Multi-Hazard Mitigation Plan Update – 2009

August 2009

Flanagan & Associates, LLC
Planning Consultants

ENGINEERING SERVICES

July 31, 2009

Mr. Bill Penka, State Hazard Mitigation Officer
Oklahoma Department of Civil Emergency Management
P.O. Box 53365
Oklahoma City, OK 73152

RE: City of Tulsa Multi-Hazard Mitigation Plan – 2009 Update

We are pleased to submit this *City of Tulsa Multi-Hazard Mitigation Plan-2009 Update*, as fulfillment of the requirements of the Pre-Disaster Hazard Mitigation Grant (PDMC-PJ-06-OK-2007-004).

This Multi-Hazard Mitigation Plan, prepared in accordance with State and Federal guidance, addresses floodplain management, dam and levee failures, tornadoes, high winds, hailstorms, lightning, winter storms, extreme heat, drought, expansive soils, wild fires, and earthquakes.

We look forward to implementing this plan to enhance protection of the lives and property of our citizens from natural hazards and hazard materials incidents. If we can answer any questions or be of further assistance, please do not hesitate to contact me at 918-596-9475.

CITY OF TULSA, DEPARTMENT OF PUBLIC WORKS

Sincerely,

Bill Robison

Bill Robison, P.E., CFM
Senior Special Projects Engineer
Stormwater Planning

Table of Contents

Acknowledgements xiii

Executive Summary xv

Background xvi
Purpose xvi
Hazard Mitigation Citizens Advisory Committee xvi
The Planning Process xvi
Plan Summary xvii
Mitigation Measures xix
Mitigation Action Plan xxi

Chapter 1: Introduction 1

1.1 About the Plan 1
1.1.1 Purpose 2
1.1.2 Scope 2
1.1.3 Authority 2
1.1.4 Funding 3
1.1.5 Goals 3
1.1.6 Definition of Terms 5
1.1.7 Points of Contact 5
1.2 Community Description 6
1.2.1 Governance 6
1.2.2 Geography 8
1.2.3 Climate 8
1.2.4 History 9
1.2.5 Demographics 13
1.2.6 Lifelines 23
1.2.7 Economy 30
1.2.8 Development 32
1.2.9 Critical Facilities 38

Chapter 2: Existing Mitigation Strategies 48

2.1 About Hazard Mitigation Programs 48
2.1.1 National Flood Insurance Program (NFIP) 49
2.1.2 Firewise Community 50
2.1.3 Fire Protection Rating 50
2.1.4 StormReady Community 50
2.1.5 Business Continuity Mitigation and Planning Programs 51

2.2 Public Information and Education 52
2.2.1 Public Information Infrastructure 52
2.2.2 Outreach Programs 53
2.3 Preventive Measures 55
2.3.1 Planning and Zoning Ordinances 55
2.3.2 Flood and Stormwater Management 57
2.3.3 Building Codes 58
2.3.4 Other Preventive Measures 59
2.4 Structural Projects 60
2.4.1 City of Tulsa Capital Improvements Plans 60
2.5 Property Protection 61
2.5.1 City of Tulsa Property Protection 61
2.6 Emergency Response Procedures and Resources 62
2.6.1 National Incident Management System (NIMS) 62
2.6.2 Emergency Operation Plan 63
2.6.3 Emergency Operations Center 64
2.6.4 Emergency Notification and Warning Systems 65
2.6.5 Fire Safety Resources 69
2.6.6 Public Safety Resources 70
2.6.7 Public Works Department Resources 71
2.6.8 Tulsa County Sheriff's Department Resources 72
2.6.9 Other City, County, State and Federal Response 72
2.6.10 Health Care Facilities and Shelters 73
2.6.11 Medical Response and Coordination 74
2.6.12 Volunteer and Community Support Organizations 75
2.7 Natural Resource Protection 77
2.7.1 City of Tulsa Resource Protection 77
2.7.2 Environmentally Sensitive Areas 78
Chapter 3: The Planning Process 80
3.1 Step One: Organize to Prepare the Plan 81
3.2 Step Two: Involve the Public 89
3.3 Step Three: Coordinate with Other Agencies and Organizations 89
3.4 Step Four: Assess the Hazard 93
3.5 Step Five: Assess the Problem 95
3.6 Step Six: Set Goals 96
3.7 Step Seven: Review Possible Activities 96
3.8 Step Eight: Draft an Action Plan 97
3.9 Step Nine: Adopt the Plan 97

3.10 Step Ten: Implement, Evaluate, and Revise....97
Chapter 4: Natural Hazards 99
Introduction 99
Hazards Summary 100
Annual Average Damages 105
Hazards Analysis: Probability and Vulnerability 105
Secondary Events 106
4.1 Floods 108
4.1.1 Hazard Profile 108
4.1.2 Existing Vulnerability 116
4.1.3 Flood Scenario 125
4.1.4 Future Trends 127
4.1.5 Conclusions 128
4.2 Tornadoes 130
4.2.1 Hazard Profile 132
4.2.2 Existing Vulnerability 138
4.2.3 Tornado Scenario 140
4.2.4 Future Trends 151
4.2.5 Conclusions 152
4.3 High Winds 154
4.3.1 Hazard Profile 154
4.3.2 Existing Vulnerability 158
4.3.3 High Wind Scenario 160
4.3.4 Future Trends 163
4.3.5 Conclusions 164
4.4 Lightning 166
4.4.1 Hazard Profile 166
4.4.2 Existing Vulnerability 170
4.4.3 Lightning Scenario 171
4.4.4 Future Trends 174
4.4.5 Conclusions 174
4.5 Hailstorm 177
4.5.1 Hazard Profile 178
4.5.2 Existing Vulnerability 180
4.5.3 Hail Scenario 182
4.5.4 Future Trends 183
4.5.5 Conclusions 184

4.6 Winter Storms 186
4.6.1 Hazard Profile 186
4.6.2 Existing Vulnerability 190
4.6.3 Winter Storm Scenario 193
4.6.4 Future Trends 200
4.6.5 Conclusions 200
4.7 Extreme Heat 202
4.7.1 Hazard Profile 202
4.7.2 Existing Vulnerability 207
4.7.3 Heat Scenario 210
4.7.4 Future Trends 212
4.7.5 Conclusions 213
4.8 Drought 215
4.8.1 Hazard Profile 215
4.8.2 Existing Vulnerability 221
4.8.3 Drought Scenario 224
4.8.4 Future Trends 224
4.8.5 Conclusions 225
4.9 Expansive Soils 227
4.9.1 Hazard Profile 227
4.9.2 Existing Vulnerability 230
4.9.3 Expansive Soils Scenario 233
4.9.4 Future Trends 233
4.9.5 Conclusions 236
4.10 Wildfires 238
4.10.1 Hazard Profile 238
4.10.2 Existing Vulnerability 243
4.10.3 Wildfire Scenario 246
4.10.4 Future Trends 246
4.10.5 Conclusions 247
4.11 Earthquakes 249
4.11.1 Hazard Profile 249
4.11.2 Existing Vulnerability 254
4.11.3 Earthquake Scenario 255
4.11.4 Future Trends 255
4.11.5 Conclusion 256
4.12 Dam and Levee Failures 257
4.12.1 Hazard Profile 258

4.12.2 Existing Vulnerability 269
4.12.3 Dam/Levee Failure Scenario 280
4.12.4 Future Trends 280
4.12.5 Conclusion 283
4.13 Hazard Composite 285
Chapter 5: Mitigation Goals and Objectives 287
The Research, Review, and Prioritization Process 287
Mitigation Categories 288
5.1 Hazard Mitigation Goals 289
5.1.1 Mission Statement 289
5.1.2 Mitigation Goal 289
5.1.3 Goals for All Natural Hazards 289
5.2 Hazard-Specific Goals and Objectives 290
Chapter 6: Action Plan & Mitigation Measures 296
6.1 Action Plan 296
Chapter 7: Plan Maintenance and Adoption 311
7.1 Monitoring, Evaluating, and Updating the Plan 311
7.2 Public Involvement 312
7.3 Incorporating the Multi-Hazard Mitigation Plan 312
Appendix A: Glossary of Terms A–1
Appendix B: Mitigation Strategies B–1
B.1 Public Information and Education B–4
B.1.1 Public Information Program Strategy B–4
B.1.2 Educational Programs B–5
B.1.3 Outreach Projects B–6
B.1.4 Technical Assistance B–7
B.1.5 Map Information B–7
B.1.6 Library B–8
B.1.7 Web Sites B–9
B.1.8 Real Estate Disclosure B–10
B.1.9 Firewise Communities B–10
B.1.10 Business Continuity Planning and Mitigation B–11
B.1.11 Conclusions B–13
B.1.12 Recommendations B–13
B.2 Preventive Measures B–15
B.2.1 Planning B–15
B.2.2 Zoning B–17

B.2.3 Floodplain Development Regulations....B–17
B.2.4 Stormwater Management....B–19
B.2.5 Building Codes....B–21
B.2.6 IBHS Fortified Home Program....B–21
B.2.7 Smoke Detectors....B–23
B.2.8 Hurricane Fasteners....B–23
B.2.9 Mobile Home Tie-Downs....B–24
B.2.10 Lightning Warning Systems....B–24
B.2.11 Power Outages from Winter Storms....B–25
B.2.12 Standby Electric Generators....B–26
B.2.13 Critical Facility Protection....B–28
B.2.14 Extreme Heat Protection....B–29
B.2.15 Proper Storage and Disposal of Hazardous Materials....B–30
B.2.16 Water Conservation....B–30
B.2.17 Open Space Preservation....B–31
B.2.18 Conclusions....B–31
B.2.19 Recommendations....B–31
B.3 Structural Projects....B–32
B.3.1 Safe Rooms....B–32
B.3.2 School Safe Rooms....B–33
B.3.3 Reservoirs and Detention....B–33
B.3.4 Levees and Floodwalls....B–34
B.3.5 Channel Improvements....B–34
B.3.6 Crossings and Roadways....B–34
B.3.7 Drainage and Storm Sewer Improvements....B–35
B.3.8 Drainage System Maintenance....B–35
B.3.9 Conclusions....B–36
B.3.10 Recommendations....B–36
B.4 Property Protection....B–37
B.4.1 The City's Role....B–37
B.4.2 Insurance....B–38
B.4.3 Acquisition and Relocation....B–39
B.4.4 Building Elevation....B–40
B.4.5 Barriers....B–40
B.4.6 Retrofitting....B–40
B.4.7 Impact Resistant Windows and Doors....B–42
B.4.8 Lightning Protection Systems....B–44
B.4.9 Surge and Spike Protection....B–45

B.4.10 Landscaping for Wildfire Prevention B–45
B.4.11 Conclusions B–46
B.4.12 Recommendations B–46
B.5 Emergency Services B–47
B.5.1 Threat Recognition B–47
B.5.2 Warning B–48
B.5.3 9-1-1 and 2-1-1 .... B–50
B.5.4 Emergency Telephone Notification Systems (ETNS) B–50
B.5.5 Response B–50
B.5.6 Emergency Operations Plan (EOP) B–51
B.5.7 Incident Command System (ICS) B–52
B.5.8 Mutual Aid / Interagency Agreements B–52
B.5.9 CERT (Community Emergency Response Team) B–53
B.5.10 Debris Management B–53
B.5.11 Critical Facilities Protection B–53
B.5.12 Site Emergency Plans B–54
B.5.13 Post-Disaster Recovery and Mitigation B–54
B.5.14 StormReady Communities B–55
B.5.15 Conclusions B–56
B.5.16 Recommendations B–56
B.6 Natural Resource Protection B–57
B.6.1 Wetland Protection B–57
B.6.2 Erosion and Sedimentation Control B–58
B.6.3 River Restoration B–59
B.6.4 Best Management Practices B–59
B.6.5 Dumping Regulations B–60
B.6.6 Conclusions B–60
B.6.7 Recommendations B–61

Appendix C: Hazard Mitigation Meeting Attendance and Agendas C–1

Appendix D: Status of 2003 City of Tulsa Mitigation Measures D–1

Appendix E: City of Tulsa Plan Update Changes E–1

Appendix F: City of Tulsa Capital Improvement Plan Projects F–1

Appendix G: City of Tulsa Critical Facilities G–1

Appendix H: Repetitive Loss Inventory by Status by Depth H–1

List of Tables

Table 1–1: Weather averages for Tulsa, Oklahoma 9
Table 1–2: National Register of Historic Places - Tulsa, Oklahoma 10
Table 1–3: Select Cities in Tulsa County Population Data 14
Table 1–4: City of Tulsa Population Data 17
Table 1–5: City of Tulsa Wastewater Treatment Plants 24
Table 1–6: PSO Outages with Greater Than 20,000 Customers Affected Jan 2003 – Dec 2007 25
Table 1–7: Highway Traffic Counts 27
Table 1–8: City of Tulsa Employment and Income Data 30
Table 1–9: Major Employers 31
Table 1–10: City of Tulsa 2008 Housing Units, Value and Type 32
Table 1–11: Tulsa Critical Facilities 39
Table 2–1: Tulsa Area Television Stations 52
Table 2–2: Master Drainage Plans and Basins 59
Table 2–3: EAS stations in or near Tulsa 66
Table 2–4: Alert and Siren Signals 69
Table 2–5: Fire Department Resources 70
Table 2–6: Police Department Resources 71
Table 2–7: Public Works Department Resources 71
Table 2–8: Tulsa County Sheriff Department Resources 72
Table 3–1: Tulsa Hazard Mitigation Committee Meetings and Activities 87
Table 3–2: How and Why Hazards Were Identified 93
Table 4–1: Sample Summary of Damages 105
Table 4–2: City of Tulsa Hazard Analysis 106
Table 4–3: Summary of Hazard Analysis Ranking Criteria 106
Table 4–4: Secondary (Cascade) Hazard Events 107
Table 4–5: Floods in Oklahoma and Tulsa for previous 10 years 114
Table 4–6: Vulnerable Tulsa Floodplain Buildings 117
Table 4–7: City of Tulsa Critical Facilities Located in the Floodplain 118
Table 4–8: 1986 Flood Scenario Damages 125
Table 4–9: Floodplain Property Data for Future Development Areas/Trends 127
Table 4–10: Fujita Scale and Enhanced Fujita Scale 131
Table 4–11: Tornadoes in Oklahoma and Tulsa County from 1950 thru 2007 134
Table 4–12: Tornado Fatalities in the United States 138
Table 4–13a: North Tulsa Tornado Scenario 142
Table 4–14a: Critical Facilities in North Tulsa Tornado Scenario 143
Table 4–13b: Central Tulsa Tornado Scenario 145

Table 4–14b: Critical Facilities in North Tulsa Tornado Scenario 145
Table 4–13c: South Central Tulsa Tornado Scenario 147
Table 4–14c: Critical Facilities in South Central Tulsa Tornado Scenario 148
Table 4–13d: South Tulsa Tornado Scenario 150
Table 4–14d: Critical Facilities in South Tulsa Tornado Scenario 151
Table 4–15: Beaufort Scale of Wind Strength 154
Table 4–17: High Wind Events in Tulsa from 1998 thru 2007 158
Table 4–18: City of Tulsa Infrastructure Expenses from High Wind Scenario 162
Table 4–19: High Wind Worst Case Scenario Damages 162
Table 4–20: Casualties and Damages Caused by Lightning from 1998 thru 2007 169
Table 4–21: Locations of Injurious Lightning Strikes 170
Table 4–22: Common Sizes and descriptions of Hail 177
Table 4–23: Reported Casualties and Damages Caused by Hail from 1996 to 2005 180
Table 4–24: Hail Scenario Damages 183
Table 4–25: Casualties and Damages Caused by Winter Storms from 1998 thru 2007 189
Table 4–26: Summary of Muskogee Event – January 2007 195
Table 4–27: Summary of Tulsa Area Event – December 2007 196
Table 4–28: Actual vs. Projected Economic Losses for Tulsa Winter Storm Scenario 198
Table 4–29: Deaths from Extreme Heat 206
Table 4–30: City of Tulsa Expansive Soils 228
Table 4–31: Critical Facilities Vulnerable to Expansive Soils 232
Table 4–32: City of Tulsa Expansive Soils – SE Osage Co. FGA 233
Table 4–33: City of Tulsa Expansive Soils – Tulsa Industrial Area FGA 233
Table 4–34: City of Tulsa Expansive Soils – SW Tulsa FGA 235
Table 4–35: City of Tulsa Expansive Soils – Wagoner County FGA 235
Table 4–36: City of Tulsa Expansive Soils – East Tulsa FGA 235
Table 4–37: Oklahoma Grass and Crop Fires, 2002-2006 242
Table 4–38: City of Tulsa Grass and Crop Fires, 2002-2006 243
Table 4–39: Critical Facilities with some Vulnerability to Wildfire 245
Table 4–40: Comparison of Mercalli and Richter Scales 252
Table 4–41: Tulsa dams and levees 259
Table 4–42a: Keystone Dam Release of 250,000 cfs 271
Table 4–43a: City of Tulsa Keystone Dam 250,000 cfs Release Critical Facilities 271
Table 4–42b: Keystone Dam Release of 350,000 cfs 271
Table 4–43b: City of Tulsa Keystone Dam 350,000 cfs Release Critical Facilities 272
Table 4–42c: Keystone Release of 450,000 cfs 272
Table 4–43c: City of Tulsa Keystone Dam 450,000 cfs Release Critical Facilities 272
Table 4–42d: Keystone Dam Max Discharge Property Exposure 274

Table 4–43d: City of Tulsa Keystone Dam Max. Discharge Critical Facilities 274
Table 4–42e: Keystone Dam Break Property Exposure 275
Table 4–43e: City of Tulsa Keystone Dam Break Critical Facilities 276
Table 4–44: Levee Failure Property Exposure 279
Table 4–45: City of Tulsa Levee Failure Critical Facilities 279
Table 5–1: STAPLEE Prioritization and Review Criteria...287
Table 6–1: Measures per Hazard 296
Table 6–2: Tulsa Prioritized Mitigation Measures 296
Table B–1: Multi-Hazard Mitigation Web Sites.. B–9
Table B–2: Cost Differentials for Fortified Home vs. standard Construction..........................B–22
Table B–3: Lightning Detection Options...B–24
Table B–4: Typical Wattage Requirements for Generator Usage B–28
Table B–5: Impact Resistant Windows Cost Estimate Table B–43
Table D–1: Stormwater Projects Status Report D–19

List of Figures

Figure 1–1: City of Tulsa Basemap 7
Figure 1–2: City of Tulsa National Register of Historic Places 12
Figure 1–3: City of Tulsa Population History, 1882 - 2010 13
Figure 1–4: Population of Selected Cities in Tulsa County....14
Figure 1–5: City of Tulsa Population Aged 65 and Above 15
Figure 1–6: City of Tulsa Population in Poverty....16
Figure 1–7: City of Tulsa Asian Population 19
Figure 1–8: City of Tulsa Hispanic Population 20
Figure 1–9: City of Tulsa Population of People with Disabilities....21
Figure 1–10: City of Tulsa Comprehensive Distribution of Identified Vulnerable Populations...22
Figure 1–11: City of Tulsa Mobile Home Park Locations 33
Figure 1–12: City of Tulsa Fenceline 35
Figure 1–13: City of Tulsa Future Growth Areas....36
Figure 1–14: City of Tulsa Critical Facilities 40
Figure 1–15: Federal, State, and County Government Facilities....41
Figure 1–16: Major Healthcare Facilities 42
Figure 1–17: Local Financial Headquarters....43
Figure 1–18: Education Facilities....44
Figure 1–19: Private Schools....45
Figure 1–20: Childcare Facilities....46
Figure 1–21: Senior Housing Facilities 47
Figure 2–1: City of Tulsa Zoning 56
Figure 2–2: City of Tulsa Warning Sirens....68
Figure 2-3: Environmentally Sensitive Areas (from INCOG)....79
Figure 4–1: City of Tulsa Basin Map 111
Figure 4–2: Tulsa Floodplains Map....112
Figure 4–3 - Map of Tulsa Repetitive Loss Properties....120
Figure 4–4: Map of Critical Facilities in the Floodplain 121
Figure 4–5: Map of Overtopped Bridges....122
Figure 4–6: Major Intersections in 100-yr Floodplain....123
Figure 4–7: City of Tulsa Barricaded Streets 124
Figure 4–8: Map of Tulsa Historic 1986 Flood Event....126
Figure 4–9: Map of Tulsa Historic Tornado Events....137
Figure 4–10: North Tulsa Tornado Scenario 141
Figure 4–11: Central Tulsa Tornado Scenario....144
Figure 4–12: South Central Tulsa Tornado Scenario 146

Figure 4–13: South Tulsa Tornado Scenario 149
Figure 4–14: Historic High Wind Events 156
Figure 4–15: Scenario for High Wind Event in City of Tulsa 161
Figure 4–16: Map of Tulsa Expansive Soils 229
Figure 4–17: Tulsa Expansive Soils Future Growth Areas 234
Figure 4–18: Tulsa Wildfire Level of Concern (with Critical Facilities) 244
Figure 4–19: Tulsa Dams and Major Levees 263
Figure 4–20: Arkansas River Levee Failure Inundation Area 266
Figure 4–21: Keystone Dam Break Inundation Area 267
Figure 4–22: Critical Facilities in Keystone Dam Break/Levee Failure Area 278
Figure 4–23: Map of River Corridor Future Development Areas 282
Figure 4–24: City of Tulsa Hazard Composite Map 286
Figure B–1: Public Service Notice for Flooding B–14

Acknowledgements

The City of Tulsa Multi-Hazard Mitigation Plan was developed with assistance from a Hazard Mitigation Grant from the Oklahoma Department of Emergency Management, the Federal Emergency Management Agency, and local funding from the City of Tulsa. The Tulsa Multi-Hazard Mitigation Plan was prepared by the City of Tulsa, Oklahoma, under the direction of the Tulsa City Council. Numerous agencies, organizations and individuals participated in the study, including:

City of Tulsa Elected Officials

Kathy Taylor .... Mayor
Jack Henderson .... City Council District 1
Rick Westcott .... City Council District 2
David Patrick .... City Council District 3
Eric Gomez .... City Council District 4
Bill Martinson .... City Council District 5
Dennis Troyer .... City Council District 6
John Eagleton .... City Council District 7
Bill Christenson .... City Council District 8
G.T. Bynum .... City Council District 9
Phillip W. Wood .... City Auditor

Tulsa Hazard Mitigation Citizen Advisory Board

Gary Cheatham, Chair .... Northeastern State University
Kyle Bierly................................. Executive VP, RotoRooter Plumbing
Dr. Judith Finn .... Pinkerton & Finn, P.C.
Robert (Bud) Fry......................... Citizen, Retired
Ann Patton .... Ann Patton Company, LLC

Tulsa Technical Advisory Committee

Charles L. Hardt, P.E. .... Director, Dept. of Public Works
Bill Robison .... Sr. Special Projects Engineer
Ken Busby.................................. Executive Director, Tulsa Arts & Humanities
Ken Hill...................................... Assistant Director, Public Works
Mike McCool .... Tulsa Area Emergency Management Director
Linda Muirheid .... Emergency Planning, Tulsa Health Department
Alan Rowland .... Financial Planning Manager, City of Tulsa
Kelly Deal .... Director, EMSA and MMRS

Technical Advisory Committee Participants

Paul Zachary, PE, CFM	Public Works, Engineering Services Deputy Director
Terry Ball, PE, CFM	Manager, Project Planning & Coordination
Graham Brannin	Public Works Planning & Intergovernment Admin.
Amanda DeCort	Historic Preservation Officer
Roy Foster	Water Quality Assurance Manager
Richard Green, CFM	Graphic Technician, City of Tulsa
Steve Penrose	Public Service Company of Oklahoma
Ed Sharrer	Historic Preservation, City of Tulsa
Brent Stout, PE, CFM	Sr. Special Projects Engineer
Deborah Stowers, PE, CFM	Lead Engineer, Stormwater Design
Mark Swiney	Sr. Assistant District Attorney
Harold Tohlen, PE, CFM	Development Services, City of Tulsa
Scott Van Loo	Stormwater Quality Manager, City of Tulsa
Corri Cousins	Secretary, SDHMAB
Althea Kabrich	Public Works
Rich Brierre	Director, INCOG
Joe Remondini, PE, CFM	Floodplain Services, U.S. Army Corps of Engineers

Consultants

R. D. Flanagan & Associates
Planning Consultants
2745 E. Skelly Drive, Suite 100
Tulsa, Oklahoma 74105
(918) 749-2696
www.rdflanagan@rdflanagan.com

Ronald D. Flanagan, CFM, Principal
David Wakefield, CFM
Bob Roberts
Graham Russell
Nancy Mulcahy

Dr. Cathy Ambler
Historic Preservation Consultant
Tulsa Oklahoma

Tulsa Partners, Inc.
PO Box 2131
Tulsa, Oklahoma 74101
(918) 632-0044
www.tulsapartners.org

Tim Lovell, Executive Director
Ann Patton
JoAnn Woody
Penni Chandler
Lilliana Crossley

James Lee Witt & Associates
1501 M Street NW
Washington, DC 20005
(504) 914-6648
www.wittassociates.com

Allesandra Jerrolleman

French & Associates, Ltd.
Planning Consultants
2601 Havelock Court
Steilacoom, WA 98388
(253) 302-5846
www.FrenchAsoc@aol.com

French Wetmore, CFM

Executive Summary

In the 1970's and early 1980s Tulsa was identified in a national study as one of the nation's most disaster-prone areas, having been declared a federal disaster area nine times in only fifteen years. Oklahoma's location at the intersection of the hot arid zone to the west, the temperate zone to the northeast, and the hot humid zone to the southeast makes it subject to a wide variety of potentially violent weather and natural hazards.

