
Table 6.20 - Engine Tiers and Use in New York with Recommended Mitigation Controls Based on the Modeling Analysis (New July 2011) 6-166
Table 6.21 - Predicted Ozone Precursor Emissions (Tpy) 6-174
Table 6.22 - Barnett Shale Annual Average Emissions from All Sources 6-178
Table 6.23 - Near-Field Pollutants of Concern for Inclusion in the Near-Field Monitoring Program (New July 2011) 6-182
Table 6.24 - Department Air Quality Monitoring Requirements for Marcellus Shale Activities (New July 2011) . 6-184
Table 6.25 - Assumed Drilling & Completion Time Frames for Single Vertical Well (New July 2011) 6-192
Table 6.26 - Assumed Drilling & Completion Time Frames for Single Horizontal Well (Updated July 2011) 6-192
Table 6.27 - Global Warming Potential for Given Time Horizon 6-201
Table 6.28 - Summary of Estimated Greenhouse Gas Emissions (Revised July 2011) 6-201
Table 6.29 - Emission Estimation Approaches – General Considerations 6-204
Table 6.30 - Radionuclide Half-Lives 6-206
Table 6.31 - Major Development Scenario Assumptions (New August 2011) 6-209
Table 6.32 - Maximum Direct and Indirect Employment Impacts on New York State under Each Development Scenario (New August 2011) 6-213
Table 6.33 - Maximum Direct and Indirect Annual Employee Earnings Impacts on New York State under Each Development Scenario (New August 2011) 6-216
Table 6.34 - Major Development Scenario Assumptions for Each Representative Region (New August 2011) ... 6-218
Table 6.35 - Maximum Direct and Indirect Employment Impacts on Each Representative Region under Each Development Scenario (New August 2011) 6-220
Table 6.36 - Maximum Direct and Indirect Earnings Impacts on Each Representative Region under Each Development Scenario (New August 2011) 6-228
Table 6.37 - Transient, Permanent and Total Construction Employment Under Each Development Scenario for Select Years: New York State (New August 2011) 6-234
Table 6.38 - Estimated Population Associated with Construction and Production Employment for Select Years: New York State (New August 2011) 6-235
Table 6.39 - Maximum Temporary and Permanent Impacts Associated with Well Construction and Production: New York State (New August 2011) 6-237
Table 6.40 - Transient, Permanent, and Total Construction Employment Under Each Development Scenario for Select Years for Representative Region A (New August 2011) 6-238

Table 6.41 - Transient, Permanent, and Total Construction Employment Under Each Development Scenario for Select Years for Representative Region B (New August 2011) 6-238
Table 6.42 - Transient, Permanent, and Total Construction Employment Under Each Development Scenario for Select Years for Representative Region C (New August 2011) 6-239
Table 6.43 - Maximum Temporary and Permanent Impacts Associated with Well Construction and Production 6-240
Table 6.44 - Maximum[1] Estimated Employment by Development Scenario for New York State (New August 2011) 6-243
Table 6.45 - New York State Rental Housing Stock (2010) (New August 2011) 6-244
Table 6.46 - Availability of Owner-Occupied Housing Units (2010) (New August 2011) 6-245
Table 6.47 - Maximum Transient and Permanent Employment by Development Scenario and Region (New August 2011) 6-245
Table 6.48 - Availability of Rental Housing Units (New August 2011) 6-247
Table 6.49 - Availability of Housing Units (New August 2011) 6-249
Table 6.50 - Example of the Real Property Tax Payments From a Typical Horizontal Well (New August 2011) ... 6-259
Table 6.51 - Example of the Real Property Tax Payments from a Typical Vertical Well (New August 2011) 6-261
Table 6.52 - Projected Change in Total Assessed Value and Property Tax Receipts[1] at Peak Production (Year 30), by Region (New August 2011) 6-261
Table 6.53 - Summary of Generic Visual Impacts Resulting from Horizontal Drilling and Hydraulic Fracturing in the Marcellus and Utica Shale Area of New York (New August 2011) 6-285
Table 6.54 - Estimated Construction Noise Levels at Various Distances for Access Road Construction (New August 2011) 6-292
Table 6.55 - Estimated Construction Noise Levels at Various Distances for Well Pad Preparation (New August 2011) 6-293
Table 6.56 - Estimated Construction Noise Levels at Various Distances for Rotary Air Well Drilling (New August 2011) 6-295
Table 6.57 - Estimated Construction Noise Levels at Various Distances for Horizontal Drilling (New August 2011) .. 6-295
Table 6.58 - Estimated Construction Noise Levels at Various Distances for High-Volume Hydraulic Fracturing (New August 2011) 6-297
Table 6.59 - Assumed Construction and Development Times (New August 2011) 6-298
Table 6.60 - Estimated Number of One-Way (Loaded) Trips Per Well: Horizontal Well[1] (New August 2011) 6-302
Table 6.61 - Estimated Number of One-Way (Loaded) Trips Per Well:Vertical Well (New August 2011) 6-303
Table 6.62 - Estimated Truck Volumes for Horizontal Wells Compared to Vertical Wells (New August 2011) 6-303
Table 6.63 - Estimated Annual Heavy Truck Trips (in thousands) (New August 2011) 6-309
Table 6.64 - Illustrative AADT Range for State Roads (New August 2011) 6-310