Citizen Advisory Committee meeting at Tulsa City Hall

This City of Tulsa Multi-Hazard Mitigation Plan 2009 Update of the original 2003 Mitigation Plan is a strategic planning guide developed in fulfillment of the Hazard Mitigation Grant Program requirements of the Federal Emergency Management Agency (FEMA), according to the *Stafford Disaster Relief and Emergency Assistance Act*. This plan Update is developed in accordance with, and fulfills requirements for, the Pre-Disaster Mitigation Grant (PDM) and Hazard Mitigation Grant (HMGP). It also fulfills requirements for the Flood Mitigation Assistance Program (FMA), Severe Repetitive Loss Program (SRL), and the Community Rating System Plan (CRS) from the Federal Emergency Management Agency (FEMA).

In December 2005, the Multihazard Mitigation Council of the National Institute of Building Sciences completed a study to assess future savings from mitigation activities. Their findings reflected the fact that mitigation activities in general produced over $4 in savings for every $1 invested in mitigation actions, with the greatest savings in the areas of flood-related events (5:1) and wind-related events (3.9:1). In addition, the report concludes, *"Mitigation is most effective when carried out on a comprehensive, community-wide, and long-term basis. Single …activities can help, but carrying out a slate of coordinated mitigation activities over time is the best way to ensure that communities will be physically, socially, and economically resilient to future hazard impacts."*

Approval of this plan will qualify the City of Tulsa to apply for PDM funds, as well as HMGP funds following a federal disaster declaration, as required under Section 322 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 2000.

Background

Virtually every area of the city is vulnerable to natural and man-made hazards. The Tulsa Hazard Mitigation Citizen Advisory Committee (THMCAC) has identified 12 hazards affecting the City of Tulsa, including floods, tornadoes, high winds, lightning, hailstorms, severe winter storms, extreme heat, drought, expansive soils, wildfires, earthquakes, and dam and levee failures.

Purpose

The purpose of this plan is to:

- Assess the progress on the previously identified mitigation measures;
- Assess the ongoing mitigation activities in the community;
- Identify and assess the hazards that pose a threat to citizens and property;
- Evaluate additional mitigation measures that should be undertaken;
- Outline a strategy for implementation of mitigation projects.

The objective of this plan is to provide guidance for community activities for the next five years. It will ensure that the city and other partners implement activities that are most effective and appropriate for mitigating natural hazards and hazardous materials incidents.

Hazard Mitigation Citizens Advisory Committee

Citizens and professionals active in disasters provided important input in the development of the plan and recommended goals and objectives, mitigation measures, and priorities for actions. The THMCAC is comprised of the members of the City of Tulsa Stormwater Drainage and Hazard Mitigation Advisory Board. Members are listed above.

The Planning Process

Planning for the City of Tulsa Multi-Hazard Mitigation Plan followed a ten-step process, based on guidance and requirements of FEMA for the PDM grant program, HMGP, the Flood Mitigation Assistance (FMA) program, and the Community Rating System (CRS).:

1. Organize to prepare the plan
2. Involve the public
3. Coordinate with other agencies and organizations
4. Assess the hazard
5. Assess the problem
6. Set goals
7. Review possible activities
8. Draft the action plan
9. Adopt the plan
10. Implement, evaluate, and revise

Plan Summary

The City of Tulsa Multi-Hazard Mitigation Plan provides guidance to help citizens protect life and property from natural hazards. The plan identifies the hazards that are most likely to strike each jurisdiction, provides a profile and risk assessment of each hazard, identifies mitigation measures for each hazard, and presents an action plan for the implementation of the mitigation measures.

Chapter 1- Introduction provides a profile of the City of Tulsa. This chapter includes a community description including demographics, lifelines, and critical facilities.

Chapter 2- Existing Mitigation Strategies provides an overview and discussion of existing resources and hazard mitigation programs.

Chapter 3- The Planning Process presents detailed information documenting the planning process including citizen and agency involvement, a table describing how and why each hazard was identified, and methodologies used in the plan for damage estimates and risk assessments.

Chapter 4- Natural and Man-Made Hazards provides an assessment of 12 natural hazards. Each assessment includes a hazard profile, catalogs historical events, identifies the vulnerable populations, and presents a conclusion.

Chapter 5- Mitigation Goals and Objectives sets disaster-specific goals and objectives and organizes proposed mitigation strategies under six mitigation categories: public information and education, preventive activities, structural projects, property protection, emergency services, and natural resource protection.

Chapter 6- Action Plan outlines an action plan for the implementation of high priority mitigation projects, including a description of the project, the responsible party, anticipated cost, funding sources, and timelines for implementation.

Chapter 7- Plan Adoption and Maintenance provides a discussion of the plan documentation of the adoption resolutions, and the Plan maintenance process. Plan maintenance includes monitoring, evaluating, and updating the plan with involvement of the public.

Appendix A- Glossary provides a glossary of terms commonly used in disaster management and hazard mitigation.

Appendix B- Mitigation Measures provides a more detailed discussion of possible Mitigation Measures outlined in Chapter 6, organized by category.

Appendix C- Mitigation Committee Meetings provides the agendas and sign-in sheets from the Citizens Advisory Committee and the Technical Advisory Committee meetings.

Appendix D: 2003 Mitigation Measures provides a report on the current status of all Mitigation Measures included in the 2003 plan – whether completed, in process, continuing in 2009 plan, or incomplete.

Appendix E- Plan Update Changes provides an overview of changes made in the plan update from the original City of Tulsa Hazard Mitigation Plan of 2003.

Appendix F- Capital Improvement Projects provides an overview of currently ongoing mitigation programs under the City of Tulsa Capital Improvements Plan.

Appendix G- Critical Facilities provides a more comprehensive list of all critical facilities within the City of Tulsa. The basic list is included in Chapter 1, Section 1.2.9.

Appendix H- Repetitive Loss Properties provides a complete list of all identified repetitive loss properties in the City under the National Flood Insurance Program guidelines.

Mitigation Measures

The following are the high priority mitigation measures defined by the Tulsa Hazard Mitigation Technical Advisory and Citizens Advisory Committees:

Mitigation Measure Description	***Hazards Addressed***
1. Incorporate an Emergency Telephone Notification System (ETNS) into the Tulsa Emergency Communications Center	Floods, Extreme, Heat, Wildfires, Winter Storms, Dam/Levee Failure
2. Construct a new Emergency Operations Center	Floods, Tornadoes, High Winds, Lightning, Hail, Winter Storms, Wildfires, Earthquakes, Dam/Levee Failure
3. Develop a Master Generator Plan for the City of Tulsa	Floods, Tornadoes, High Winds, Lightning, Winter Storms, Earthquakes, Dam/Levee Failure
4. Develop a SafeRoom plan for City of Tulsa facilities	Tornadoes, High Winds
5. Individual SafeRoom rebate program	Tornadoes, High Winds
6. Install Lightning Warning & Alert Systems in public recreation areas	Lightning
7. Public Education & Information Program Development	Floods, Tornadoes, High Winds, Lightning, Hail, Winter Storms, Extreme Heat, Drought, Expansive Soil, Wildfires, Earthquakes, Dam/Levee Failure
8. Develop a Special Needs registry through the 9-1-1 databases to assist with educating, alerting, evacuating, or responding to vulnerable populations during disaster	Floods, Tornadoes, High Winds, Hail, Winter Storms, Extreme Heat, Wildfires, Earthquakes, Dam/Levee Failure
9. Provide for back-up power sources for City water treatment plants to avoid water shortages during extended power outages	Floods, Tornadoes, High Winds, Lightning, Winter Storms, Earthquakes, Dam/Levee Failure
10. Provide backup power generators to five additional city fueling facilities	Winter Storms, High Winds, Tornadoes, Earthquakes
11. Implement structural and non-structural flood mitigation measures for flood-prone properties, as recommended in the basin-wide master drainage plans	Floods, Dam/Levee Failures
12. Develop enhanced Emergency Planning for Special Needs populations in the City of Tulsa Emergency Operations Plan and other planning documents	Floods, tornadoes, High Winds, Lightning, Hail, Winter Storms, Heat, Wildfires, Earthquakes, Dam/Levee Failure

Mitigation Measure Description	***Hazards Addressed***
13. Acquire and remove Repetitive Loss Properties and repeatedly flooded properties where the City's Repetitive Loss and master drainage plans identify acquisition to be the most cost effective and desirable mitigation measure	Floods, Dam/Levee failure
14. Develop a Comprehensive Levee evaluation and repair Plan	Floods, Dam/Levee failure
15. Develop a Levee Public Education and Evacuation Plan for at-risk areas of the community	Floods, Dam/Levee failure
16. Disaster Resistant Business Program	Floods, Tornadoes, High Winds, Lightning, Hail, Winter Storms, Extreme Heat, Wildfires, Earthquakes, Dam/Levee Failure
17. Consider establishing an administrative procedure or change in City codes for requiring builders to check for expansive soils when they apply for permits for new residential construction and for using foundations that mitigate expansive soil damages when in a moderate or high-risk area	Expansive Soils
18. Continue to update and revise basin-wide master drainage plans where changed conditions warrant	Floods, Dam/Levee Failure
19. Develop multi-lingual Disaster Education PSA's and educational videos	Floods, Tornadoes, High Winds, Lightning, Hail, Winter Storms, Extreme Heat, Drought, Expansive Soil, Wildfires, Earthquakes, Dam/Levee Failure
20. Develop a separate "public safety" information area in all public libraries and public recreation facilities to disseminate disaster safety information appropriate to the area and the season	Floods, Tornadoes, High Winds, Lightning, Winter Storms, Extreme Heat, Wildfires, Earthquakes, Dam/Levee Failures
21. Educate residents, building professionals and SafeRoom vendors on the ICC/NSSA "Standard for the Design and Construction of Storm Shelters" and consider incorporating into current regulatory measures	Tornadoes, High Winds
22. Train builders, developers, architects and engineers in techniques of disaster-resistant homebuilding	Floods, Tornadoes, High Winds, Lightning, Hail, Winter Storms, Extreme Heat, Drought, Expansive Soil, Wildfires, Earthquakes
23. Develop a comprehensive public education program on the dangers of carbon monoxide during extended power outages	Winter Storms, Tornadoes, High Winds

Mitigation Measure Description	*Hazards Addressed*
24. Develop a model SafeRoom project for a Mobile Home Park in Tulsa	Tornadoes, High Winds
25. Supplement the current Heat Coalition program to loan window air conditioners to an extremely medically vulnerable population during the summer months	Extreme Heat
26. Review the safety of Playground materials during extreme heat events	Extreme Heat
27. Implement a Firewise Community Education and Information Program	Wildfire
28. Provide stricter floodplain regulations along the Arkansas River corridor	Floods, Dam/Levee Failure
29. Consider establishing an administrative procedure or change in City codes for requiring builders to develop a drainage plan ensuring "no adverse impact" when they apply for permits for new residential construction	Floods, Dam/Levee Failure
30. Continue National Flood Insurance Program (NFIP) and Community Rating System (CRS) Participation	Floods, Dam/Levee Failure

Mitigation Action Plan

The mitigation action plan includes strategies for implementing the mitigation measures, including information on the responsible agency, time frame, cost estimate, funding sources, and a statement of the measurable results.

For further information, contact:

Bill Robison
Sr. Special Projects Engineer
2317 South Jackson, Room S-312
Tulsa, OK 74107
(918) 596-9475
brobison@cityoftulsa.org

Chapter 1: Introduction

1.1 About the Plan

This City of Tulsa Multi-Hazard Mitigation Plan 2009 Update is a strategic planning guide developed in fulfillment of the Pre-Disaster Mitigation Grant Program requirements of the Federal Emergency Management Agency (FEMA), according to the *Stafford Disaster Relief and Emergency Assistance Act*. This act provides federal assistance to state and local governments to alleviate suffering and damage from disasters. It broadens existing relief programs to encourage disaster preparedness plans and programs, coordination and responsiveness, insurance coverage, and hazard mitigation measures.

This plan Update is developed in accordance with, and fulfills requirements for, the Pre-Disaster Mitigation Grant (PDM) and Hazard Mitigation Grant (HMGP). It also fulfills requirements for the Flood Mitigation Assistance Program (FMA), Severe Repetitive Loss Program (SRL), and the Community Rating System Plan (CRS) from the Federal Emergency Management Agency (FEMA). While this plan addresses 12 natural hazards, the City of Tulsa completed a separate Phase II Hazard Mitigation Plan that addressed technological and man-made hazards, such as water quality emergencies, power failures, civil unrest and terrorism issues.

Included in this Chapter:

1.1 About the Plan
- 1.1.1 Purpose
- 1.1.2 Scope
- 1.1.3 Authority
- 1.1.4 Funding
- 1.1.5 Goals
- 1.1.6 Definition of Terms
- 1.1.7 Points of Contact

1.2 Community Information
- 1.2.1 Governance
- 1.2.2 Geography
- 1.2.3 Climate
- 1.2.4 History
- 1.2.5 Demographics
- 1.2.6 Lifelines
- 1.2.7 Economy
- 1.2.8 Development
- 1.2.9 Critical Facilities

1.1.1 Purpose

The purpose of this plan is to:

- Provide a description of the planning area (Chapter 1).
- Assess the ongoing mitigation activities in the City of Tulsa (Chapter 2).
- Describe the planning process used to develop the mitigation plan (Chapter 3).
- Identify and assess the hazards that pose a threat to citizens, businesses and property (Chapter 4).
- Establish Goals and Objectives for community mitigation measures (Chapter 5)
- Evaluate Mitigation Measures that should be undertaken to protect citizens, businesses and property (Appendix B).
- Identify and recommend an Action Plan for implementation of mitigation projects (Chapter 6).
- Develop a strategy for the adoption, maintenance, upkeep, and revision of the City of *Tulsa Multi-Hazard Mitigation Plan* (Chapter 7).

In December 2005, the Multihazard Mitigation Council of the National Institute of Building Sciences completed a study to assess future savings from mitigation activities. Their findings reflect the fact that mitigation activities in general produced over $4 in savings for every $1 invested in mitigation actions, with the greatest savings in the areas of flood-related events (5:1) and wind-related events (3.9:1). In addition, the report concludes, *"Mitigation is most effective when carried out on a comprehensive, community-wide, and long-term basis. Single activities can help, but carrying out a slate of coordinated mitigation activities over time is the best way to ensure that communities will be physically, socially, and economically resilient to future hazard impacts."*

The objective of this plan is to provide guidance for mitigation activities for the next five years. It will ensure that the City of Tulsa implements hazard mitigation activities that are most effective and appropriate for the natural hazards that threaten the community.

1.1.2 Scope

The scope of the *City of Tulsa Multi-Hazard Mitigation Plan* is citywide. It addresses 12 natural hazards deemed a threat to the citizens of Tulsa. Both short-term and long-term hazard mitigation opportunities are addressed beyond existing federal, state, and local funding programs.

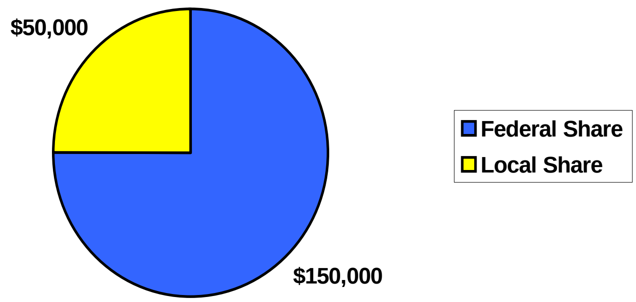
1.1.3 Authority

Section 322 of the Robert T. Stafford Disaster Assistance and Emergency Relief Act, 42 USC 5165, enacted under Section 104 the Disaster Mitigation Act of 2000, P.L. 106-390, provides new and revitalized approaches to mitigation planning. A major requirement of the law is the development of a local hazard mitigation plan. Section 322, in concert with other sections of the Act, provides a significant opportunity to reduce the Nation's disaster losses through mitigation planning.

1.1.4 Funding

Funding for the *City of Tulsa Multi-Hazard Mitigation Plan Update* was provided by a $150,000 Pre-Disaster Mitigation grant from the Federal Emergency Management Agency (FEMA) and the Oklahoma Department of Emergency Management (OEM), with a $50,000 local match. Of the $150,000, $65,000 is dedicated to adding a Historic Property and Cultural Resource Annex, under the guidelines of FEMA document 386-6, published May 2005.

City of Tulsa Multi-Hazard Mitigation Plan Funding



Total Funding: $200,000

1.1.5 Goals

The Tulsa Technical Advisory Committee (TTAC) and the Tulsa Citizens' Advisory Committee, the Storm Drainage and Hazard Mitigation Advisory Board (SDHMAB) developed the goals for the *City of Tulsa Multi-Hazard Mitigation Plan*, with input from interested citizens. The local goals were developed taking into account the hazard mitigation strategies and goals of the federal and state governments.

National Mitigation Strategy and Goal

FEMA has developed ten fundamental principles for the nation's mitigation strategy:

1. Risk reduction measures ensure long-term economic success for the community as a whole rather than short-term benefits for special interests.
2. Risk reduction measures for one natural hazard must be compatible with risk reduction measures for other natural hazards.
3. Risk reduction measures must be evaluated to achieve the best mix for a given location.
4. Risk reduction measures for natural hazards must be compatible with risk reduction measures for technological hazards and vice versa.
5. All mitigation is local.
6. Emphasizing proactive mitigation before emergency response can reduce disaster costs and the impacts of natural hazards. Both pre-disaster (preventive) and post-disaster (corrective) mitigation is needed.
7. Hazard identification and risk assessment are the cornerstones of mitigation.

8. Building new federal-state-local partnerships and public-private partnerships is the most effective means of implementing measures to reduce the impacts of natural hazards.
9. Those who knowingly choose to assume greater risk must accept responsibility for that choice.
10. Risk reduction measures for natural hazards must be compatible with the protection of natural and cultural resources.

FEMA's goal is to:

1. Substantially increase public awareness of natural hazard risk so that the public demands safer communities in which to live and work
2. Significantly reduce the risk of loss of life, injuries, economic costs, and destruction of natural and cultural resources that result from natural hazards.

State of Oklahoma Mitigation Strategy and Goals

The State of Oklahoma has developed an Enhanced Natural Hazards Mitigation Plan (updated 2008) to guide all levels of government, business, and the public to reduce or eliminate the effects of natural disasters. The primary goals of the plan are to:

- Protect public health and safety
- Eliminate losses from severe repetitive loss properties
- Eliminate losses from repetitive loss properties
- Improve government recovery capability
- Provide **pre** and **post**-disaster recovery guidance
- Reduce losses/damage to property and infrastructure
- Preserve natural and historic resources in vulnerable areas
- Preserve the environment
- Focus on those mitigation measures that are cost effective and provide the best benefit to communities.

The key measures to implement these goals include:

- Enhance communication between tribal, state, federal agencies and local governments to facilitate post-disaster recovery and pre/post-disaster mitigation;
- Coordinate federal, state, local, and private resources to enhance the preparedness and mitigation processes;
- Ensure consistency between federal and state regulations;
- Provide protection from hazards for critical facilities;
- Support legislation that protects hazardous areas from being developed.

Another important goal of the Oklahoma State Mitigation plan is to expand the focus of mitigation measures to include the major hazard threats to Oklahoma such as floods, tornado, severe weather, earthquakes, winter storms and wildfires.

Tulsa's Goal

To improve the safety and well-being of the citizens residing and working in the City of Tulsa by reducing the potential of deaths, injuries, property damage, environmental and other losses from natural hazards, and to do this in a manner that creates a disaster-resistant community, enhances economic development opportunities, and advances community goals and quality of life resulting in a more livable, viable, and sustainable community.

Goals for the mitigation of each of the hazards are presented in Chapter 5.

1.1.6 Definition of Terms

Hazard Mitigation is defined as: Sustained actions taken to reduce or eliminate long-term risk to human life and property from natural, man-made, and technological hazards and their effects. Note that this emphasis on "long-term" risk distinguishes mitigation from actions geared primarily to emergency preparedness and short-term recovery.

A glossary of additional terms commonly used in hazard mitigation is included in Appendix A.

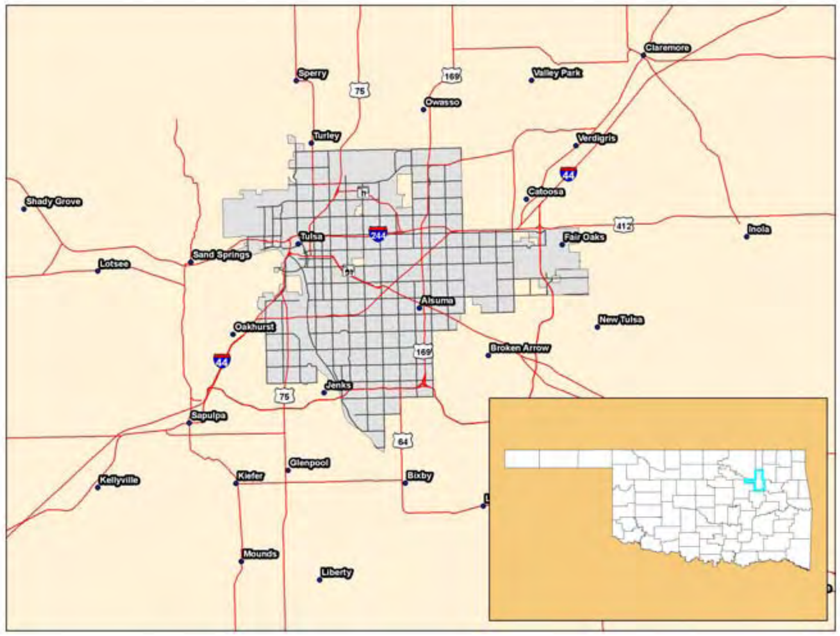
1.1.7 Points of Contact

The primary points of contact for information regarding this plan are:

Paul Zachary, P.E., CFM
Deputy Director of Engineering Services
City of Tulsa, Dept. of Public Works
2317 S. Jackson Ave, Room 200
Tulsa, OK 74107
(918) 596-9565
(918) 596-7277 Fax
pzachary@cityoftulsa.org

William Robison, P.E., CFM
Senior Projects Engineer
City of Tulsa, Dept. of Public Works
2317 S. Jackson Ave, Room S312
Tulsa, OK 74107
(918) 596-9475
(918) 596-9708 Fax
brobison@cityoftulsa.org

1.2 Community Description



The City of Tulsa is faced with a variety of natural hazards. While winter storms, dam releases, lightning, floods, and tornadoes have made national headlines in recent years, any part of a city can be impacted by these as well as high winds, drought, hail, fire, and other threats. In some cases, such as flooding and dam failure, the areas most at risk have been delineated and mapped. A basemap of the City of Tulsa, with its major features and highways, is shown in Figure 1–1.

The City of Tulsa is primarily located in Tulsa County, in Northeast Oklahoma, 99 miles northeast of Oklahoma City, at the intersection of Interstate 44 and the Arkansas River. Tulsa had a 2000 Census population of 393,049 and a 2006 population estimate of 382,872.

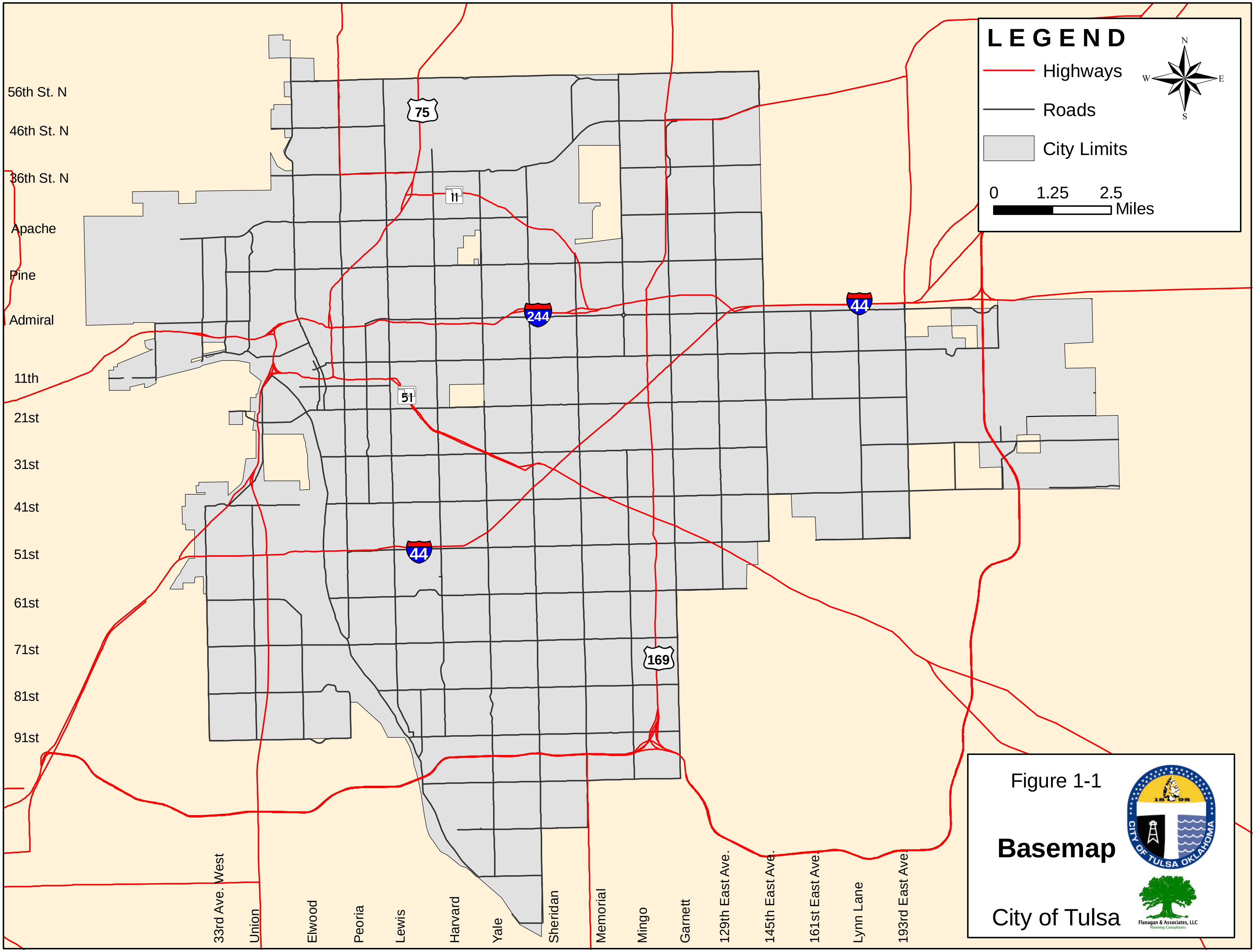
1.2.1 Governance

The City of Tulsa was established as a town in 1898 under territorial law while Oklahoma was designated as Indian Territory. After Oklahoma became the 46th state in 1907, the City of Tulsa adopted its first city charter on July 3, 1908.

The City was governed by a Board of Commissioners comprised of a Mayor and four Commissioners - Police & Fire, Streets & Public Property, Waterworks & Sewerage, and Finance & Revenue. This form of government prevailed until May 8, 1990, when it changed to a Mayor and City Council form.

All legislative powers of the City of Tulsa, except for the rights of initiative and referendum reserved to the people of the City of Tulsa by the Constitution of Oklahoma, are exercised by a Council composed of nine Councilors elected by districts.

The executive and administrative powers of the City of Tulsa and any executive and administrative powers conferred on the city by the Constitution or the laws of Oklahoma are exercised by the Mayor.



LEGEND
Highways
Roads
City Limits
0
1.25
2.5
Miles
N
S
E
W
56th St. N
46th St. N
36th St. N
Apache
Pine
Admiral
11th
21st
31st
41st
51st
61st
71st
81st
91st
33rd Ave. West
Union
Elwood
Peoria
Lewis
Harvard
Yale
Sheridan
Memorial
Mingo
Garnett
129th East Ave.
145th East Ave.
161st East Ave.
Lynn Lane
193rd East Ave.
75
11
51
244
44
169
Figure 1-1
Basemap
City of Tulsa
1898
CITY OF TULSA OKLAHOMA
Flanagan & Associates, LLC
Planning Consultants

1.2.2 Geography

Latitude: 36.15 N **Longitude:** 95.98 W **FIPS Code:** 040-75000

Tulsa is situated between the edge of the Great Plains and the foot of the Ozark Mountains in a generally forested region of rolling hills. The city touches the eastern extent of the Cross Timbers, an ecoregion of forest and prairie transitioning from the drier plains of the west to the wetter forests of the east. With a wetter climate than points westward, Tulsa serves as a gateway to "Green Country", a designation for northeast Oklahoma that stems from the region's green vegetation and relatively high amount of hills and lakes compared to central and western areas of Oklahoma, which lie largely in the drier Great Plains region of the Central United States. Northeastern Oklahoma is the most topographically diverse part of the state, containing seven of Oklahoma's 11 ecoregions and more than half of its state parks. The region encompasses 30 lakes or reservoirs and borders the neighboring states of Kansas, Missouri, and Arkansas.

The city is split by the prominent Arkansas River, which flows in a wide, sandy-bottomed channel. Its flow through the area is controlled by upstream flood control reservoirs, but its width and depth can vary widely throughout the year. However, a low-water dam maintains a full channel at all times in the area adjacent to downtown Tulsa. Heavily wooded and with abundant parks and water areas, the city holds several prominent hills, especially in its southern portions. While its central and northern sections are generally flat to gently undulating, the Osage Hills extension into the northwestern part of the city further varies the landscape. Holmes Peak in the northwest corner of the city is the tallest point in five counties at 1030 ft.

1.2.3 Climate

Lightning over downtown Tulsa is common in the spring months

Tulsa is situated near the heart of Tornado Alley and has a temperate climate with a yearly average temperature of 61°F and an average rainfall of 39 inches. Weather patterns vary by season with occasional extremes in temperature and rainfall.

Primarily in the spring and early summer months, the city is vulnerable to severe thunderstorms containing large hail, damaging winds, or small tornadoes, providing the area with a disproportionate share of its annual rainfall. Severe weather is not limited, though, to this season. On December 5, 1975, Tulsa experienced a tornado. Due to its potential for major flooding events, the city has developed one of the most extensive flood control systems in the nation. A comprehensive flood management plan was developed in 1984 following a severe flood caused by a stalled weather front that dropped 15 inches of rain overnight, killing 14, injuring 288, and destroying 7,000 buildings totaling $180 million in damage. In the early 1990s and again in 2000, FEMA honored Tulsa as leading the nation in floodplain management.

Temperatures of 100° F or higher are often observed from July to early September, usually accompanied by high humidity brought in by southerly winds. Lack of air circulation due to heat and humidity during the summer months leads to higher concentrations of ozone, prompting the city to release “Ozone Alerts,” encouraging all parties to do their part in complying with the Clean Air Act and E.P.A. standards. The autumn season is usually short, consisting of pleasant, sunny days followed by cool nights. Winter temperatures, while generally mild, occasionally experience extremes below 0° while annual snowfall averages about 9 inches.

Table 1–1: Weather averages for Tulsa, Oklahoma

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Avg hi °F	46	52	61	72	79	88	93	93	84	74	60	50	71
Avg low °F	26	30	39	50	59	68	72	70	62	51	38	30	50
Precip (inches)	1.5	1.9	3.1	3.8	5.7	4.5	3.4	2.9	4.2)	3.4	2.6	2.0	39.2

Source: Weatherbase April 2007

1.2.4 History

The city now known as Tulsa was first settled by the Lockapoka Creek Indians between 1828 and 1836. Driven from their native Alabama by the forced removal of Indians from southeastern states, the Lockapokas established a new home at a site near Cheyenne and 18th Street. Under a large oak tree, they rekindled their ceremonial fire. This site was abandoned and destroyed during the Civil War, but afterwards the Lockapoka Creeks returned to their home along the Arkansas and relit the council fire.

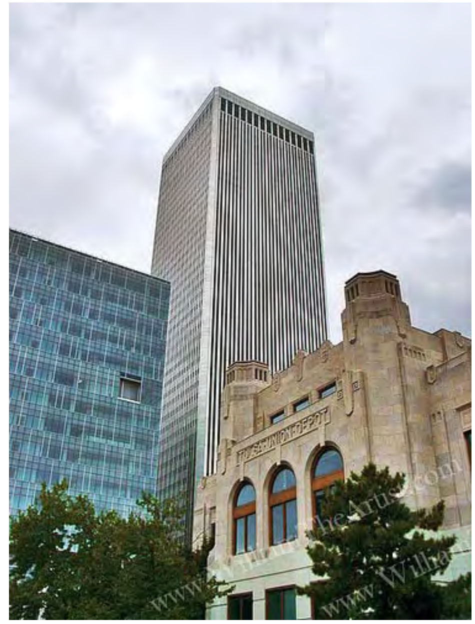
In 1848, Lewis Perryman, a prominent Creek rancher, opened a cattle ranch and the first trading post near the Lockapoka settlement. His son George built a large white ranch house here, and in March 1878, a mail station was established at the Perryman store. The community served by the station was officially designated as "Tulsa."

The big oil strike at Glenpool in 1905, just 15 miles south of Tulsa, made Oklahoma and Indian Territory the center of oil speculation and exploration. At the time of statehood in 1907, Tulsa’s population was 7,298.

By 1920, Tulsa had grown to a city of 72,000, primarily due to oil discoveries. During the 1930s and 1940s, the U.S. Army Corps of Engineers built levees along the Arkansas River, primarily to protect the critical oil refineries during the Second World War. During the war, Tulsa grew in importance as an aviation center, with the Spartan School of Aeronautics and the mile-long Douglas Aircraft plant, which produced bombers. Years later, McDonnell-Douglas and Rockwell International would contribute to the nation’s space program and national defense.

The 1950s and 60s saw Tulsa’s growth to the south and east, and into the watersheds of Mingo and Joe Creeks. Flooding on the inland creeks and along the Arkansas River became increasing problems as the town continued to expand. The Corps of Engineers completed the Keystone Dam, on the Arkansas River, in 1964. A more detailed discussion of Tulsa’s flood history is presented in Chapter 3.

Tulsa enjoyed a period of economic prosperity during the 1970s and early 80s, but with the oil bust of the mid 1980s, Tulsa's economy took a downturn. City leaders searched for opportunities to diversify and to continue to improve the quality of life in one of America's most livable cities. In the year 2000, the focus of community leaders turned to inner-city redevelopment, sustainable growth, and safety from natural hazards. Additional information is in Section 1.2.6 – Economics.



The Oklahoma Jazz Hall of Fame (formerly the Union Train Depot) coexists in the shadow of modern downtown buildings

Cultural and Historical Properties

Located in the former estate of oil pioneer Waite Phillips, Philbrook Museum is considered one of the top 50 fine art museums in the United States, and is one of five to offer a combination of historic home, gardens, and art collections. The collections of Thomas Gilcrease are housed at the Gilcrease Museum, which also holds the world's largest, most comprehensive collection of art and artifacts of the American West. The Sherwin Miller Museum of Jewish Art preserves the largest collection of Judaica in the Southwest United States.

Other museums, such as the Tulsa Air and Space Museum, the Oklahoma Jazz Hall of Fame, and the Tulsa Geosciences Center, document histories of the region, while the Greenwood Cultural Center preserves the culture of the city's African American heritage. The Cultural Center houses a collection of artifacts and photography that document the history of the Greenwood area (known as The Black Wall Street) prior to the Tulsa Race Riot of 1921.

In addition, Cain's Ballroom, considered the birthplace of Western Swing, housed the performance headquarters of Bob Wills and the Texas Playboys during the 1930s. The centerpiece of the downtown Brady Arts District, the Brady Theater, is the largest of the city's five operating performing arts venues listed on the National Register of Historic Places.

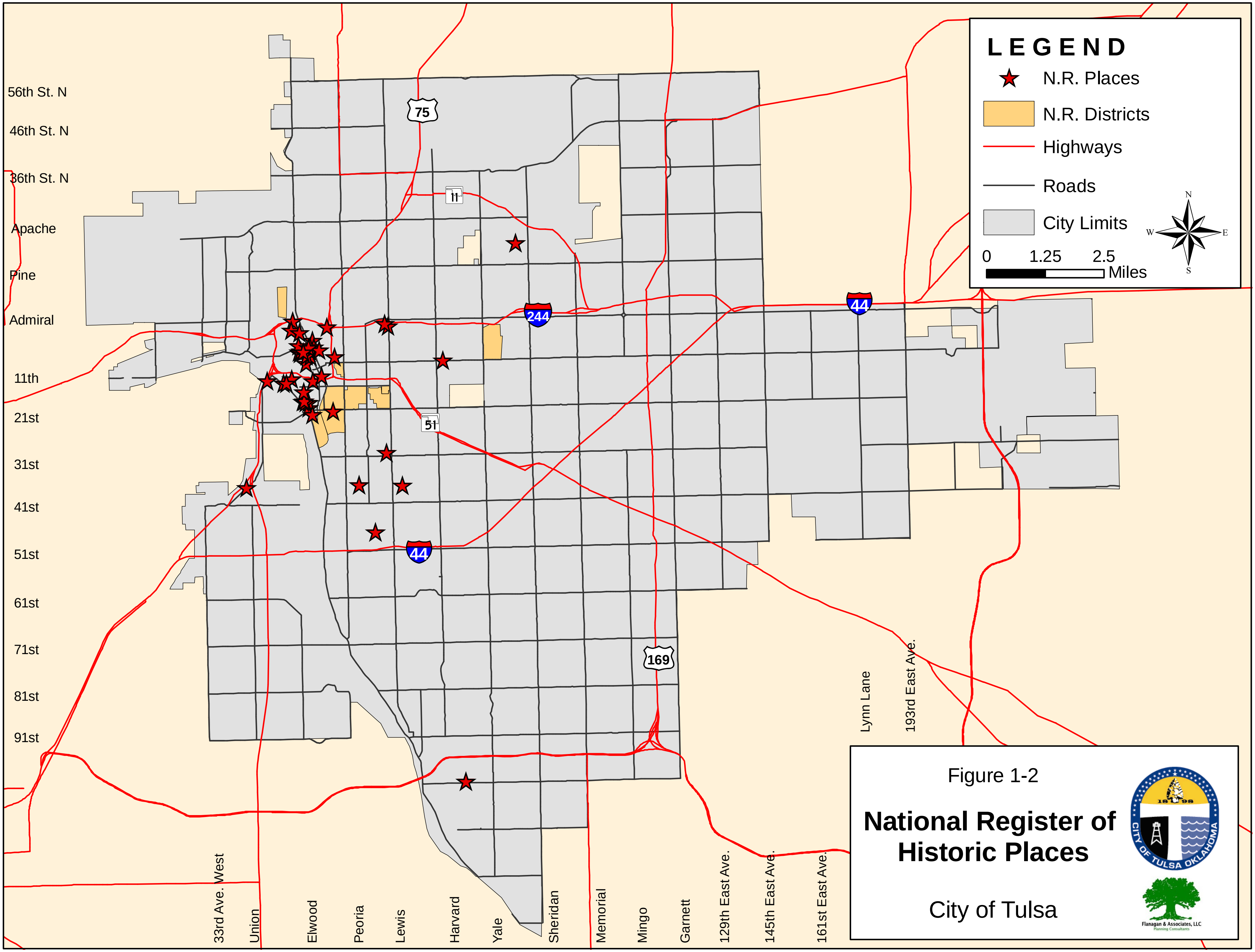
The Tulsa Zoo and Living Museum doubles as a museum that documents the cultures and history of various climates in North America.

Tulsa has 53 buildings on the National Register of Historic Places as of May, 2008 listed in Table 1-2, and shown in Figure 1-2.

Table 1–2: National Register of Historic Places - Tulsa, Oklahoma

	Name	Address
1	66 Motel	3660 Southwest Blvd.
2	Ambassador Hotel	1314 S. Main
3	Boston Ave Methodist Episcopal Church	1301 South Boston
4	Boulder-on-the-Park	1850 S. Boulder Ave.
5	Brady Heights Historic Dist	Bounded by Marshall and Easton, Denver & Cheyenne
6	Cain's Dancing Academy	423 N. Main

	Name	Address
7	Circle Theater	10 S. Lewis
8	Clinton-Hardy House	1322 S. Guthrie
9	Convention Hall	105 W. Brady
10	48 Building	409 S. Boston
11	Creek Council Tree Site	18th and Cheyenne
12	Dawson School	Jct. of East Ute Pl & N. Kingston Pl.
13	Carl K. Dresser House	235 W. 18th St.
14	Eleventh Street Arkansas River Bridge	US 66 over Arkansas R., from Tulsa to W. Tulsa
15	Gillette Historic District	Bounded by S. Yorktown & S. Lewis, E. 15th & E. 17th
16	Gillette-Tyrell Building	423 S. Boulder
17	Harwelden	2210 S. Main
18	Holy Family Cathedral, Rectory, & School	W. 8th and S. Boulder
19	Hooper Brothers Coffee Company Bldg	731--733 E. Admiral
20	Robert Lawton Jones House	1916 E. 47th
21	Maple Ridge Historic Residential Dist	Roughly bounded by Hazel, S. Peoria, 14th, & Railroad
22	Mayo Hotel	115 W. 5th
23	James McBirney House	1414 S. Galveston
24	McFarlin Building	11 E. 5th
25	Robert M. McFarlin House	1610 Carson
26	Mincks-Adams Hotel	403 S. Cheyenne
27	Moore Manor	228 W. 17th Pl.
28	Oklahoma Natural Gas Company Building	624 S. Boston
29	Foster B. Parriott House	2216 E. 30th
30	Petroleum Building	420 S. Boulder
31	Philcade Building	511 S. Boston
32	Phillips 66 Station #473	2224 E. Admiral
33	Waite Phillips Mansion	2727 S. Rockford
34	Philtower	427 S. Boston
35	Pierce Block	301 E. 3rd
36	Public Service of Oklahoma Building	600 S. Main
37	Riverside Historic Residential District	Roughly bounded by Midland Rail Bike Trail, Riverside, S. Boston, E. 24th & E 21st
38	Riverside Studio	1381 Riverside
39	Sinclair Service Station	3501 E. 11th
40	William G. Skelly House	2101 S. Madison
41	Southwestern Bell Main Dial Building	424 Detroit
42	St. John Vianney Training School for Girls	4001 E. 101st
43	Swan Lake Historic District	Roughly bounded by E. 15th, S. Utica, E. 21st & S. Peoria
44	Tracy Park Historic District	Roughly bounded by Norfolk, Peoria, 11th & 13th Sts.
45	Tribune Building	20 E. Archer
46	Tulsa Fire Alarm Building	1010 E 8th
47	Tulsa Municipal Building	124 E. 4th
48	United States Post Office & Courthouse	224 S. Boulder
49	James Alexander Veasey House	1802 S. Cheyenne
50	Vickery Phillips 66 Station	602 S. Elgin
51	Westhope	3704 S. Birmingham
52	White City Historic District	Roughly bounded by E. 2nd, S. Fulton /Frisco RR Tracks, E. 11th, & S. Yale
53	Yorktown Historic District	Bounded by 16th & 17th, Victor & Wheeling, 20th, & Lewis



LEGEND
N.R. Places
N.R. Districts
Highways
Roads
City Limits
0 1.25 2.5 Miles
N
S
E
W
56th St. N
46th St. N
36th St. N
Apache
Pine
Admiral
11th
21st
31st
41st
51st
61st
71st
81st
91st
33rd Ave. West
Union
Elwood
Peoria
Lewis
Harvard
Yale
Sheridan
Memorial
Mingo
Garnett
129th East Ave.
145th East Ave.
161st East Ave.
Lynn Lane
193rd East Ave.
75
11
244
44
51
169
Figure 1-2
National Register of Historic Places
City of Tulsa
CITY OF TULSA OKLAHOMA
18 98
Flanagan & Associates, LLC

1.2.5 Demographics

Demography is the use of population characteristics (age and income distribution and trends, mobility, educational attainment, home ownership and employment status, for instance) for purposes of social studies.