PHOTOS

Photo 6.1 - A representative view of completion activities at a recently constructed well pad (New August 2011) . 6-267
Photo 6.2 - A representative view of completion activities at a recently constructed well pad, showing a newly created access road in foreground (New August 2011) 6-268
Photo 6.3 - A representative view of a newly constructed water impoundment area (New August 2011) 6-269
Photo 6.4 - A representative view of a water procurement site (New August 2011) 6-269
Photo 6.5 - A representative view of active high-volume hydraulic fracturing (New August 2011) 6-271
Photo 6.6 - Electric Generators, Active Drilling Site (New August 2011) 6-296
Photo 6.7 - Truck-mounted Hydraulic Fracturing Pump (New August 2011) 6-297
Photo 6.8 - Hydraulic Fracturing of a Marcellus Shale Well Site (New August 2011) 6-298
Photo 6.9 - Map Depicting Trenton-Black River Wells and Historical Wells Targeting Other Formations in Chemung County 6-329
Photo 6.10 - Map Depicting the Location of Trenton-Black River Wells in the Eastern-end of Quackenbush Hill Field 6-330
Photo 6.11 - Trenton-Black River Well Site (Rhodes) 6-330

Photo 6.12 - Trenton-Black River Well Site (Gregory) 6-331
Photo 6.13 - Trenton-Black River Well Site (Schwingel) 6-331
Photo 6.14 - Trenton-Black River Well Site (Soderblom)..... 6-332
Photo 6.15 - Map Depicting the Locations of Two Trenton Black River Wells in North-Central Chemung County 6-333
Photo 6.16 - Trenton-Black River Well Site (Little) 6-334
Photo 6.17 - Trenton-Black River Well Site (Hulett) 6-334
Photo 6.18 - Map Depicting the Location of Trenton-Black River Wells in Western Chemung County and Eastern Steuben County 6-335
Photo 6.19 - Trenton-Black River Well Site (Lovell) 6-336
Photo 6.20 - Trenton Black River Well Site (Henkel) 6-336