As was clearly demonstrated in Hurricane Katrina in 2005, the vulnerability of a segment of the community to disasters will often vary according to demographic factors such as income level, age, race, language, education, disability and home ownership. For example, individuals and families in low-income areas often have less extensive safety nets (transportation, savings, credit, food supplies, extended family networks) than those in high-income districts. Similarly, aging populations are more vulnerable to extreme heat and cold and often have fewer financial resources for purchasing supplies. Knowing the size and geographical location of potential at risk populations (such as small children, the elderly and the impoverished) are important to assessing the community's vulnerability.

Tulsa has a 2000 Census population of 393,049 and a 2006 population estimate of 382,872, which accounted, in 2000, for 48.6 percent of the population in the Tulsa Metropolitan Statistical Area (MSA). Over the last 8 years, the population of Tulsa has actually been declining for the first time since the Great Depression in the 1930s. For an overall view of the City of Tulsa population history since 1882, see Figure 1-3. All other things being equal, this decline is anticipated to continue for the next few years. A great deal of this is due to population movement to Tulsa suburbs. During the 1990's, the growth rate for Tulsa County was twice that of the City of Tulsa and the movement to the communities of Bixby, Broken Arrow, Jenks, and other suburbs is continuing to the present day. One factor to consider is that while residential living is moving to the suburbs, many of these suburban residents continue to work in the City of Tulsa. For additional information on growth of nearby communities, see Figure 1-4 and Table 1-3. (*Source: Community Service Council Census Information Center*.)

Figure 1–3: City of Tulsa Population History, 1882 - 2010

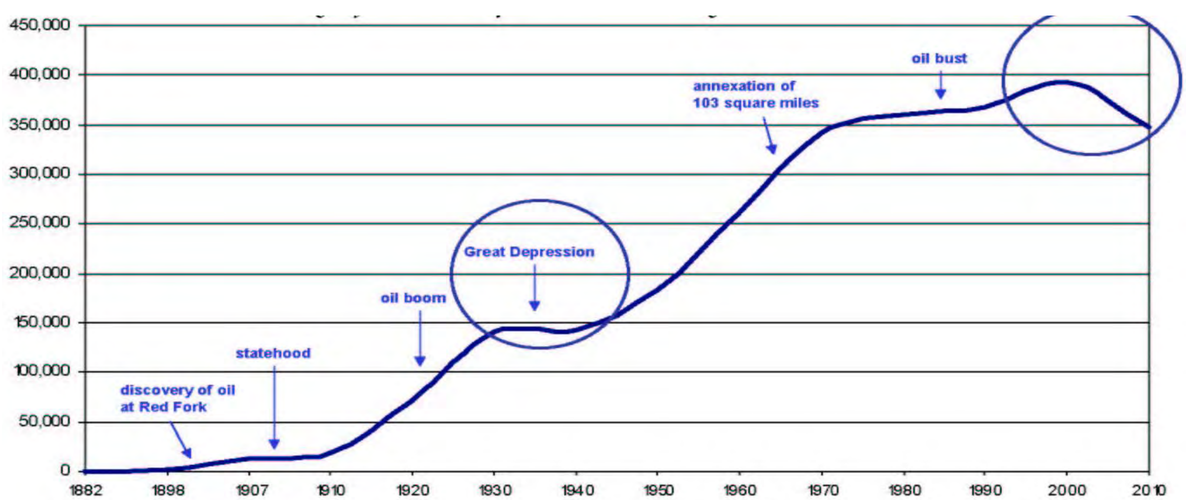


Figure 1–4: Population of Selected Cities in Tulsa County

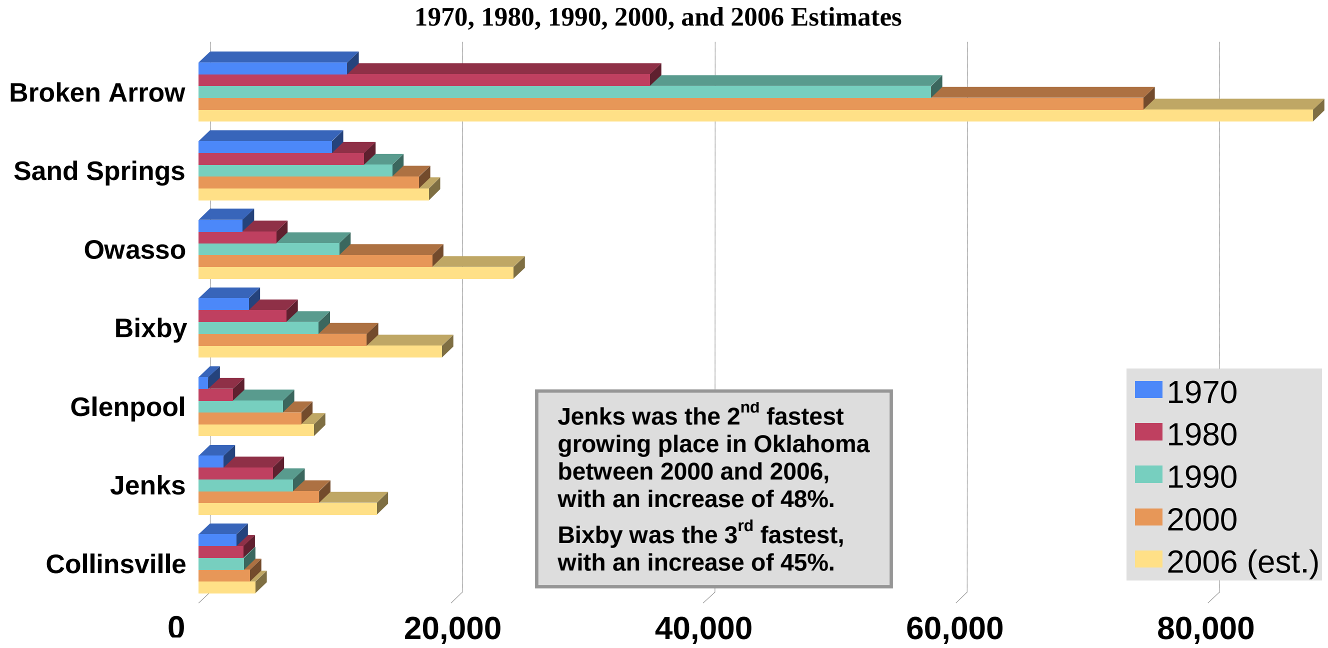


Table 1–3: Select Cities in Tulsa County Population Data

Source:* *US Census Bureau, 1970, 1980, 1990 & 2000 Censuses; Population Estimates Program, 2006.

Prepared by the Community Service Council of Greater Tulsa

	Broken Arrow	Sand Springs	Owasso	Bixby	Glenpool	Jenks	Collinsville
1970	11,787	10,565	3,491	3,973	770	1,997	3,009
1980	35,761	13,121	6,149	6,969	2,706	5,876	3,556
1990	58,043	15,346	11,151	9,502	6,688	7,493	3,612
2000	74,859	17,451	18,502	13,336	8,123	9,557	4,077
2006 (est.)	88,310	18,250	24,940	19,290	9,140	14,120	

The density of Tulsa in 2000 was 2,000 people per square mile, compared with the population density of Tulsa County at 882.6 persons per square mile. The population center is 36th Street South and Pittsburg Ave, while the geographic center is 26th and Memorial, 2½ miles to the east-northeast.

Of Tulsa's population, 23.3% are under 18 years of age (2006 estimated) and 13.0% are over 65. About 65.8 percent of Tulsa's population is in the labor force (16 years of age and older). A map depicting the percentage of population aged 65 and above by Census block is shown in Figure 1-5; and a map depicting the percentage of population below poverty level by Census block is shown in Figure 1-6. Tulsa's demographic data is summarized in Table 1-4.

Tulsans, on the average, are better educated than other Americans. Over 28 percent of Tulsans above the age of 25 have a bachelor's degree or better. Nine percent of the city's population over the age of 25 has a graduate or professional degree, which is higher than the national average.

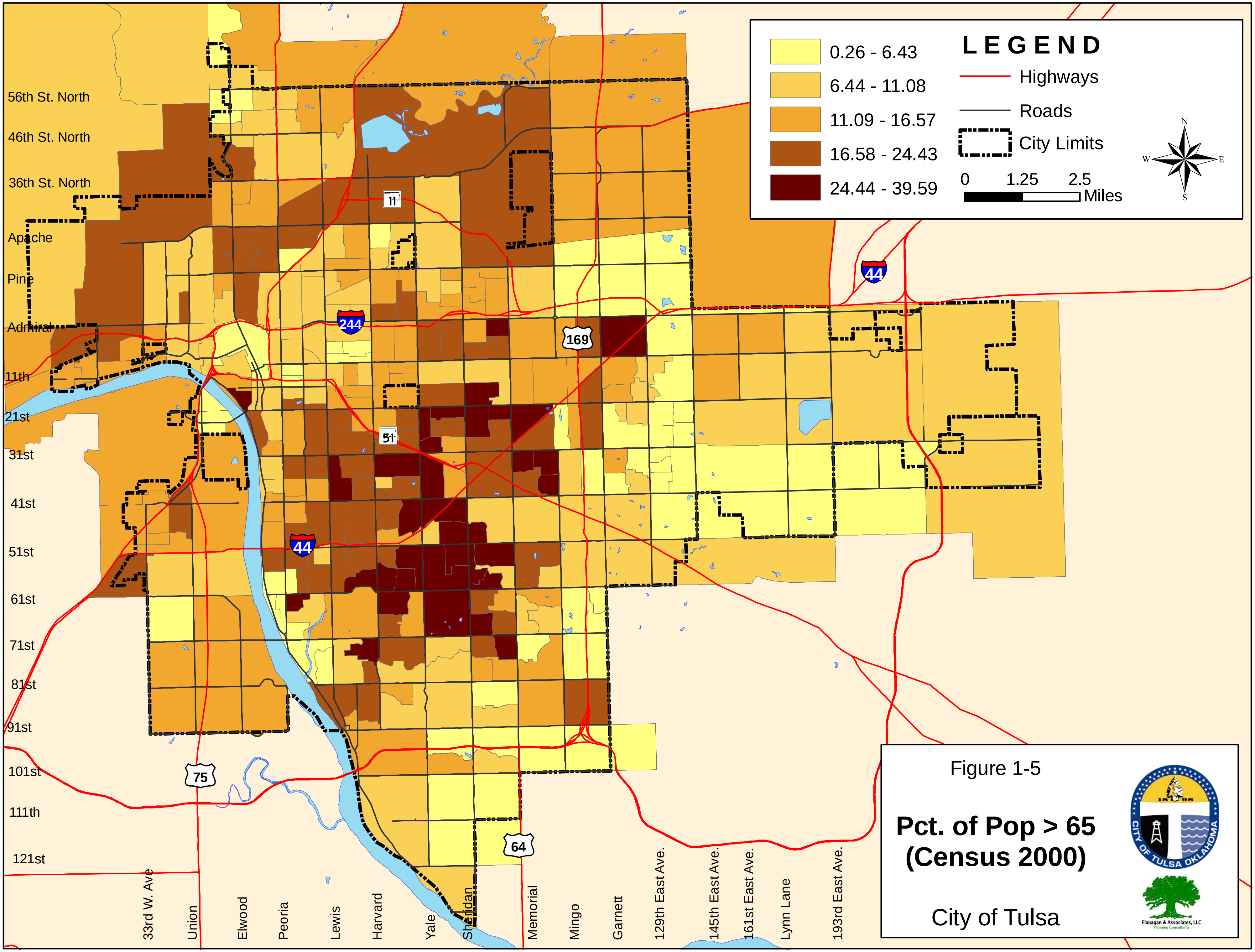


Figure 1-5

Pct. of Pop > 65 (Census 2000)

City of Tulsa

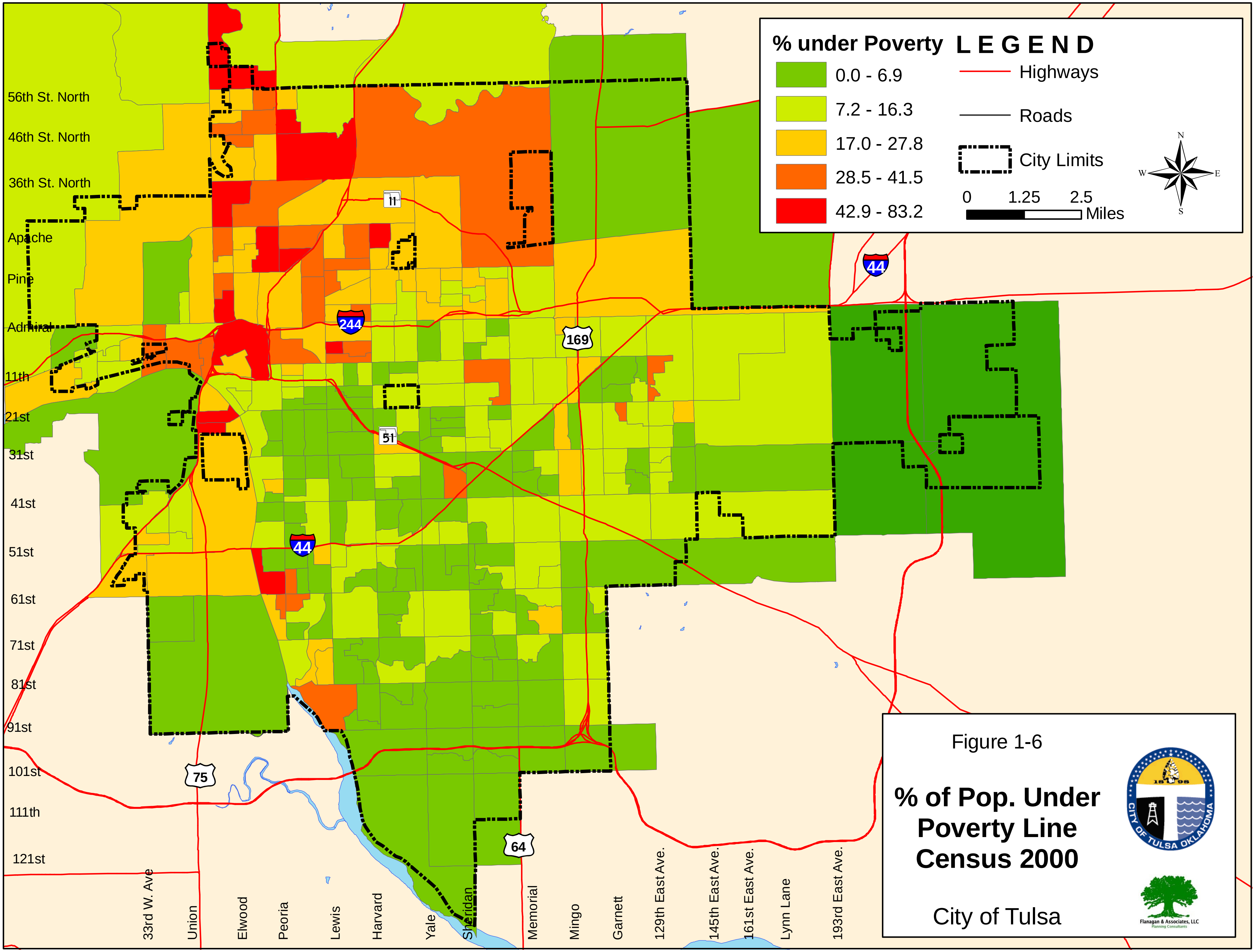


Figure 1-6

% of Pop. Under Poverty Line Census 2000

City of Tulsa

Table 1–4: City of Tulsa Population Data
Source: 2000 Census and 2006 Population Estimates

Subject	Number (2000)	City % (2000)	State % (2000)	Estimate (2006)	City % (2006)	State % (2006)
Total Population	393,049	100	11.4	382,872 ↓	100	10.7 ↓
Under 5 years old	28,318	7.2	6.8	30,175 ↑	7.9 ↑	7.0 ↑
Between 5-18 years old	69,022	17.6	19.1	62,732 ↓	16.4 ↓	18.0 ↓
65 years and older	50,508	12.9	13.2	49,765 ↓	13.0 ↑	13.3 ↑
White	275,488	70.1	76.2	260,855 ↓	68.3 ↓	75.4 ↓
African-American	60,794	15.5	7.6	64,700 ↑	16.9 ↑	7.4 ↓
Native American	18,551	4.7	7.9	14,051 ↓	3.7 ↓	6.8 ↓
Hispanic	28,111	7.2	5.2	42,763 ↑	11.2 ↑	6.8 ↑
Language other than English spoken at home (5 years and over)	36,209	9.9	7.4	41,563 ↑	11.8 ↑	8.3 ↑
Poverty Status in 1999 * (Families)	10,840	14.8	11.2	--	16.8 ↑	12.8 ↑
Poverty Status in 1999 * (Individuals)	54,121	20.2	14.7	--	20.3 ↑	17.0 ↑

* The Census Bureau uses a set of money income thresholds that vary by family size and composition to determine who is in poverty. For more information on the thresholds and what qualifies as eligible vs. non-eligible income, go to www.census.gov/hhes/www/poverty/povdef.html.

1.2.5.1 Vulnerable Populations

In any community, there are residents who may have greater vulnerability to the effects of disasters than does the general population. These groups may have little or nothing in common, and their needs may be very different. There is no "one size fits all" solution for handling populations with greater vulnerability. Some may need special consideration in warning, communication or evacuation, some may have special sheltering needs, whether medical or non-medical, and some may require other considerations in emergency planning and mitigation. Almost all have the ability to participate in a meaningful and active way in the planning, response, and mitigation activities of the community.

> *"The term "special needs" is widely used within the emergency management world. It generally refers to an extremely broad and heterogeneous population, including people with disabilities, minority groups, people who do not speak English, children and the elderly. Given this lack of specificity, it is conceivable that "special needs" could cover over 50 percent of the nation's population, rendering the term meaningless. These groups represent a large and complex variety of concerns and challenges. Many of these groups have little in common beyond the fact that they are often left out of emergency planning."* (June Isaacson Kailes, Disability Policy Consultant. From the International Association of Emergency Managers Bulletin, Vol. 22, No. 4, April 2005.)

These vulnerable populations may include:

- The elderly;
- People in poverty;
- People who speak a language other than English;
- People with mobility, hearing, visual or other physical disabilities;
- People with developmental or other cognitive disabilities;
- People with no access to private transportation;
- People with medical needs or medical/life support devices;
- People with pets.