Chapter 7 – Mitigation Measures

CHAPTER 7 EXISTING AND RECOMMENDED MITIGATION MEASURES 7-1

7.1 PROTECTING WATER RESOURCES 7-1
7.1.1 Water Withdrawal Regulatory and Oversight Programs 7-2
7.1.1.1 Department Jurisdictions 7-2
7.1.1.2 Other Jurisdictions - Great Lakes-St. Lawrence River Basin Water Resources Compact 7-5
7.1.1.3 Other Jurisdictions - River Basin Commissions 7-6
7.1.1.4 Impact Mitigation Measures for Surface Water Withdrawals 7-14
7.1.1.5 Impact Mitigation Measures for Groundwater Withdrawals 7-24
7.1.1.6 Cumulative Water Withdrawal Impacts 7-25
7.1.2 Stormwater 7-26
7.1.2.1 Construction Activities 7-30
7.1.2.2 Industrial Activities 7-30
7.1.2.3 Production Activities 7-31
7.1.3 Surface Spills and Releases at the Well Pad 7-32
7.1.3.1 Fueling Tank and Tank Refilling Activities 7-33
7.1.3.2 Drilling Fluids 7-35
7.1.3.3 Hydraulic Fracturing Additives 7-38
7.1.3.4 Flowback Water 7-39
7.1.3.5 Primary and Principal Aquifers 7-40
7.1.4 Potential Ground Water Impacts Associated With Well Drilling and Construction 7-42
7.1.4.1 Private Water Well Testing 7-44
7.1.4.2 Sufficiency of As-Built Wellbore Construction 7-49
7.1.4.3 Annular Pressure Buildup 7-55
7.1.5 Setback from FAD Watersheds 7-55
7.1.6 Hydraulic Fracturing Procedure 7-56
7.1.7 Waste Transport 7-59
7.1.7.1 Drilling and Production Waste Tracking Form 7-59
7.1.7.2 Road Spreading 7-60
7.1.7.3 Flowback Water Piping 7-61
7.1.7.4 Use of Tanks Instead of Impoundments for Centralized Flowback Water Storage 7-61
7.1.7.5 Closure Requirements 7-62
7.1.8 SPDES Discharge Permits 7-62
7.1.8.1 Treatment Facilities 7-63
7.1.8.2 Disposal Wells 7-65
7.1.9 Solids Disposal 7-66
7.1.10 Protecting NYC's Subsurface Water Supply Infrastructure 7-68
7.1.11 Setbacks 7-69
7.1.11.1 Setbacks from Groundwater Resources 7-71
7.1.11.2 Setbacks from Other Surface Water Resources 7-74

7.2 PROTECTING FLOODPLAINS 7-76

7.3 PROTECTING FRESHWATER WETLANDS 7-76

7.4 MITIGATING POTENTIAL SIGNIFICANT IMPACTS ON ECOSYSTEMS AND WILDLIFE 7-77
7.4.1 Protecting Terrestrial Habitats and Wildlife 7-77
7.4.1.1 BMPs for Reducing Direct Impacts at Individual Well Sites 7-77
7.4.1.2 Reducing Indirect and Cumulative Impacts of Habitat Fragmentation 7-79
7.4.1.3 Monitoring Changes in Habitat 7-87
7.4.2 Invasive Species 7-88
7.4.2.1 Terrestrial 7-89

7.4.2.2 Aquatic 7-92
7.4.3 Protecting Endangered and Threatened Species 7-98
7.4.4 Protecting State-Owned Land 7-100

7.5 MITIGATING AIR QUALITY IMPACTS 7-101
7.5.1 Mitigation Measures Resulting from Regulatory Analysis (Internal Combustion Engines and Glycol Dehydrators) 7-102
7.5.1.1 Control Measures for Nitrogen Oxides-NO_x 7-102
7.5.1.2 Control Measures for Sulfur Oxides - SO_x 7-105
7.5.1.3 Natural Gas Production Facilities Subject to NESHAP 40 CFR Part 63, Subpart HH (Glycol Dehydrators) 7-106
7.5.2 Mitigation Measures Resulting from Air Quality Impact Assessment and Regional Ozone Precursor Emissions 7-107
7.5.3 Summary of Mitigation Measures to Protect Air Quality 7-108
7.5.3.1 Well Pad Activity Mitigation Measures 7-108
7.5.3.2 Mitigation Measures for Off-Site Gas Compressors 7-110

7.6 MITIGATING GHG EMISSIONS 7-110
7.6.1 General 7-110
7.6.2 Site Selection 7-111
7.6.3 Transportation 7-111
7.6.4 Well Design and Drilling 7-112
7.6.5 Well Completion 7-112
7.6.6 Well Production 7-113
7.6.7 Leak and Detection Repair Program 7-114
7.6.8 Mitigating GHG Emissions Impacts - Conclusion 7-116

7.7 MITIGATING NORM IMPACTS 7-117
7.7.1 State and Federal Responses to Oil and Gas NORM 7-117
7.7.2 Regulation of NORM in New York State 7-118

7.8 SOCIOECONOMIC MITIGATION MEASURES 7-120

7.9 VISUAL MITIGATION MEASURES 7-121
7.9.1 Design and Siting Measures 7-122
7.9.2 Maintenance Activities 7-126
7.9.3 Decommissioning 7-127
7.9.4 Offsetting Mitigation 7-128

7.10 NOISE MITIGATION MEASURES 7-128
7.10.1 Pad Siting Equipment, Layout and Operation 7-128
7.10.2 Access Road and Traffic Noise 7-129
7.10.3 Well Drilling and Hydraulic Fracturing 7-130
7.10.4 Conclusion 7-134

7.11 TRANSPORTATION MITIGATION MEASURES 7-135
7.11.1 Mitigating Damage to Local Road Systems 7-135
7.11.1.1 Development of Transportation Plans, Baseline Surveys, and Traffic Studies 7-136
7.11.1.2 Municipal Control over Local Road Systems 7-137
7.11.1.3 Road Use Agreements 7-138
7.11.1.4 Reimbursement for Costs Associated with Local Road Work 7-139
7.11.2 Mitigating Incremental Damage to the State System of Roads 7-140
7.11.3 Mitigating Operational and Safety Impacts on Road Systems 7-141
7.11.4 Other Transportation Mitigation Measures 7-142
7.11.5 Mitigating Impacts from the Transportation of Hazardous Materials 7-142

7.11.6 Mitigating Impacts on Rail and Air Travel 7-143

7.12 COMMUNITY CHARACTER MITIGATION MEASURES 7-144

7.13 EMERGENCY RESPONSE PLAN 7-146

FIGURES

Figure 7.1 - Hydrologic Regions of New York (New July 2011) (Taken from Lumia et al, 2006) 7-21
Figure 7.2 - Key Habitat Areas for Protecting Grassland and Interior Forest Habitats (Updated August 2011) 7-80
Figure 7.3 - Scaling Factors for Matrix Forest Systems in the High Allegheny Ecoregion (New July 2011) 7-84

TABLES

Table 7.1 - Regulations Pertaining to Watershed Withdrawal (Revised July 2011) 7-7
Table 7.2 - Regional Passby Flow Coefficients (cfs/sq. mi.) (Updated August 2011) 7-22
Table 7.3 - NYSDOH Water Well Testing Recommendations 7-46
Table 7.4 - Principal Species Found in the Four Grassland Focus Areas within the area underlain by the Marcellus Shale in New York (New July 2011) 7-81
Table 7.5 - Summary of Regulations Pertaining to Transfer of Invasive Species 7-94
Table 7.6 - Required Well Pad Stack Heights to Prevent Exceedances 7-109

PHOTOS

Photo 7.1 - View of a well site during the fracturing phase of development, with maximum presence of on-site equipment. (New August 2011) 7-125
Photo 7.2 - Sound Barrier. Source: Ground Water Protection Council, Oklahoma City, OK and ALL Consulting, Tulsa OK, 2009 (New August 2011) 7-132
Photo 7.3 - Sound Barrier Installation (New August 2011) 7-133
Photo 7.4 - Sound Barrier Installation (New August 2011) 7-133

Chapter 8 – Permit Process and Regulatory Coordination

CHAPTER 8 PERMIT PROCESS AND REGULATORY COORDINATION 8-1

8.1 INTERAGENCY COORDINATION 8-1
8.1.1 Local Governments 8-1
8.1.1.1 SEQRA Participation 8-1
8.1.1.2 NYCDEP 8-4
8.1.1.3 Local Government Notification 8-4
8.1.1.4 Road-Use Agreements 8-4
8.1.1.5 Local Planning Documents 8-4
8.1.1.6 County Health Departments 8-5
8.1.2 State 8-5
8.1.2.1 Public Service Commission 8-6
8.1.2.2 NYS Department of Transportation 8-18
8.1.3 Federal 8-19
8.1.3.1 U.S. Department of Transportation 8-19
8.1.3.2 Occupational Safety and Health Administration – Material Safety Data Sheets 8-21
8.1.3.3 EPA's Mandatory Reporting of Greenhouse Gases 8-24
8.1.4 River Basin Commissions 8-28
8.2 INTRA-DEPARTMENT 8-29
8.2.1 Well Permit Review Process 8-29
8.2.1.1 Required Hydraulic Fracturing Additive Information 8-29
8.2.2 Other Department Permits and Approvals 8-32
8.2.2.1 Bulk Storage 8-32
8.2.2.2 Impoundment Regulation 8-33
8.2.3 Enforcement 8-42
8.2.3.1 Enforcement of Article 23 8-42
8.2.3.2 Enforcement of Article 17 8-44
8.3 WELL PERMIT ISSUANCE 8-48
8.3.1 Use and Summary of Supplementary Permit Conditions for High-Volume Hydraulic Fracturing 8-48
8.3.2 High-Volume Re-Fracturing 8-48
8.4 OTHER STATES' REGULATIONS 8-49
8.4.1 Ground Water Protection Council 8-51
8.4.1.1 GWPC - Hydraulic Fracturing 8-51
8.4.1.2 GWPC - Other Activities 8-52
8.4.2 Alpha's Regulatory Survey 8-53
8.4.2.1 Alpha - Hydraulic Fracturing 8-53
8.4.2.2 Alpha - Other Activities 8-54
8.4.3 Colorado's Final Amended Rules 8-61
8.4.3.1 Colorado - New MSDS Maintenance and Chemical Inventory Rule 8-61
8.4.3.2 Colorado - Setbacks from Public Water Supplies 8-62
8.4.4 Summary of Pennsylvania Environmental Quality Board. Title 25-Environmental Protection, Chapter 78, Oil and Gas Wells 8-63
8.4.5 Other States' Regulations - Conclusion 8-63