The following maps identify some of these more vulnerable populations for the purposes of planning and to help ensure that these groups are meaningfully included in the planning process. The maps are from 2000 U.S. Census Bureau data, and include:

- Figure 1-7: Asian population
- Figure 1-8: Hispanic population
- Figure 1-9: People with disabilities (as defined by the U.S. Census Report)
- Figure 1-10: Comprehensive map of Vulnerable Populations

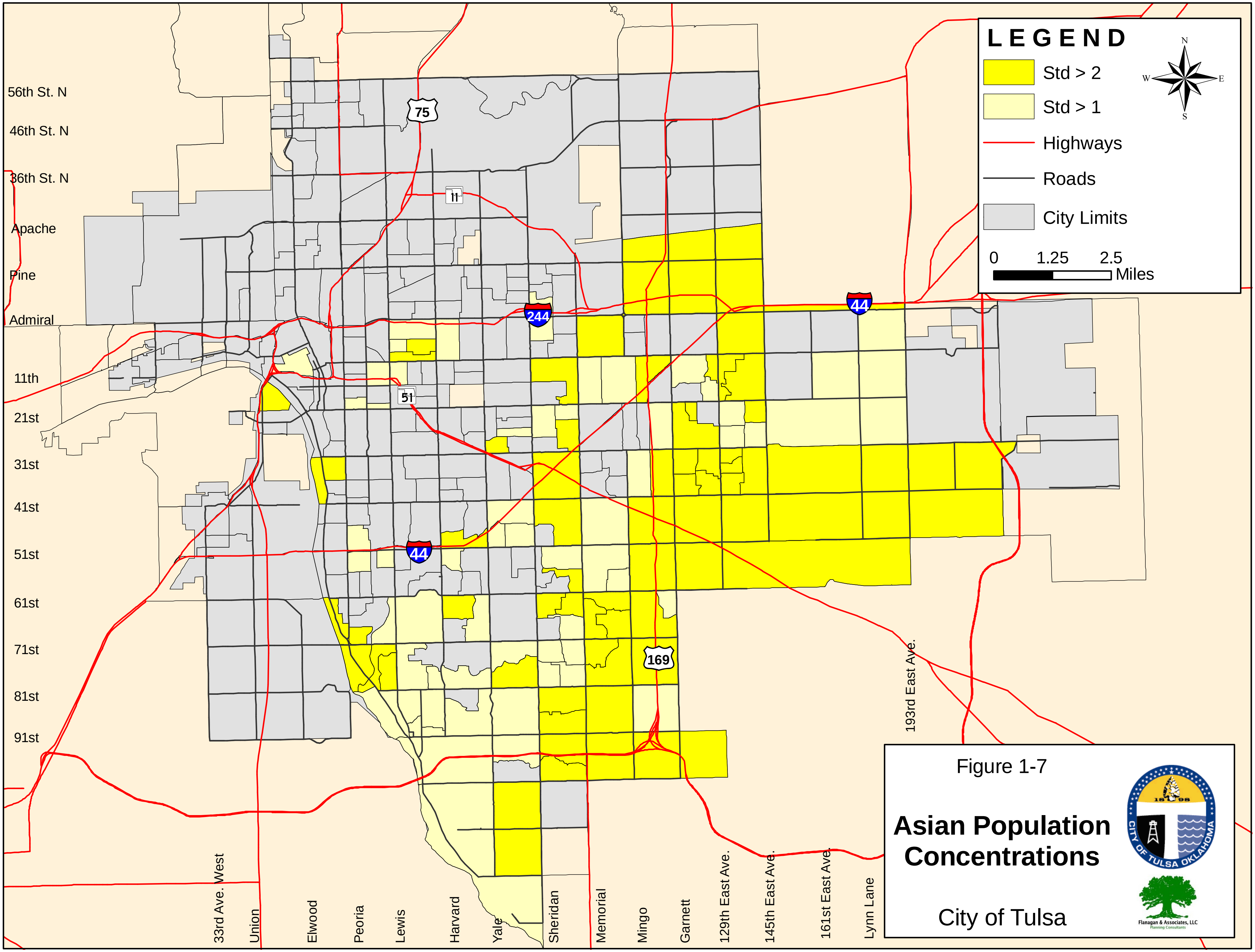


Figure 1-7

Asian Population Concentrations

City of Tulsa

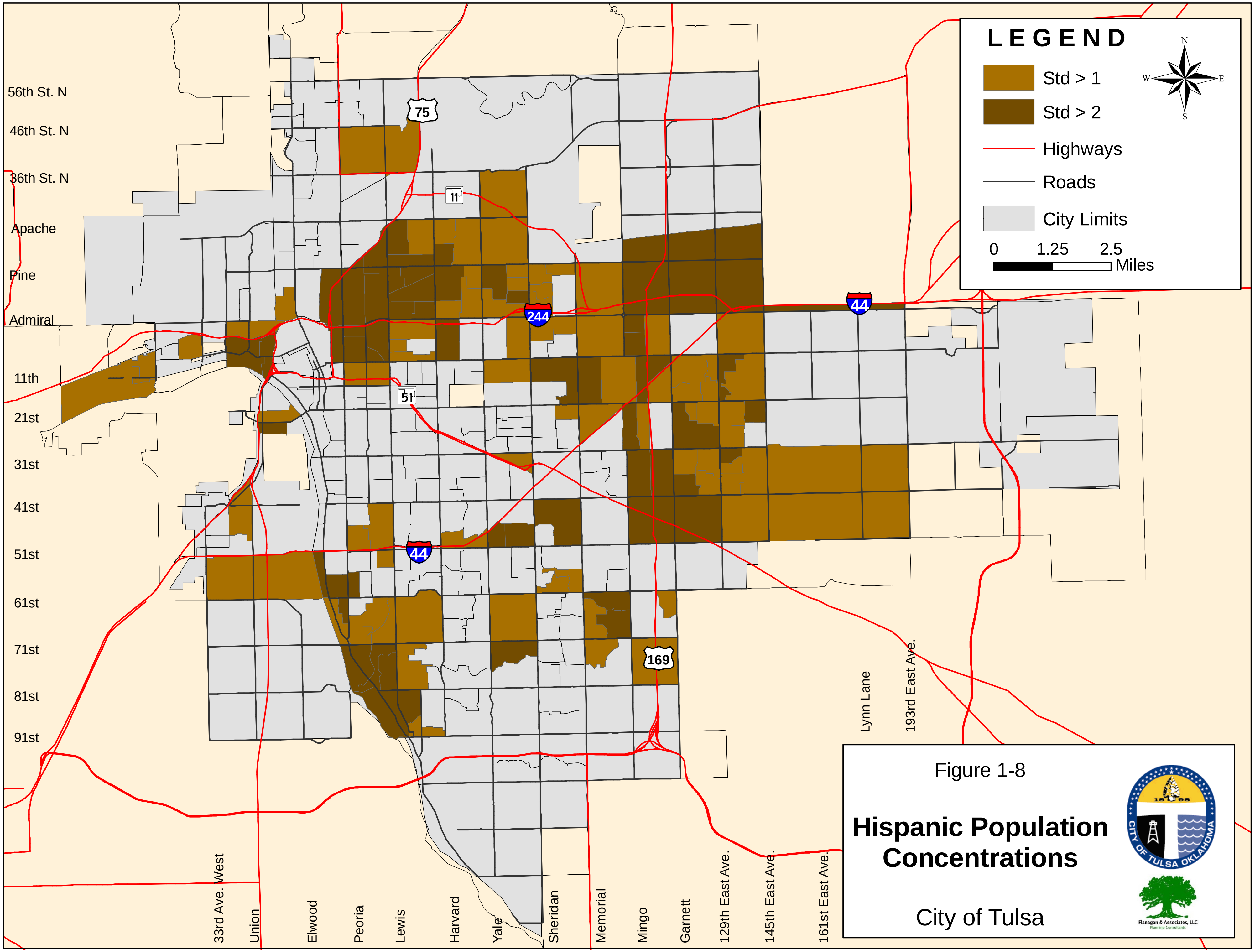


Figure 1-8

Hispanic Population Concentrations

City of Tulsa

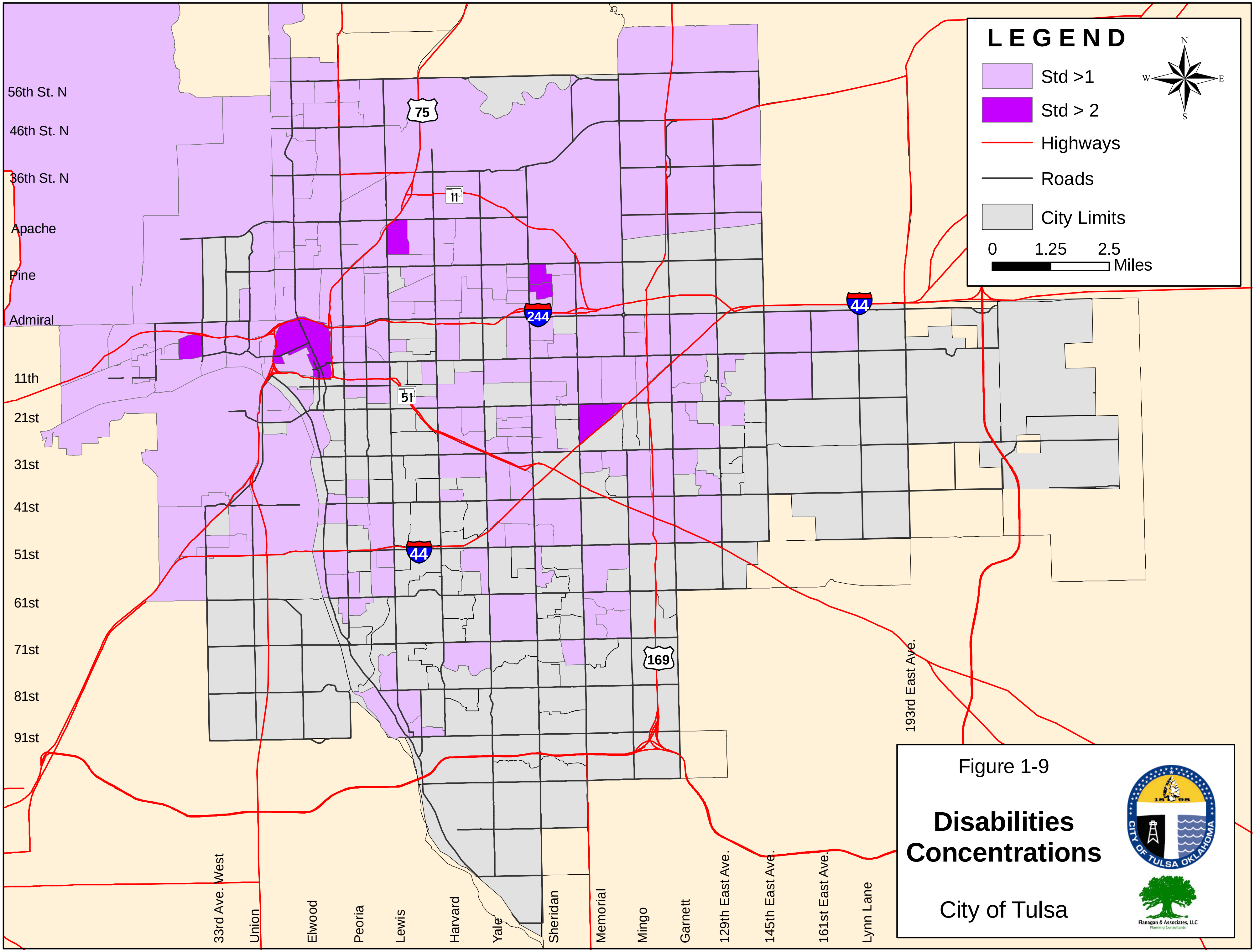


Figure 1-9

Disabilities Concentrations

City of Tulsa

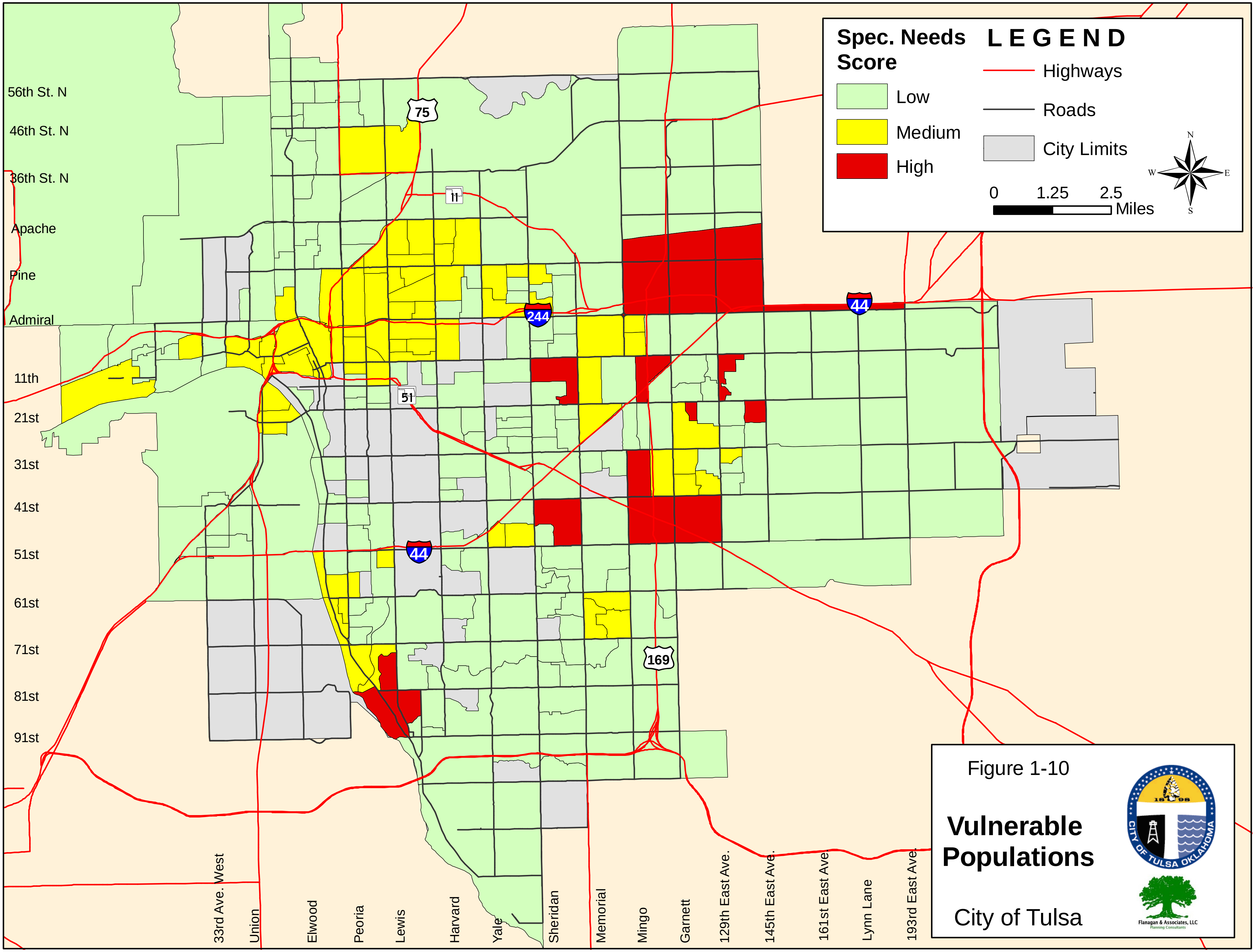


Figure 1-10

Vulnerable Populations

City of Tulsa

1.2.6 Lifelines

Lifelines are defined as systems that are necessary for human life and urban function, especially during emergencies. Transportation and utility systems, as well as emergency service facilities are considered the lifelines of a community. Transportation systems include interstate, US and state highways, roadways, railways, waterways, ports, harbors, and airports. Utility systems consist of electric power, gas and liquid fuels, telecommunications, water, and wastewater. Emergency service facilities include Emergency Alert System (EAS) communication facilities, hospitals, and the police and fire departments. Emergency service facilities are dealt with in detail in Section 2.6.

Utility Systems

Water Service

Tulsa's raw water is brought from Spavinaw/Eucha and Oologah Lakes. Lake Hudson, located approximately 40 miles to the east of the city, has provided water in the past and remains available for future use.

The first Spavinaw flowline is 54 inches to 60 inches in diameter and is 53.9 miles long. The second flowline from Spavinaw ranges from 66 inches to 72 inches in diameter and is 52.2 miles long.

The first Oologah flowline is 42 inches in diameter and runs 16.7 miles to the 66-inch Bird Creek to Lynn Lane pipeline that is 7.9 miles long. The second Oologah flowline is 54 inches-72 inches in diameter and is 22.87 miles long.

Raw water is stored in Yahola Lake (2.0 billion gallon capacity) near Mohawk Water Treatment Plant and Lynn Lane Reservoir (1.1 billion gallon capacity) near A.B. Jewell Water Treatment Plant

The two plants treat between 90 and 190 million gallons of drinking water a day. The City of Tulsa supplies drinking water to more than 133,500 metered accounts in the City and more than 500,000 people in the metropolitan area. Treatment plants, distribution lines, and other infrastructure have been built and upgraded over the years to keep pace with Tulsa's growing need for high quality drinking water.

Due to the foresight of City officials and the support of ratepayers, Tulsa has not been forced to restrict water use since the summer of 1981. Expansion of the A.B. Jewell Plant and construction of the new Mohawk Plant increased Tulsa's treatment capacity to 220 million gallons per day – well above the record use of 190.56 MGD recorded on July 25, 1999. Average daily usage during 2006 was 107 MGD.

The Distribution Systems Section has more than 204 full-time equivalent employees who manage and maintain 2,010 miles of underground water lines, and thousands of valves, water meters, more than 14,000 hydrants, and 11 treated water storage reservoirs.

Wastewater Treatment

Tulsa has four wastewater treatment plants – Southside, Lower Bird Creek, Haikey Creek, and Northside – incorporating pumping and grit removal, aeration, sludge treatment, final clarifying and disinfection.

In addition, the Northside Plant operates four flow-diversion facilities that are used to store excess flows as rainwater enters the joints of sewer pipes during extreme wet-weather periods. Collectively, they have a capacity of 83.2 million gallons. Following the period of significant rainfall, the stored wastewater is slowly released back into the sewer system and treated at a managed rate.

Southside Wastewater Treatment Plant

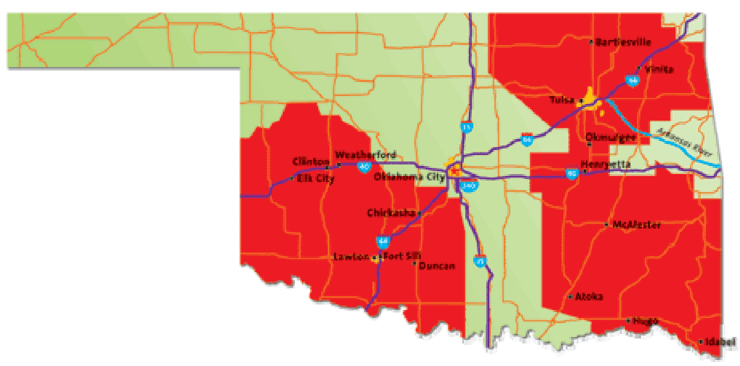
Information on each of the stations is in the following table.

Table 1–5: City of Tulsa Wastewater Treatment Plants

Plant	Built	Upgraded	Lift Stations	Avg flow
Southside	1950	1972 1996	2 offsite 1 onsite	42 MGD
Northside	1958	1984 1995	2 offsite 1 onsite	42.6 MGD
Haikey Creek	1976	1983 1996	2 offsite	16 MGD
Lower Bird Creek	1996	--	2 offsite	2.0 MGD
TOTAL				**102.6 MGD**

Electrical Service

Tulsa's electric power is provided by AEP/Public Service Company of Oklahoma (PSO). Its headquarters is in Tulsa, with regulatory and external affairs offices in Oklahoma City. PSO serves 514,000 customers in Oklahoma and PSO recently became part of the American Electric Power system (AEP), which serves more than 5 million customers across 11 states.



PSO Service territory in Oklahoma (in Red)

AEP ranks among the nation's largest generators of electricity, owning more than 38,000 megawatts of generating capacity in the U.S. AEP also owns the nation's largest electricity transmission system, a nearly 39,000-mile network that includes more 765 kilovolt extra-high voltage transmission lines than all other U.S. transmission systems combined. AEP's transmission system directly or indirectly serves about 10 percent of the electricity demand in the Eastern Interconnection, the interconnected transmission system that covers 38 eastern and central U.S. states and eastern Canada, and approximately 11 percent of the electricity demand in ERCOT, the transmission system that covers much of Texas. AEP's coal-fired plants account for 73 percent of its generating capacity, natural gas represents 16 percent, and nuclear 8 percent. The remaining 3 percent comes from wind, hydro, pumped storage and other sources.

Electrical System Outages

The electrical grid infrastructure is vulnerable to a number of the natural disasters that will be addressed in this plan, primarily high winds, tornadoes, and severe winter storms. The following table displays the number of power outages over the last 5 years from the primary provider of electrical power in the City of Tulsa.

Table 1–6: PSO Outages with Greater Than 20,000 Customers Affected
Jan 2003 – Dec 2007

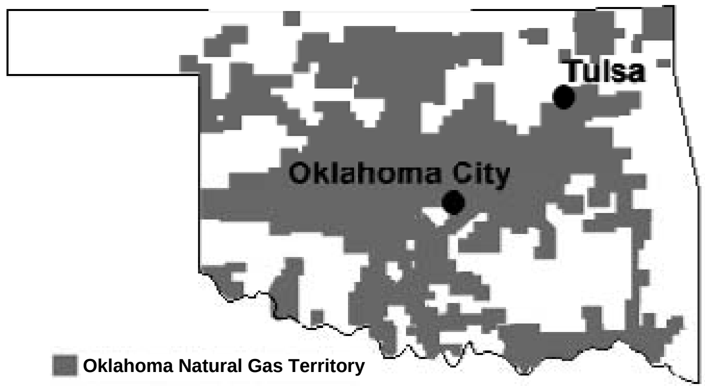
Year	Interruption Start Date	Number of Interruptions	Total Accounts Affected	Total Customer Hours Interrupted	Average Customer Hours (Days) Interrupted	Cause
2003	08/01/2003	349	45,572	332,004	7.29 (0.30)	High Winds
2004	05/13/2004	204	23,443	98,218	4.19 (0.17)	T'storms/High Winds
2004	06/02/2004	508	63,255	1,226,376	19.40 (0.81)	T'storms/High Winds
2005	06/04/2005	296	35,945	340,162	9.46 (0.39)	High Winds
2005	06/16/2005	384	36,729	227,710	6.2 (0.26)	High Winds
2005	11/27/2005	245	34,765	244,247	7.03 (0.29)	High Winds
2007	10/17/2007	324	29,404	182,168	6.2 (0.26)	High Winds
2007	12/09/2007	241	106,837	8,697,662	81.41 (3.39)	Ice Storm
2007	12/10/2007	579	219,646	16,444,032	74.87 (3.12)	Ice Storm
2007	12/11/2007	138	25,419	904,240	35.57 (1.48)	Ice Storm

It is apparent that, while the majority of these outages are caused by high winds and thunderstorms, the most severe are those from ice storms. This is primarily due to the extensive and widespread physical damage to lines and poles during a heavy ice storm.

Loss of electrical power is perhaps more critical than the loss of other infrastructure services due to our dependence on power to support the other services – including water treatment plants, telecom services, fuel delivery, and so on. In addition, many people depend on electrically driven life-assistive devices such as breathing machines or dialysis equipment.

Power outages also create additional threats to life and health. Traffic signals may be disrupted, creating the potential for vehicle accidents. In the most recent major power outages in the City of Tulsa, a number of people were treated for carbon monoxide poisoning due to inappropriate use of alternative heating or generating devices. At least 40 were transported to local hospitals with CO related symptoms. Residential fires increased dramatically due to both electric lines coming into the home being damaged, and unsafe alternate sources of heat – charcoal grills, gas stoves and ovens, or combustion heaters. Unsafe use of home generators can also put electric service personnel at risk due to "backfeeding" into service lines. For additional information on power outages and emergency generators, see Appendix B, Section B.2.11 and B.2.12.