FIGURES
Figure 8.1- Protection of Waters - Dam Safety Permitting Criteria 8-35

TABLES
Table 8.1 - Regulatory Jurisdictions Associated with High-Volume Hydraulic Fracturing (Revised July 2011) 8-3
Table 8.2 - Intrastate Pipeline Regulation 8-10
Table 8.3 - Water Resources and Private Dwelling Setbacks from Alpha, 2009 8-60

Chapter 9 – Alternative Actions

CHAPTER 9 ALTERNATIVE ACTIONS 9-1

9.1 NO-ACTION ALTERNATIVE 9-1

9.2 PHASED PERMITTING APPROACH 9-3
9.2.1 Inherent Difficulties in Predicting Gas Well Development Rates and Patterns 9-4
9.2.2 Known Tendency for Development to Occur in Phases without Government Intervention 9-4
9.2.3 Prohibitions and Limits that Function as a Partial Phased Permitting Approach 9-5
9.2.3.1 Permanent Prohibitions 9-6
9.2.3.2 Prohibitions in Place for at Least 3 Years 9-6
9.2.3.3 Prohibitions in Place for At Least 2 Years 9-6
9.2.4 Permit Issuance Matched to Department Resources 9-7

9.3 "GREEN" OR NON-CHEMICAL FRACTURING TECHNOLOGIES AND ADDITIVES 9-7
9.3.1 Environmentally-Friendly Chemical Alternatives 9-9
9.3.2 Summary 9-10

TABLES

Table 9.1 - Marcellus Permits Issued in Pennsylvania, 2007 - 2010 9-5

Chapter 10 – Review of Selected Non-Routine Incidents in Pennsylvania

CHAPTER 10 REVIEW OF SELECTED NON-ROUTINE INCIDENTS IN PENNSYLVANIA 10-1

10.1 GAS MIGRATION – SUSQUEHANNA AND BRADFORD COUNTIES 10-1
10.1.1 Description of Incidents 10-1
10.1.2 New York Mitigation Measures Designed to Prevent Gas Migration Similar to the Pennsylvania Incidents 10-1

10.2 FRACTURING FLUID RELEASES – SUSQUEHANNA AND BRADFORD COUNTIES 10-2
10.2.1 Description of Incidents 10-2
10.2.2 New York Mitigation Measures Designed to Prevent Fracturing Fluid Releases 10-3

10.3 UNCONTROLLED WELLBORE RELEASE OF FLOWBACK WATER AND BRINE – CLEARFIELD COUNTY 10-4
10.3.1 Description of Incident 10-4
10.3.2 New York Mitigation Measures Designed to Prevent Uncontrolled Wellbore Release of Flowback Water and Brine 10-4

10.4 HIGH TOTAL DISSOLVED SOLIDS (TDS) DISCHARGES – MONONGAHELA RIVER 10-4
10.4.1 Description of Incidents 10-4
10.4.2 New York Mitigation Measures Designed to Prevent High In-Stream TDS 10-4

Chapter 11 – Summary of Potential Impacts and Mitigation Measures

CHAPTER 11 SUMMARY OF POTENTIAL IMPACTS AND MITIGATION MEASURES 11-1

TABLES

Table 11.1 - Summary of Potential Impacts and Proposed Mitigation Measures (New July 2011) 11-2