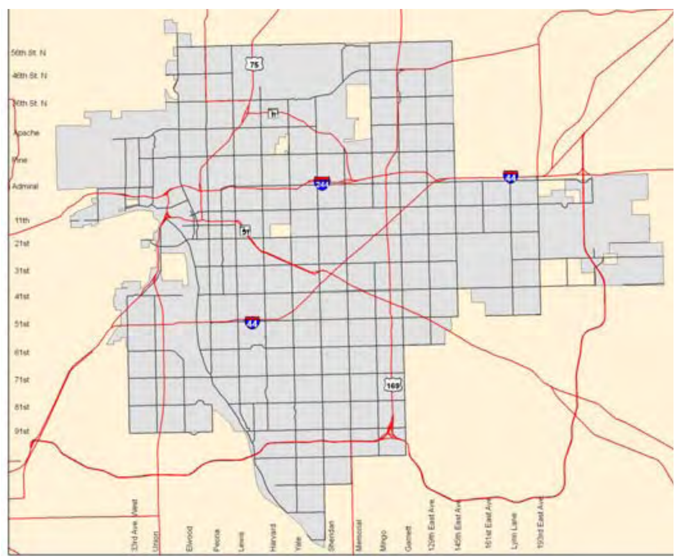
Natural Gas Service



Tulsa's gas service is provided by Oklahoma Natural Gas (ONG), a subsidiary of its parent company, ONEOK, founded in 1906. Oklahoma Natural Gas serves approximately 800,047 residential, commercial and industrial customers in Oklahoma. The company has affiliates that operate transmission and gathering operations in Oklahoma that include 2,348 miles of pipeline and five strategically-located underground storage facilities, also located in Oklahoma.

Transportation Systems

Major Highways and Roads



The City of Tulsa has a number of major highways including:

- **Interstate 44**—runs SW-NE from Wichita Falls, TX to St. Louis, MO, a distance of 328 miles in Oklahoma. Most of I-44 is turnpike: the H.E. Bailey Turnpike from Texas to Oklahoma City, the Turner Turnpike from Oklahoma City to Tulsa, and the Will Rogers Turnpike from Tulsa to the Missouri border. Through Tulsa I-44 is also known as the Skelly Bypass and is routed alongside S. 51st St. It is a heavily traveled highway, including tourist, business, and commercial truck traffic. Linking, as it does, several turnpikes and expressways, I-44 carries a high volume of hazardous material traffic, including chemical and petroleum products, and in some cases, radiological materials.
- **Interstate 244**—Loops from I-44 in the southwest around the northern and western sides of the city, and reconnects with I-44 immediately before the Turner Turnpike in western Tulsa. Through the city, I-244 ranges from four to six lanes and carries a substantial amount of traffic, both passenger and commercial.
- **US Hwy 64**—at 589 miles in length, US Hwy 64 is the longest U.S. highway in Oklahoma. It runs from Clayton, NM through the Panhandle to Ft. Smith AR. In Tulsa, US Hwy 64 becomes the Broken Arrow Expressway before branching off to

the south with the Mingo Valley Expressway and US Hwy 169 to Memorial Blvd. at S. 96th St., and then on to Bixby and Leonard. US Hwy 64 is heavily traveled by commercial and commuter traffic.

- **US Hwy 75**—runs from the Dallas-Ft. Worth area through Tulsa to the Canadian border. US Hwy 75 is a four-lane divided highway from I-40, at Henryetta, to the Kansas border, and provides excellent access to I-44, the Muskogee Turnpike, Cimarron Turnpike and the Indian Nation Turnpike. The rapid growth of Southwest Tulsa, particularly Jenks, Glenpool and Bixby, has increased traffic on the southern section of US 75, while the Wal-Mart Distribution Center in Bartlesville (approximately 40 miles to the north of Tulsa), and the highway's intersection with both I-44 and I-40 combine to make this a particularly heavily traveled four-lane highway.
- **OK Hwy 51**—is Oklahoma's third longest State highway at 330 miles in length. OK Hwy 51 is four lanes from I-35 to Stillwater and two lanes from there to Sand Springs, where it joins the Keystone Expressway. In downtown Tulsa, it branches off to the southeast, becoming the Broken Arrow Expressway. The highway carries a great deal of commuter and commercial traffic through Tulsa County.
- **Mingo Valley Expressway**—travels north-south from Collinsville in northeast Tulsa County to the Creek County Turnpike at about S. 96th and Garnett Rd. It is heavily traveled with both commercial and commuter traffic. The Mingo Valley Expressway is also US Hwy 169, which runs from Tulsa to Minnesota. US Hwy 169 begins at the U.S. Hwy 64 East interchange of the Creek Turnpike. U.S. 169 is freeway grade north to Collinsville.

Traffic counts on these highways are presented in Table 1-7.

Table 1–7: Highway Traffic Counts
(Source: Oklahoma Department of Transportation, 2006)

Highway	*Daily Traffic Counts*
Interstate 44 west Tulsa County (Creek County line)	46,100
Interstate 44 east Tulsa County (Rogers County line)	46,700
US Hwy 75 north Tulsa County (66th St. N)	33,800
US Hwy 75 south Tulsa County (Glenpool)	37,800
US Hwy 412 west Tulsa County (west Sand Springs)	25,700
US Hwy 412 east Tulsa County (225th E. Ave.)	39,400
US Hwy 64 west Tulsa County (Sand Springs)	50,700
US Hwy 64 southeast Tulsa County (Bixby)	26,000
OK Hwy 51 west Tulsa County	43,200
OK Hwy 51 east Tulsa County (209th E. Ave.)	78,000
Creek County Expy east Tulsa County (Mingo Rd.)	41,800
Mingo Valley Expy north Tulsa County (Apache Rd.)	56,914
Mingo Valley Expy south Tulsa County (S. 71st St.)	86,200
Broken Arrow Expy southeast Tulsa County (145th E. Ave.)	78,600

Future transportation for the Tulsa area has been mapped out in *Destination 2030*, a long-range transportation plan that contains elements on roadways, public transportation, bicycle and pedestrian ways, and freight movements. *Destination 2030* is a joint product of INCOG, ODOT and the Metropolitan Tulsa Transit Authority. For major highways, the Plan includes:

- Expansion of US Hwy 169 from Owasso to I-244 from four to six lanes
- Expansion of I-44 from Sheridan Rd. to the Arkansas River from four to six lanes
- Expansion of US Hwy 75 from I-44 to 151st St. South from four to six lanes
- Extension of Gilcrease Expressway from Lewis Ave. to I-44.

The Plan encourages the development of bicycle-pedestrian trails, park-and-ride facilities and fuel-efficient automobiles. Regarding safety and congestion, the Plan supports the adoption of transportation incident management programs, the development of a regional Traffic Management Center, and the identification and abatement of high accident locations. Also recommended are infrastructure improvements at Tulsa International Airport (more air cargo facilities and better landside access) and the Port of Catoosa.

Bus Lines and Taxi Service

The primary metropolitan bus service provider for the Tulsa area is the Metro Tulsa Transit Authority (MTTA), a public trust of the City of Tulsa, established in 1968. In addition to regular bus service, MTTA operates the Lift Program, a curb-to-curb paratransit service for persons with disabilities who have been determined ADA Paratransit Eligible. The Lift Program offers service utilizing lift-equipped vans and taxis operating within the Tulsa City Limits.

An MTTA's lift-equipped paratransit buses, part of the Lift Program

Tulsa is also served by multiple nationwide or charter bus services, including the following:

- **Greyhound** – With a terminal at 317 S. Detroit. Greyhound is the largest provider of intercity bus transportation in the US.
- **Jefferson Lines** – Operates out of the Greyhound terminal, and provides service throughout the Midwestern states.
- **Kincaid Coach** – A charter bus service that operates out of multiple cities. In Tulsa, they maintain seven 54-passenger coaches, one 47-passenger coach, and one 40-passenger sleeper coach.
- **Pacesetter Coach** – provides limited charter bus service in the Tulsa area. Specific information on number of buses was unavailable.

The community is also serviced by over 20 taxicab, airport shuttle, and limousine companies that operate throughout the Tulsa metropolitan area.

Railway

The City of Tulsa is reviewing the feasibility of a light-rail transit system to support commuter traffic, but no action is anticipated for several years, and studies, at this point, do not indicate the major locations of potential routes.

Currently Tulsa is served by the Burlington Northern Santa Fe (BNSF) and the Union Pacific (UP) rail lines. Running north-south through Tulsa, the BNSF operates on tracks originally built by the St. Louis and San Francisco Railroad (Frisco). The trackage was absorbed into the BNSF's Texas Division when the Frisco was dissolved in 1981. The BNSF is one of the two largest railroads in the US, and is particularly strong in the Midwest and West.

The Cherokee Rail Yard in Tulsa supports a substantial amount of traffic, sometimes up to 22 trains a day with upwards of 100 cars each.


The Tulsa Cherokee Railroad yard in West Tulsa

Primary cargoes shipped through Tulsa are agricultural and mining products. Among the agricultural products are soybean meal, corn and corn syrup, nut and vegetable oil, cottonseed meal and oil, wheat and wheat bran, and malt. Mining products include coal, oil, propane, asphalt, gypsum, and limestone. In addition, hazardous materials, such as ammonia, fuel, or compressed natural gas is transported. Due to technological advances in recent years, the odds of a hazardous materials release from a railroad car, even in a significant derailment, is considered a very unlikely event.

Union Pacific, the largest railroad in North America, covers 23 states across the western two-thirds of the United States, and is a leading carrier of low-sulfur coal used in electrical power generation. It has broad coverage of the large chemical-producing areas along the Gulf Coast, and serves all six major gateways to Mexico. Union Pacific operates another north-south line in western Oklahoma that serves Enid, El Reno and Duncan, and connects Kansas wheat areas to the Texas ports. Union Pacific operates switchyards and related facilities at Muskogee, Tulsa, Oklahoma City, Chickasha, Enid and McAlester.

In addition, a study has been instituted to determine the feasibility of a mass transit commuter rail system between Tulsa and Broken Arrow, a major suburb to the southeast. This system could be several years in development.

Airports

The City of Tulsa is served by several airports, including:

- Tulsa International Airport – Average of 167 aircraft based at field with an average of 79 operations/day. This is Tulsa's primary commercial airport. TIA also houses the 138th Fighter Wing of the Air National Guard and is the global maintenance headquarters for American Airlines.
- Richard Lloyd Jones Airport (Riverside) – Average of 543 aircraft based at field with 926 operations/day. Riverside is primarily an airport for business-owned private aircraft.
- In addition, there are heliport pads at all major Tulsa hospitals.

1.2.7 Economy

Though the oil industry has historically dominated Tulsa's economy, efforts in economic diversification have created a base in the sectors of aerospace, finance, technology, telecommunications, high tech, and manufacturing. The Tulsa International Airport (TUL) and the Tulsa Port of Catoosa, the nation's most inland seaport, connect the region with international trade and transportation. An American Airlines maintenance base at Tulsa International Airport is the city's largest employer and the largest maintenance facility in the world, serving as the airline's global maintenance and engineering headquarters, while the Tulsa Port of Catoosa and the Tulsa International Airport house extensive industrial parks.

Products from Tulsa manufacturers account for about 60% of Oklahoma's exports, and in 2001, the city's total gross product was in the top one-third of metropolitan areas, states, and countries, with more than $29 billion in total goods, growing at a rate of $250 million each year. In 2006, Forbes magazine rated Tulsa as second in the nation in income growth, and one of the best cities to do business in the country. Usually among the lowest in the nation in terms of cost of doing business, the Tulsa Metropolitan Area in 2005 was rated among the five lowest metropolitan areas in the United States for that category.

During a national recession from 2001 to 2003, the city lost 28,000 jobs. In response, a development initiative, Vision 2025, promised to incite economic growth and recreate lost jobs. Projects spurred by the initiative promised urban revitalization, infrastructure improvement, tourism development, riverfront retail development, and further diversification of the economy. Employment and income data for Tulsa are presented in Table 1-8.

Table 1–8: City of Tulsa Employment and Income Data
Source: 2000 Census and 2006 Population Estimates

Subject	*Number (2000)*	*%*	*Number (2006)*	*%*
Population 15 Years and Older	311,145	79.1%	297,663	77.7%
Population in Labor Force	202,164	66.0%	195,669	51.1%
Employed	190,954	62.3%	Not included	
Total Households	165,743	100%	165,236	100%
Household Income Below Poverty Level	10,840	10.9%	15,793	16.8%

Major Employers

Tulsa's major employers are listed in Table 1-9.

A number of large financial corporations are headquartered in Tulsa, the largest being the BOK Financial Corporation, the parent company to the Bank of Oklahoma, the Bank of Texas, the Bank of Arkansas, the Bank of Albuquerque, the Bank of Arizona, Colorado State Bank and Trust, and the Bank of Kansas City.

The semi-national convenience store chain QuikTrip, the national car rental companies of Vanguard and Dollar-Thrifty, and Mazzio's semi-national pizza chain, also call Tulsa home. Many international oil and gas-related companies have headquarters in Tulsa, including Williams Companies, SemGroup, Syntroleum, ONEOK, Samson and Excel Energy. Meanwhile, there are 30 companies in Tulsa that employ more than 1,000 people, though small businesses make up more than 80% of the city's companies.

Table 1–9: Major Employers
Oklahoma Department of Commerce, 2007

Company	Employees (Approx)	Sector
American Airlines, Inc.	8,000	Aircraft Maintenance
Tulsa Public Schools	6,500	Education
Saint Francis Health System	4,500	Healthcare
Tulsa, City of	4,258	Government
St. John Medical Center	4,250	Healthcare
Oneok	3,000	Public Utility
Bank of Oklahoma, NA	2,750	Financial Services
Tulsa Community College	2,200	Education
Tulsa, County of	2,000	Government
Broken Arrow Public Schools	1,900	Education
Hillcrest Medical Center	1,800	Healthcare
Union Public Schools	1,800	Education
MCI	1,700	Data Services
Reasor's Foods	1,700	Grocers
DecisionOne	1,600	Service Call Center
NORDAM Group	1,600	Aerospace Manufacturing
Direct TV	1,500	Entertainment
Dollar Thrifty Automotive	1,500	Auto Rental
EDS	1,500	Information Technology
Oklahoma State University Medical Center	1,500	Health Care
State Farm Insurance	1,500	Insurance
Cingular Wireless	1,400	Telecommunications
Blue Cross/Blue Shield	1,300	Insurance
IBM	1,300	Information Technology

Company	Employees (Approx)	Sector
Arrow Trucking Co. Inc.	1,200	Transportation
Quik Trip Corporation	1,200	Convenience Stores
Spirit Aerosystems	1,200	Aerospace Manufacturing
University of Tulsa	1,100	Education
Warehouse Market	1,100	Grocers
AEP Public Service Co.	1,000	Public Utility
AT & T	1,000	Telecommunications
Avis Budget Group	1,000	Auto Rental
Centrilift	1,000	Manufacturing
Cherokee Casino Resort	1,000	Entertainment
Echostar	1,000	Entertainment
Jenks Public Schools	1,000	Education
Level 3 Communications	1,000	Telecommunications
Oral Roberts University	1,000	Education
Whirlpool Corporation	1,000	Manufacturing
Williams Companies Inc.	900	Oil & Gas
AAON Inc.	719	Manufacturing

1.2.8 Development

According to the Tulsa County Assessor's Office, there are 129,794 properties with improvements within the City of Tulsa, with a total value, adjusted for fair market value $16,108,795,699. Numbers of properties with improvements (buildings, garages, pools, storage, and so forth) and improvement values, by type, are shown in the table below. No land values are included. Due to their vulnerability to natural hazards, the locations of mobile homes have been identified on the map in Figure 1–11.

Table 1–10: City of Tulsa 2008 Housing Units, Value and Type
Source: Tulsa County Assessor's Office

Improvement Type	*Number*	*Total Value*
Residential Single Family	115,791	$10,888,265,645
Residential Multi-Family	3,499	1,514,814,899
Residential Single/Mobile Home	2,626	2,099,689
Commercial	3,122	1,306,767,476
Industrial	2,753	1,126,311,308
Other	2,003	2,396,847,990
Total	**129,794**	**$16,108,795,699**

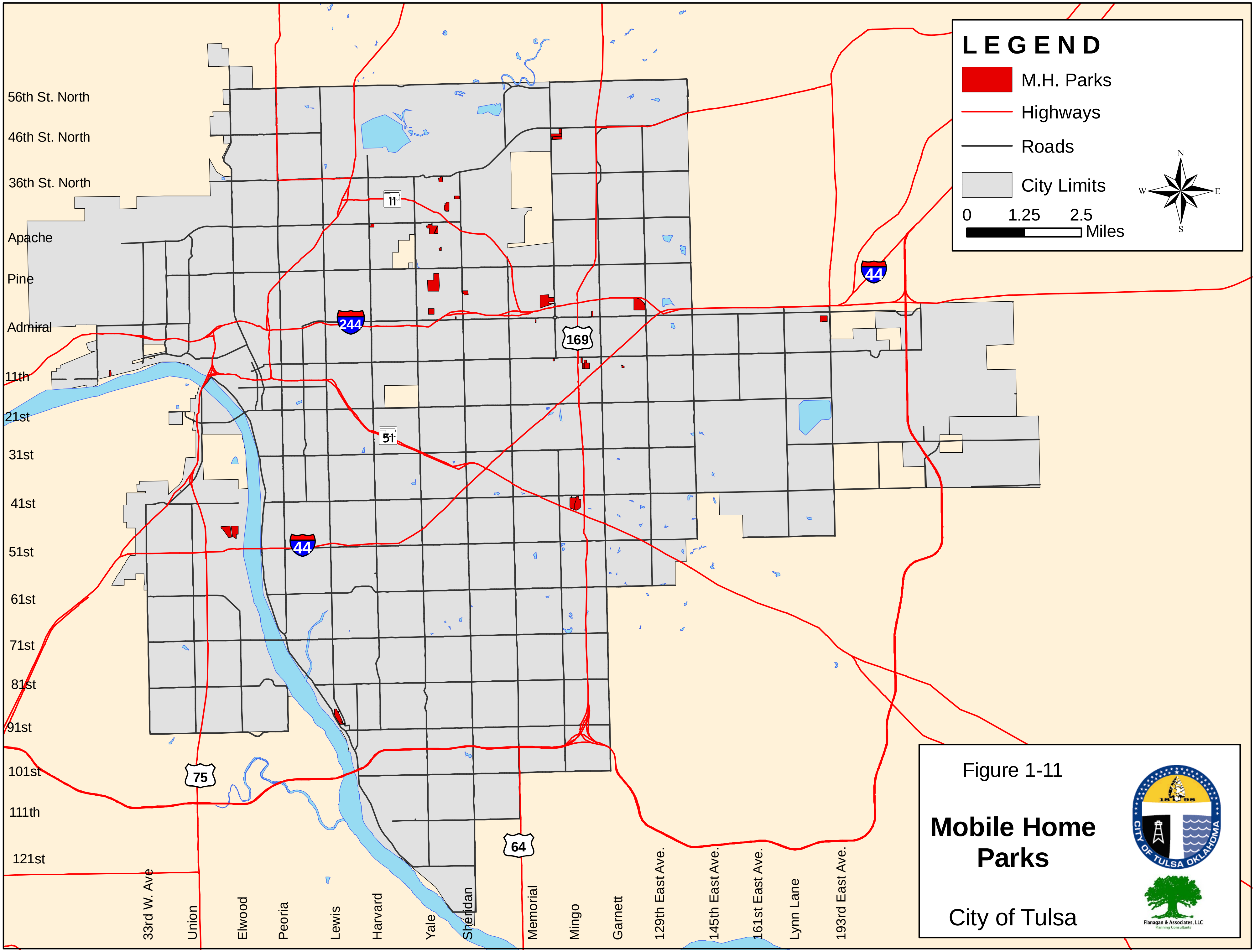


Figure 1-11

Mobile Home Parks

City of Tulsa

Future Development

Tulsa's population growth rate is 0.7 percent annually over the last 40 years, although it has declined within the city proper during the last few years. The Tulsa MSA is growing at a rate of 1.3 percent, the same as the national growth rate. Comparatively, the State of Oklahoma is growing at 1 percent annually. (For additional information, see Section 1.2.5 – Demographics.)

Although the obvious direction of Tulsa's growth is south and east, there is great interest among city leaders in redeveloping Downtown Tulsa as the center of culture and the historical heart of the city. The vision of Tulsa's future is already evident in such projects as the Brady District, the Blue Dome District (around Second Street and Detroit Avenue), the Sixth Street Project (which includes the Village at Central Park), the Tribune Lofts at Main and Archer streets, and the Renaissance Uptown Apartments at Tenth Street and Denver Avenue.

The new BOK Center in downtown Tulsa will also affect development in the area. The 18,041-seat venue will be home to the Af2 Tulsa Talons and the CHL Tulsa Oilers. The BOK Center was designed to host major concerts, family shows, ice shows and other world-class entertainment.

Located off Interstate 244 in downtown Tulsa, the BOK Center will be diagonal from the Tulsa Convention Center once completed with its renovations in 2009, making it an entertainment and business complex.

One of the keys to the future development of Downtown Tulsa is making use of the structures already in place. In January 2002, Tulsa adopted the International Existing Building Code (IEBC), which makes it possible for entrepreneurs and property owners to use existing structures without being required to make major changes that would be prohibitively expensive.

Early in 2007, the City began the process of updating its 30-year old Comprehensive Plan through a program called PLANiTULSA. Public meetings, surveys, and other avenues of input will guide the process over the coming year to create the new plan.

Growth Trends

The City of Tulsa has about 45 square miles within its fenceline designated for future development, and about 49 square miles of vacant, developable land within its city limits. A "fenceline" is a narrow strip of annexed land around the perimeter of an area of un-annexed land that a community identifies and claims for future growth to protect the area for annexation. (See Figure 1-12)

The planning team examined Tulsa's existing city limits, fenceline, and capital improvements plans to determine areas of future growth and expansion. The team examined the Tulsa Metropolitan Area Planning Commission's Comprehensive Plan and detailed District Plans to establish planned future land use, densities, and policies. Areas of vacant land for future growth (see Figure 1-13) include infill and urban redevelopment of the central and older section of the city, the northwest part of Tulsa in Osage County, east of 145th East Avenue between Admiral Boulevard and 51st Street, the newly annexed

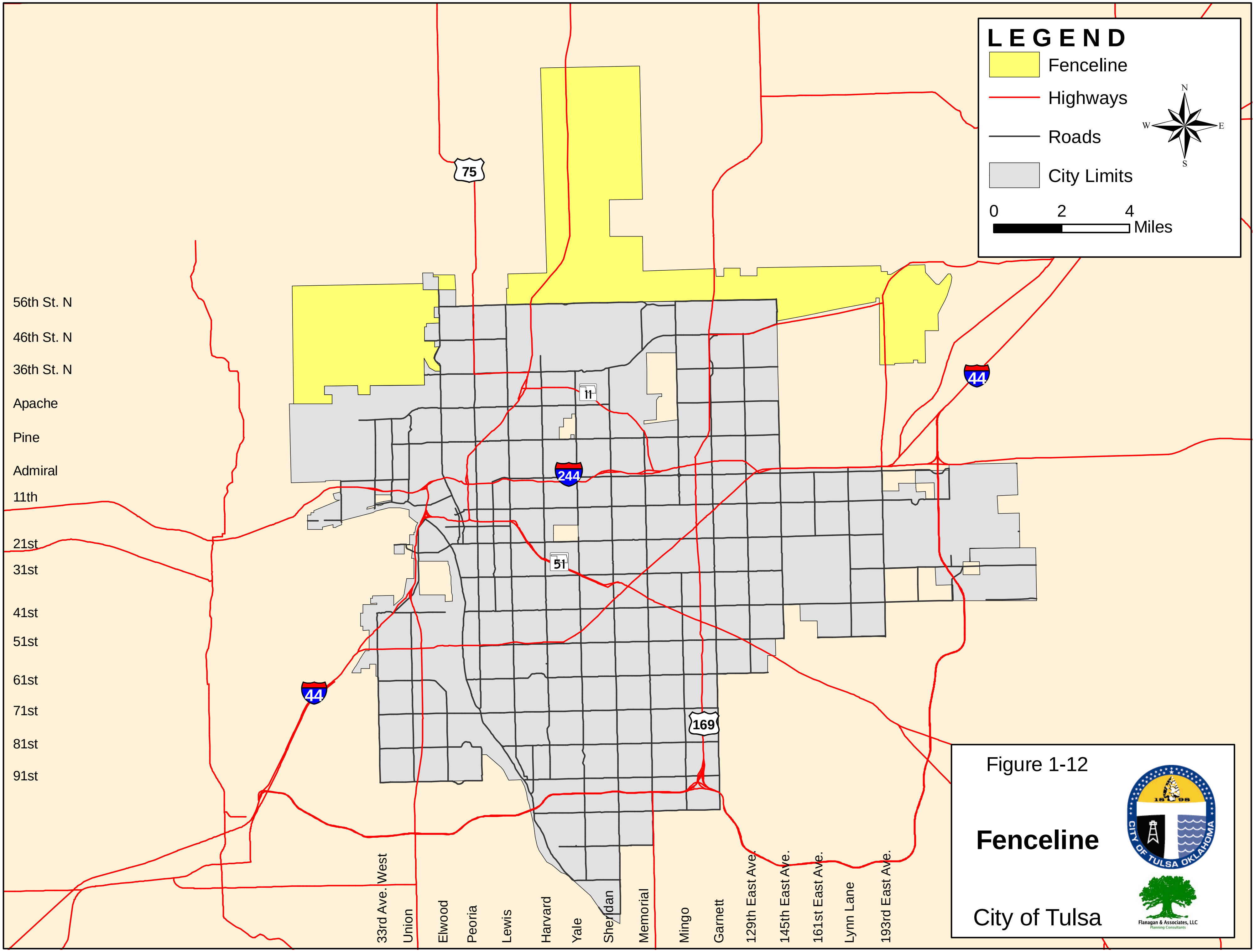
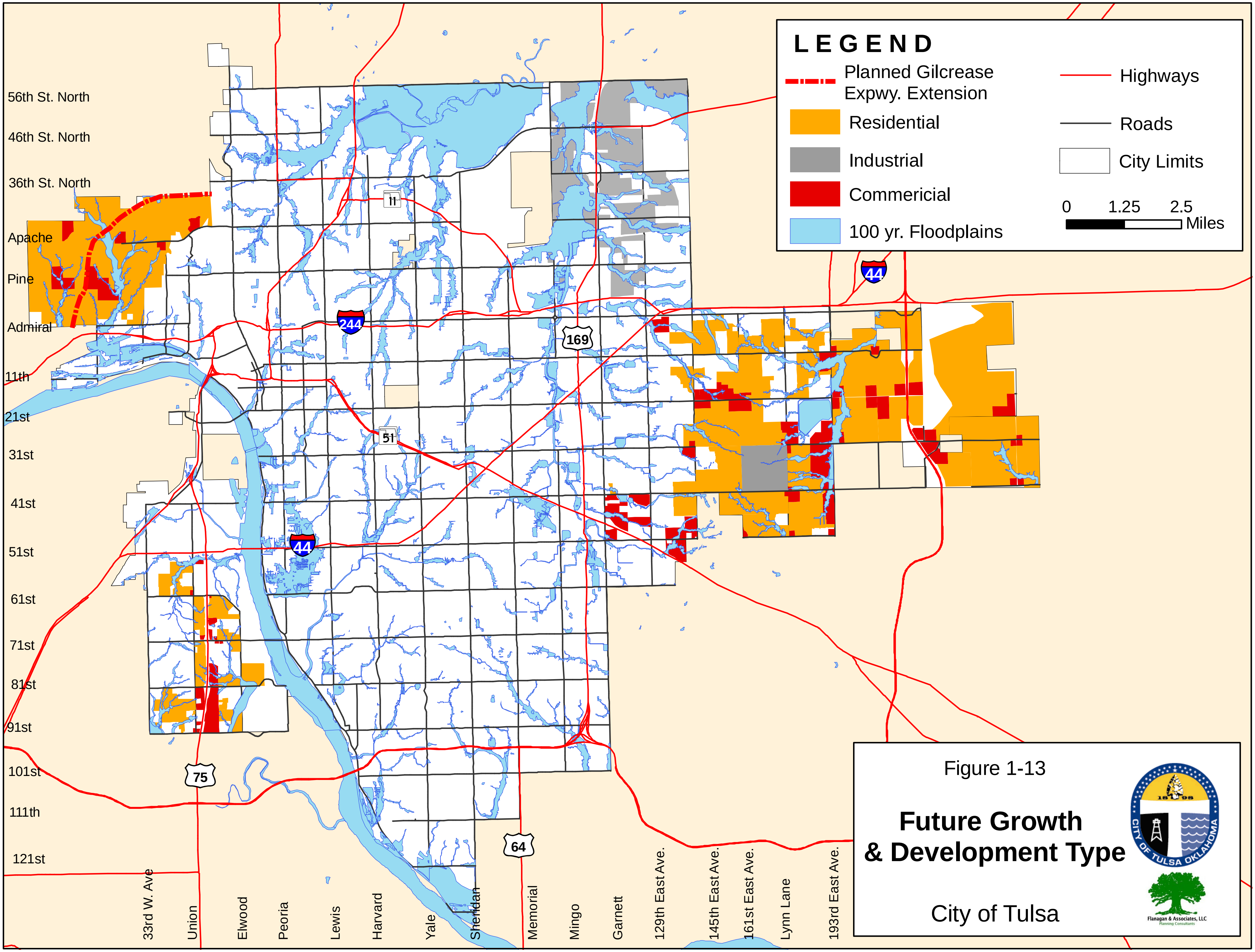


Figure 1-12

Fenceline

City of Tulsa


LEGEND
Planned Gilcrease Expwy. Extension
Residential
Industrial
Commericial
100 yr. Floodplains
Highways
Roads
City Limits
0 1.25 2.5 Miles
56th St. North
46th St. North
36th St. North
Apache
Pine
Admiral
11th
21st
31st
41st
51st
61st
71st
81st
91st
101st
111th
121st
33rd W. Ave
Union
Elwood
Peoria
Lewis
Harvard
Yale
Sheridan
Memorial
Mingo
Garnett
129th East Ave.
145th East Ave.
161st East Ave.
Lynn Lane
193rd East Ave.
244
44
169
11
51
75
64
Figure 1-13
Future Growth & Development Type
City of Tulsa
Flanagan & Associates, LLC

13 square miles in Wagoner County, the Fair Oaks section of Wagoner County, and the southwest section of the city in the Mooser/Hager Creek basin.

Vacant available areas that are not expected to experience much growth pressure include north Tulsa County and the industrial area east of the Tulsa International Airport.

Southeast Osage County includes about 8 square miles of undeveloped annexed land, and another 12.85 square miles of undeveloped land within Tulsa's fenceline. The west loop of the Gilcrease Expressway is being extended to serve this area. The extension of other municipal utilities into the area, such as water and sanitary sewer, is expected to spur development. Due to the rugged nature of the terrain, development will most likely be residential with small-scale commercial developments.

North Tulsa County includes 32.15 square miles around which Tulsa has placed a fenceline. The Comprehensive Plan designates the area primarily as industrial and highway-oriented commercial. The wide expanses of the Bird Creek floodplain are set aside for open space.

Airport Industrial Area, from Tulsa International Airport east to the Rogers County line, encompasses some 6.38 square miles and is designated for industrial development. This area is served by U.S. Highway 169, the Mingo Valley Expressway. Because it is underlain by massive limestone deposits, it has been difficult and expensive to develop.

East Tulsa, between 145th East Avenue and the Tulsa-Wagoner County line and between Admiral Place and East 51st Street, includes approximately 10 square miles of land planned for mixed uses, primarily residential. The area has been slow to develop due to its limestone outcroppings.

Newly Annexed Wagoner County Area consists of 13 square miles of Fair Oaks. The area is designated for mixed uses, and is served by the recently completed East Creek Turnpike.

The Mooser/Hager Creek Basins, an area of future growth located in southwest Tulsa, include about 4 square miles of scenic, rugged woodland. The area is served by U.S. Highway 75, and has been experiencing recent commercial and residential development. The highway corridor is expected to develop with commercial/business park and higher density residential uses, while the balance of the basin is expected to consist of mixed uses, primarily lower-density residential.

The floodplains of the future growth areas have been or are being identified and mapped, and new development will be regulated, although several areas that have had Master Drainage Plans developed in the past need to be updated and reviewed. The City's ordinances prohibit development and fill in the floodplains. Stormwater detention requirements ensure that no adverse stormwater impact will result from new development. Tulsa's stringent stormwater and floodplain management ordinances and development regulations require that new development occur outside of the 100-year floodplain, and not be damaged or damage other properties due to flooding. In addition, any new critical facilities will be protected to the 500-year flood level. Roadways and bridges are required to pass the 100-year regulatory flood.

The growth areas will all continue to be subject to non-site specific natural hazards, such as tornadoes, lightning, hail, winter storms, extreme heat, drought, expansive soils, wildfires, and earthquakes. Dam and levee failures are not a problem for these future growth areas. The multi-hazard mitigation measures identified and recommended in this plan should lessen the impacts of natural hazards on future development and population of the community.

1.2.9 Critical Facilities

Critical facilities are defined differently by different organizations and agencies, but are usually classified as those facilities vital to the health, safety, and welfare of the population and that are especially important following hazard events, or as those facilities that, if put out of operation by any cause, would have a broadly adverse impact on the community as a whole.

FEMA includes the following:

- Structures or facilities that produce, use or store highly volatile, flammable, explosive, toxic and/or water-reactive materials;
- Hospitals, nursing homes, and housing likely to contain occupants who may not be sufficiently mobile to avoid death or injury during a disaster;
- Police stations, fire stations, vehicle and equipment storage facilities, and emergency operations centers that are needed for disaster response activities before, during, and after an event;
- Public and private utility facilities that are vital to maintaining or restoring normal services to affected areas before, during and after an event.

This may also include buildings designated as emergency shelters, schools, childcare centers, senior citizen centers, major medical facilities, disability centers, and City Hall. Since 9/11, FEMA has also added banks and other major financial institutions to their critical facilities list. The City of Tulsa's critical facilities are summarized in Table 1-11, listed in Appendix G, and mapped in Figures 1–14 through 1-21.

Table 1–11: Tulsa Critical Facilities

Total Facilities	693				
	Facility Count	Category Total		Facility Count	Category Total
City of Tulsa		**137**	**Educational Facilities**		**165**
Fire Department	38		Colleges	6	
Administrative	9		Junior Colleges	9	
Water	34		Tulsa Public Schools	95	
Waste Water	30		Private Schools	35	
Public Works	16		Jenks District	4	
Police Department	10		Union District	15	
Government		**38**	**Childcare (licensed for >12)**		**322**
County	13		Childcare	107	
State	6		Drop In	2	
Federal	19		Family Centers	23	
Major Medical Facilities		**27**	Head Start	9	
Hospitals	22		Large Family Centers	144	
Psychiatric Centers	4		Camps	30	
EMSA	1		School Age Centers	7	
Local Financial Headquarters		**20**	**Senior Housing**		**42**
Financial Headquarters	20		Residential	3	
			Nursing Homes	17	
			Mentally Challenged	5	
			Hospital Based Skilled Nursing	3	
			Continuum of Care	3	
			Assisted Living	11	

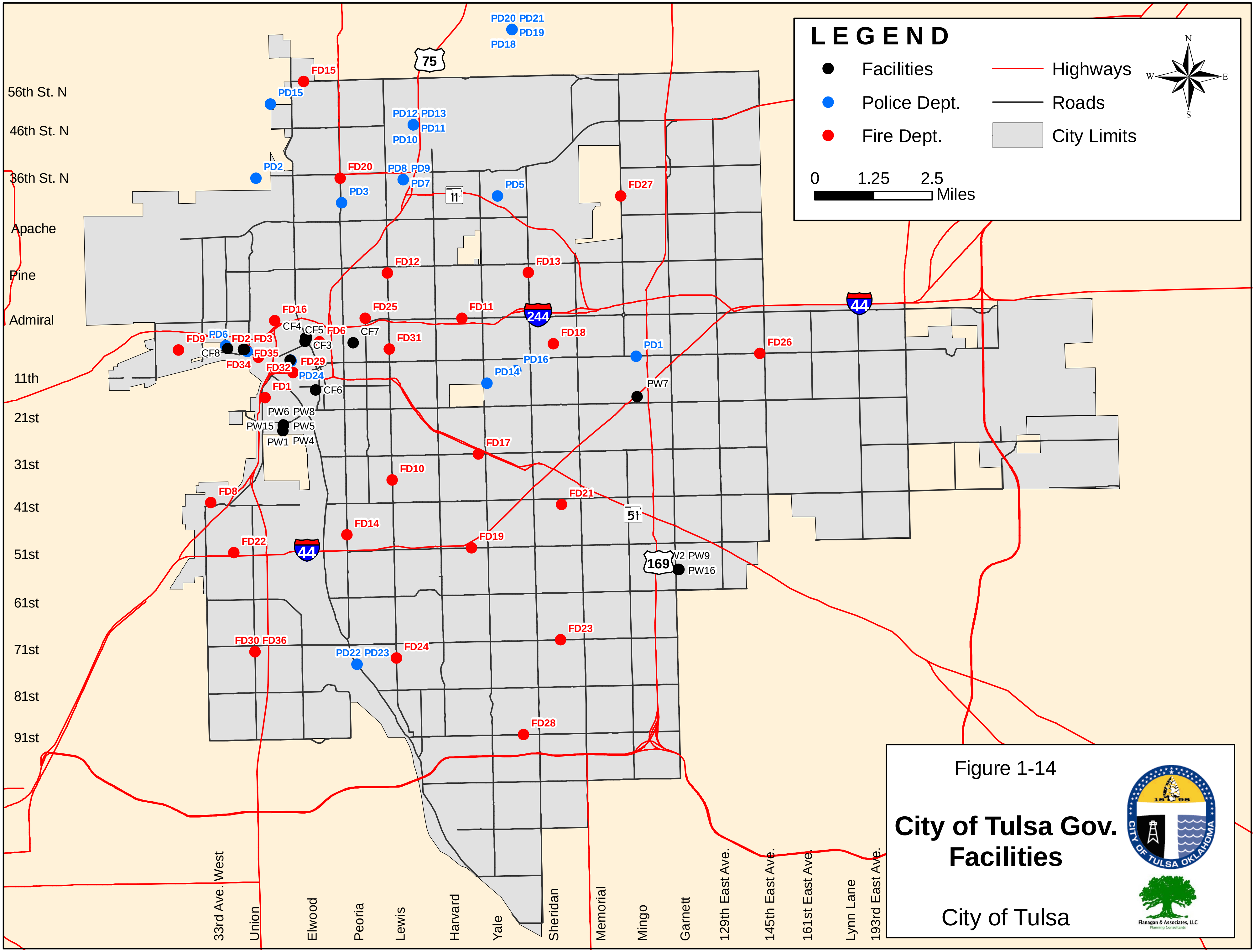


Figure 1-14

City of Tulsa Gov. Facilities

City of Tulsa

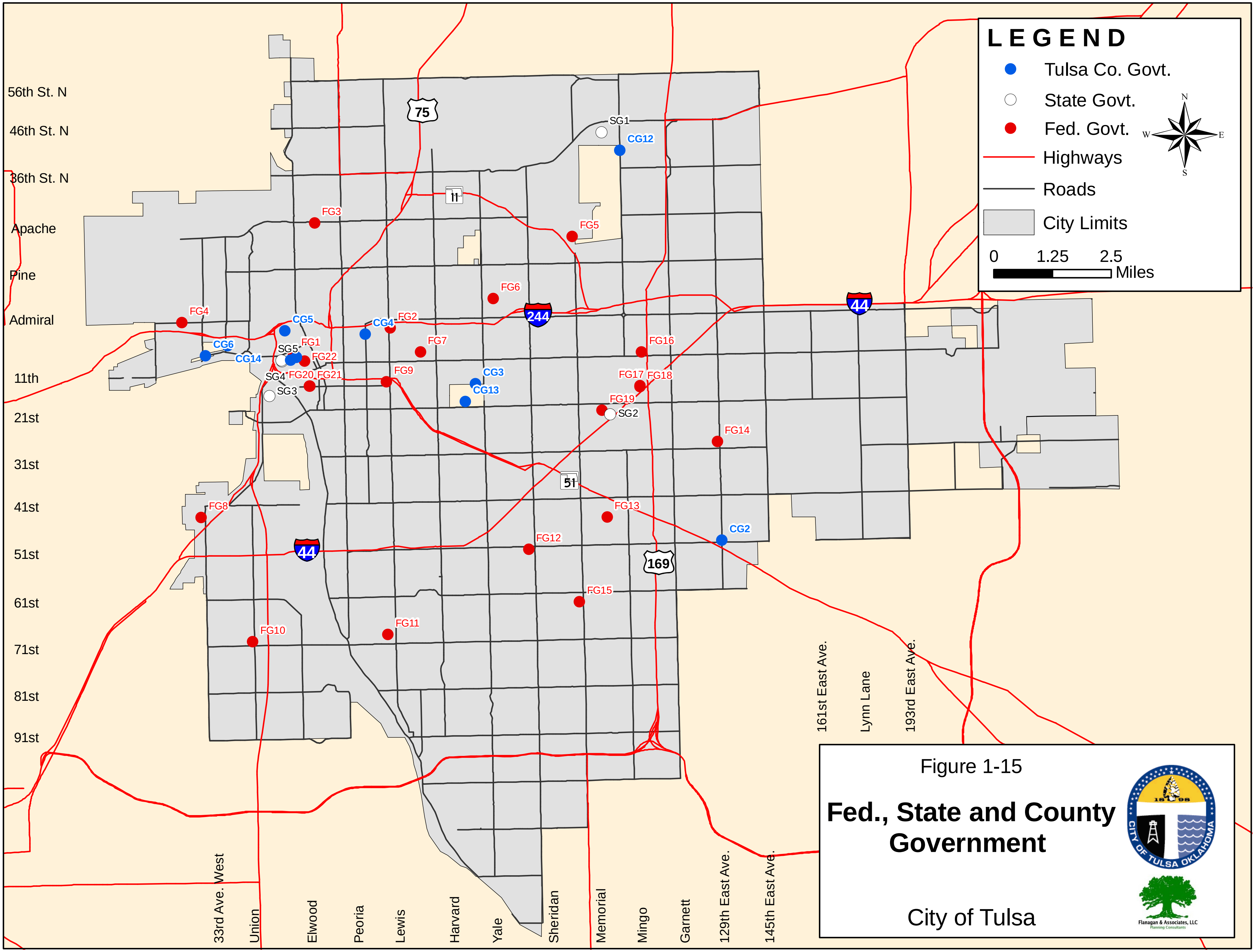


Figure 1-15

Fed., State and County Government

City of Tulsa

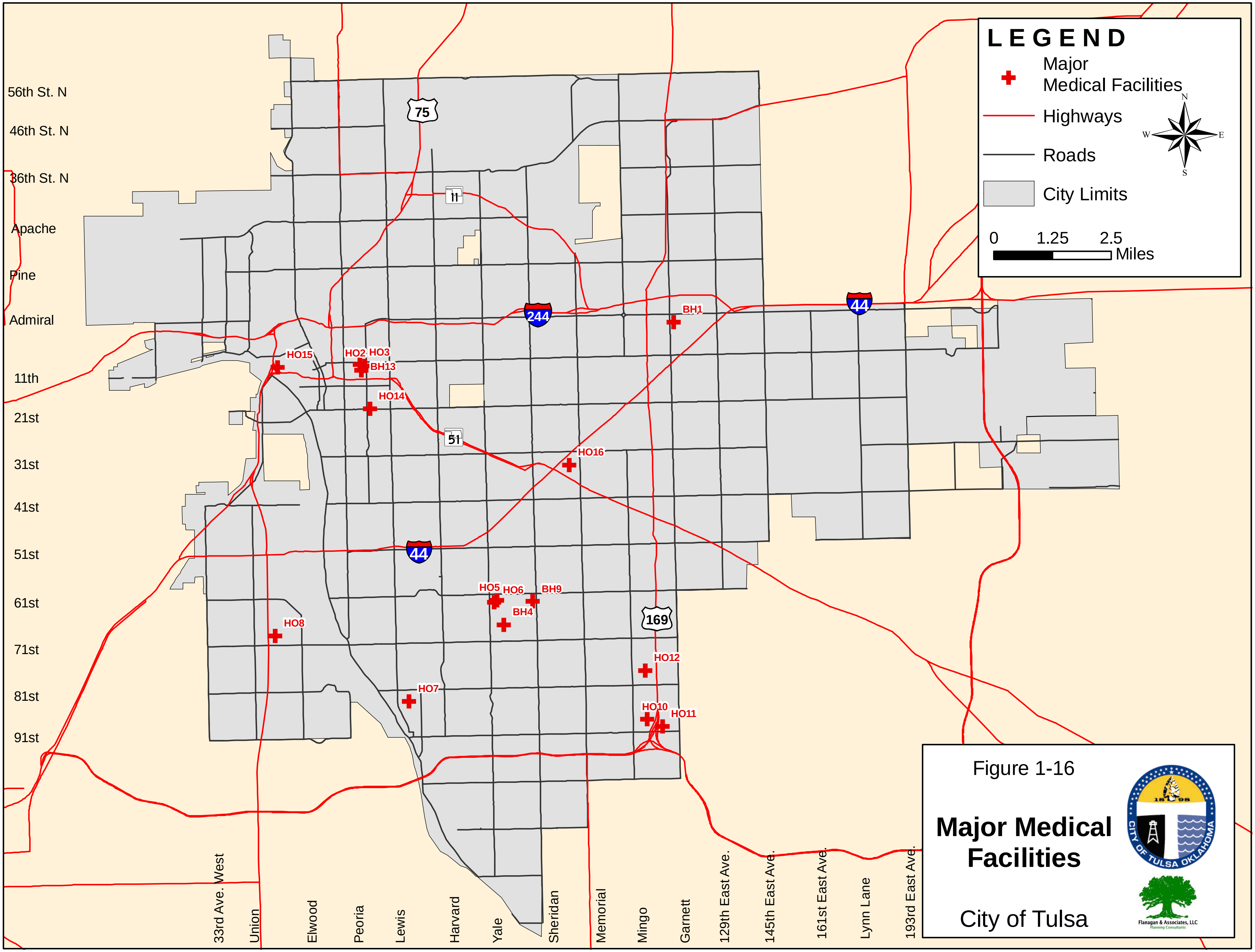


Figure 1-16

Major Medical Facilities

City of Tulsa

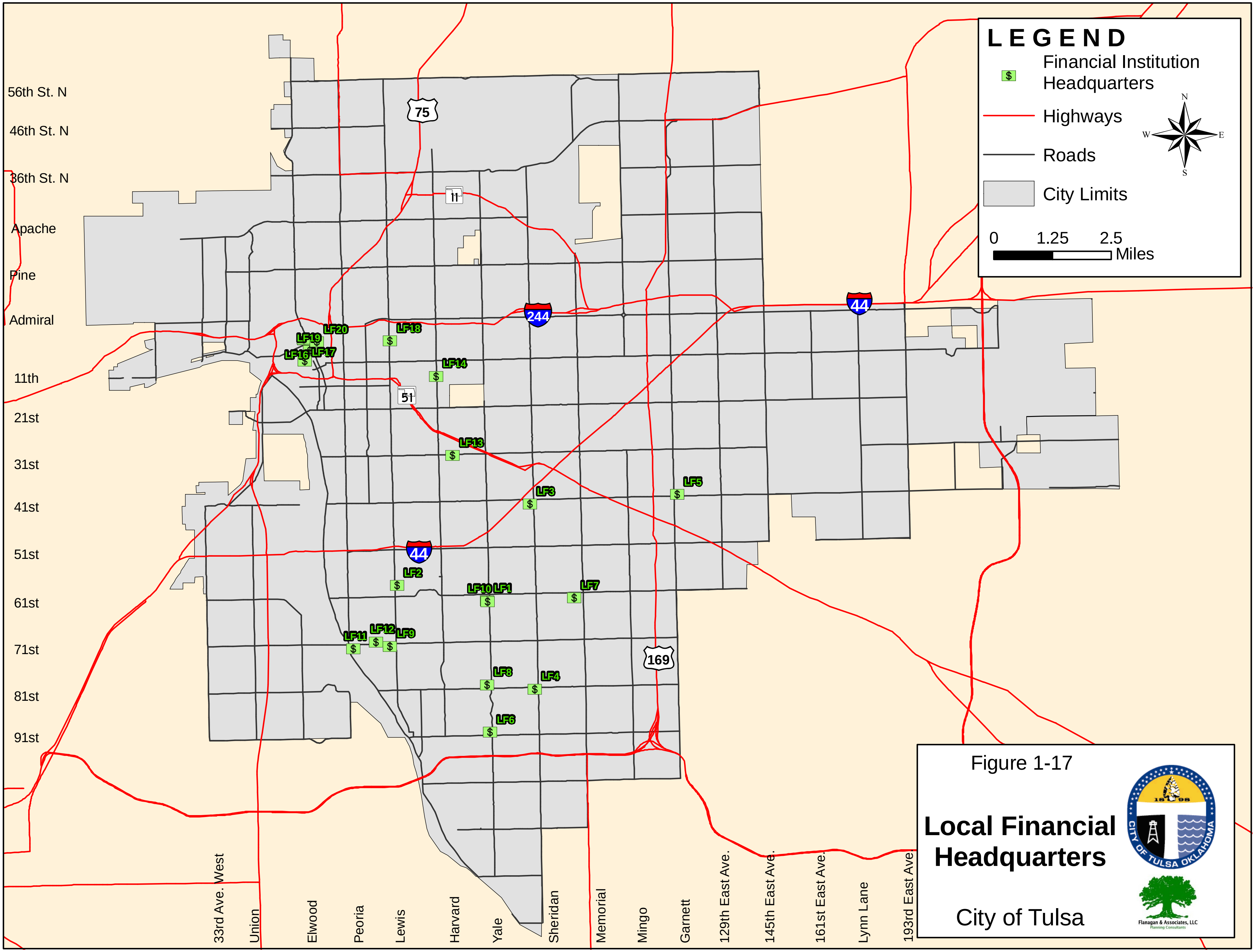


Figure 1-17

Local Financial Headquarters

City of Tulsa

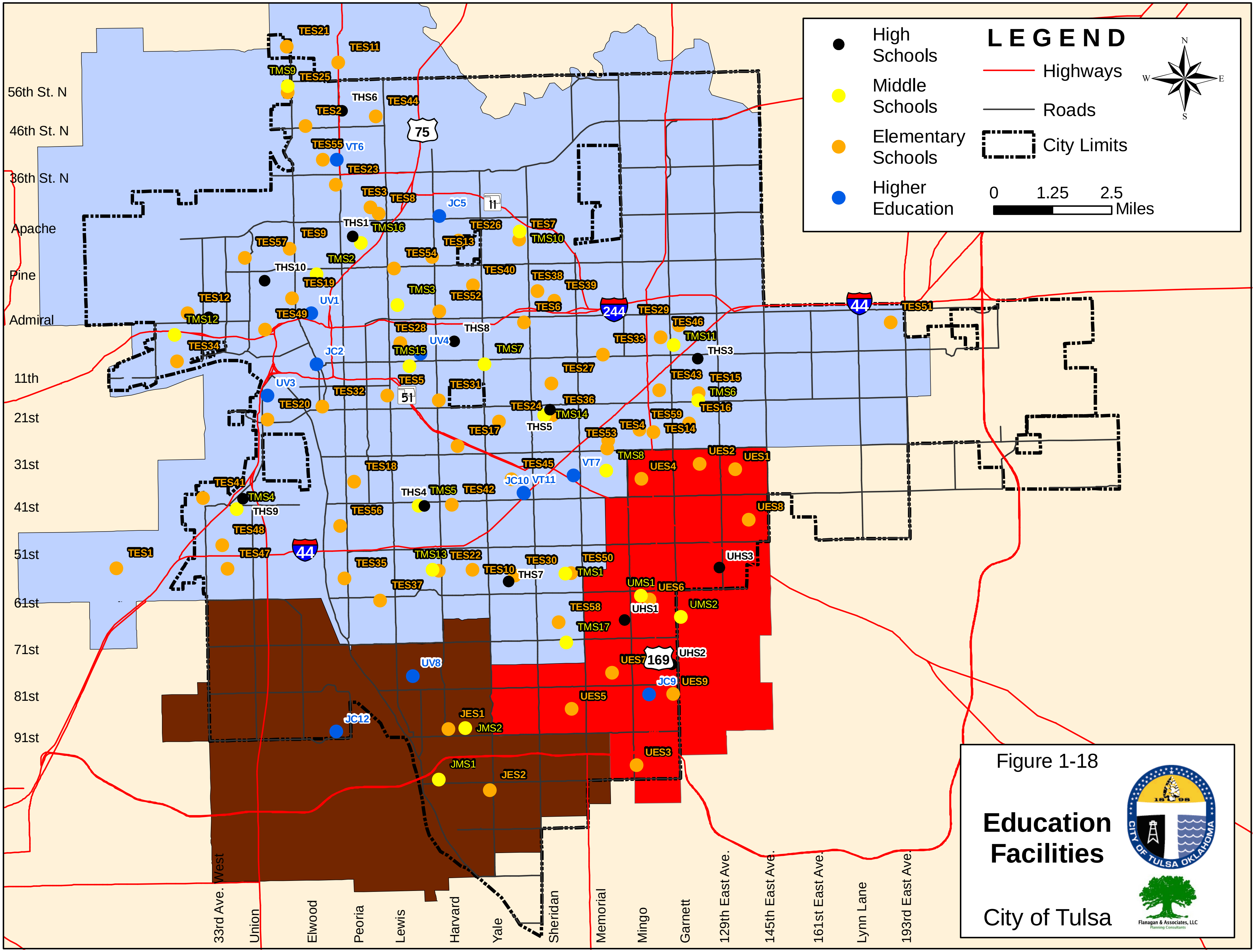


Figure 1-18

Education Facilities

City of Tulsa

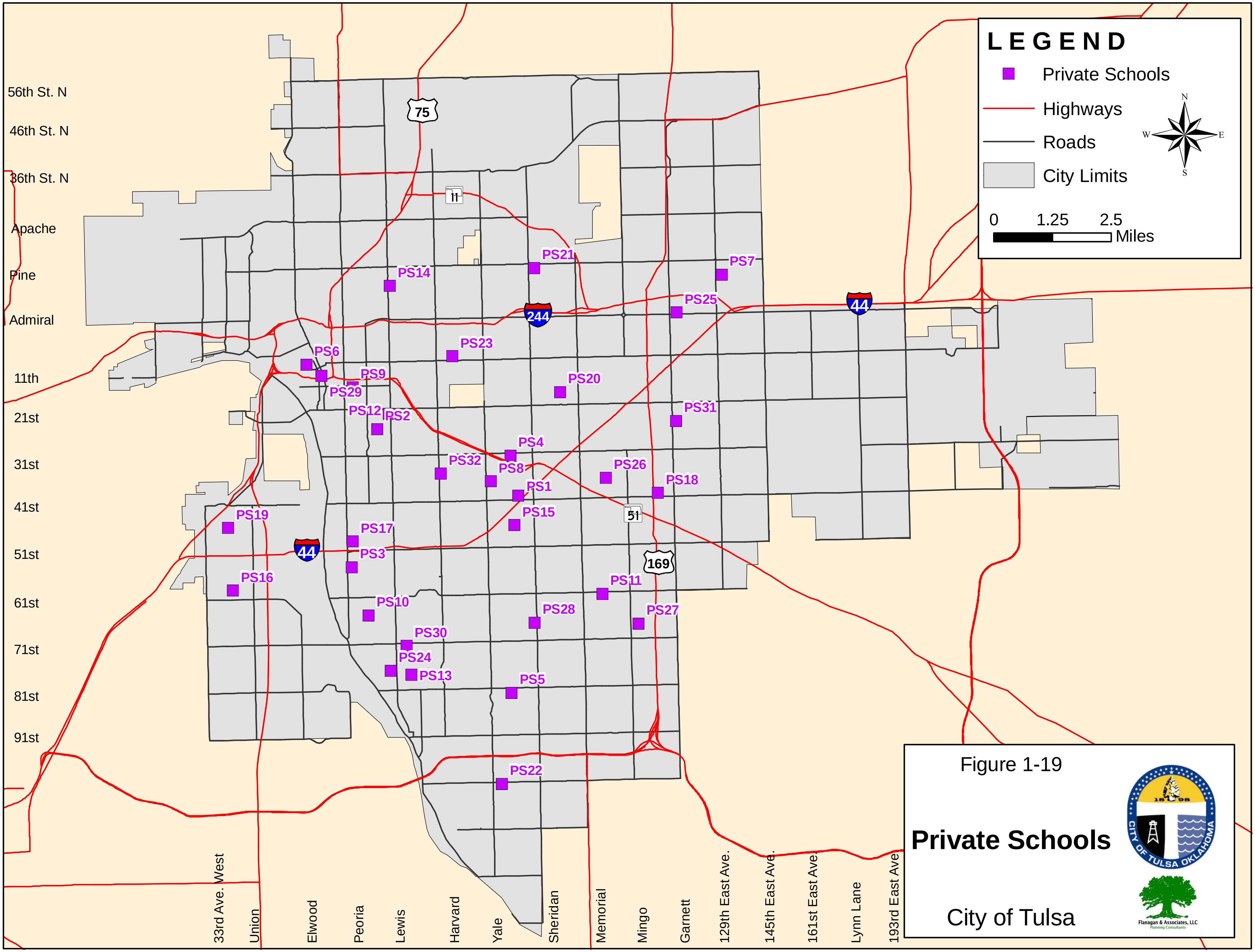


Figure 1-19

Private Schools

City of Tulsa

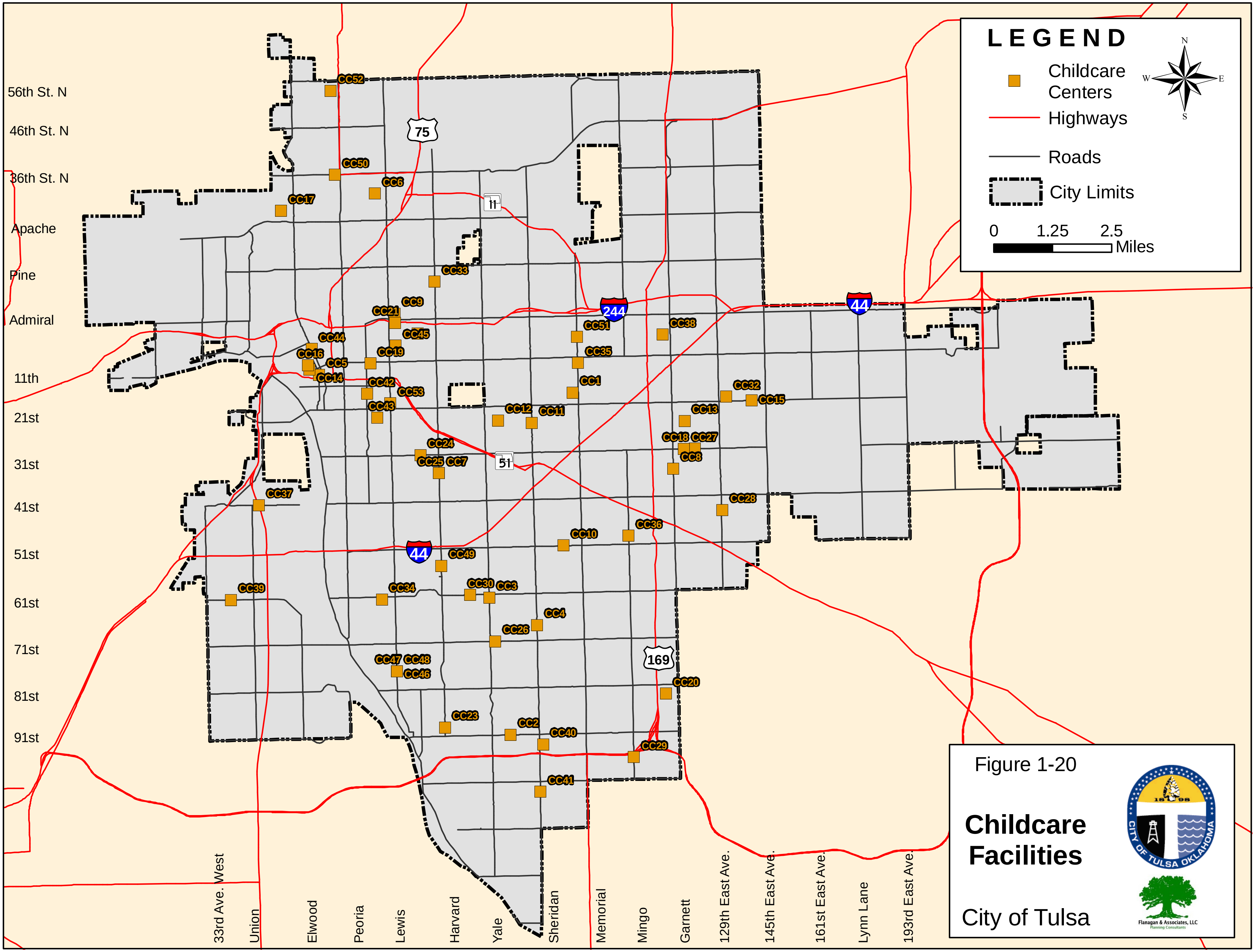
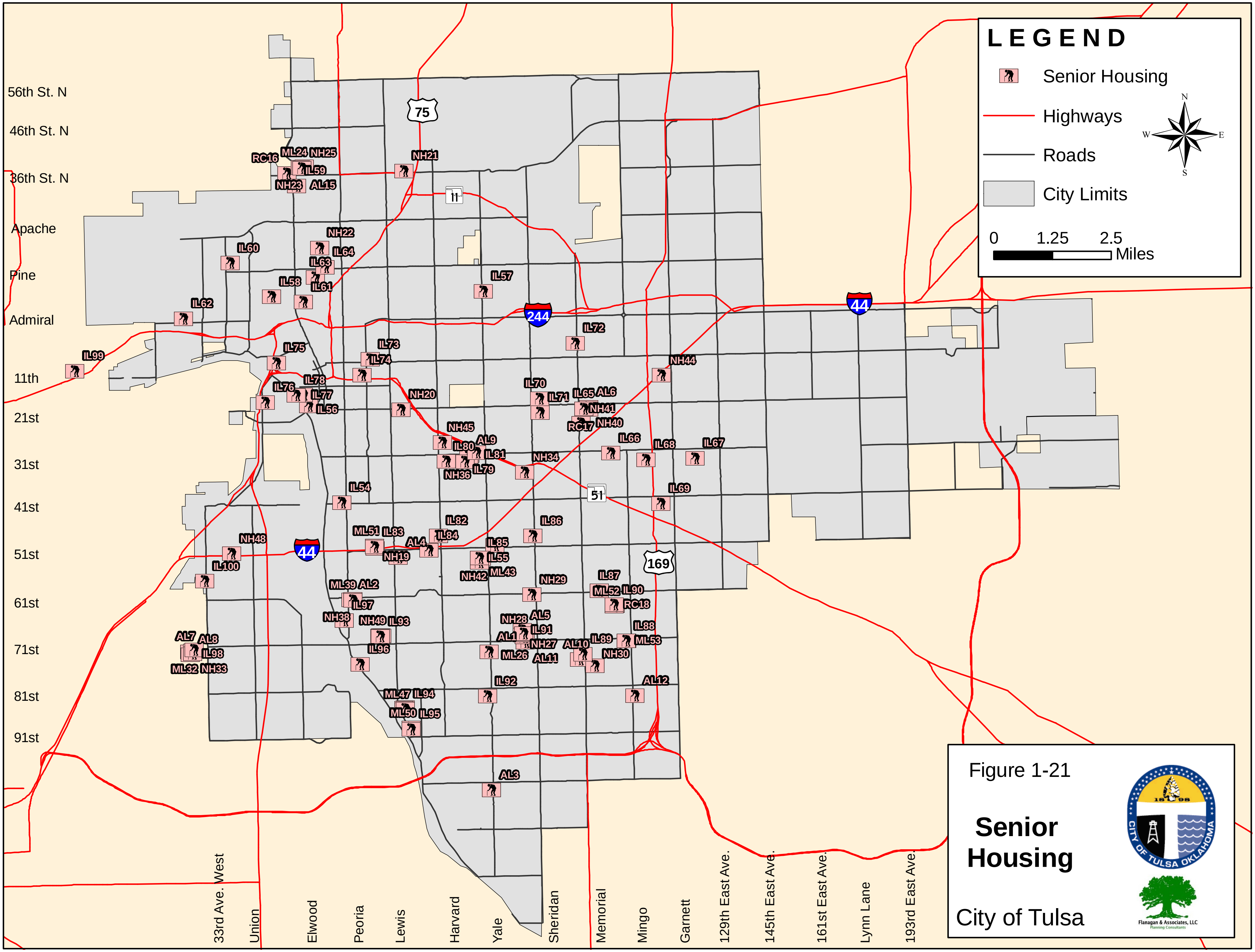


Figure 1-20

Childcare Facilities

City of Tulsa


LEGEND
Senior Housing
Highways
Roads
City Limits
N
S
E
W
0
1.25
2.5
Miles
56th St. N
46th St. N
36th St. N
Apache
Pine
Admiral
11th
21st
31st
41st
51st
61st
71st
81st
91st
33rd Ave. West
Union
Elwood
Peoria
Lewis
Harvard
Yale
Sheridan
Memorial
Mingo
Garnett
129th East Ave.
145th East Ave.
161st East Ave.
Lynn Lane
193rd East Ave.
75
11
244
44
51
169
RC16 ML24 NH25
IL59
NH23 AL15
NH21
NH22
IL60
IL64
IL63
IL58
IL61
IL57
IL62
IL99
IL75
IL73
IL74
IL72
NH44
IL78
IL76
IL77
IL56
NH20
IL70
IL71
IL65 AL6
NH41
RC17 NH40
NH45
AL9
IL80
IL81
IL79
NH36
NH34
IL66
IL68
IL67
IL54
IL69
IL86
IL82
ML51 IL83
IL84
AL4
IL85
IL55
NH19
NH42 ML43
NH48
IL100
ML39 AL2
IL97
NH38
NH49 IL93
IL96
NH29
IL87
ML52 IL90
RC18
NH28 AL5
AL1
IL91
NH27
ML26
AL11
AL10
IL89
NH30
IL88
ML53
AL7 AL8
IL98
ML32 NH33
IL92
AL12
ML47 IL94
ML50 IL95
AL3
Figure 1-21
Senior Housing
City of Tulsa
1898
CITY OF TULSA OKLAHOMA
Flanagan & Associates, LLC

Chapter 2: Existing Mitigation Strategies

2.1 About Hazard Mitigation Programs

Included in this Chapter:

2.1 About Hazard Mitigation Programs
2.2 Public Information and Education
2.3 Preventive Measures
2.4 Structural Projects
2.5 Property Protection
2.6 Emergency Response Procedures & Resources
2.7 Natural Resource Protection

Communities can do a number of things to prevent or mitigate the impacts of natural disasters. Such actions range from instituting regulatory measures (e.g., building and zoning codes) and establishing Emergency Operations Plans and Emergency Operations Centers, to purchasing fire trucks and ambulances and constructing large and small infrastructure projects like levees and safe rooms. Most communities have already made considerable investments in these critical areas. The sections that follow in this Chapter survey the regulations, plans and infrastructure that the community has in place for avoiding or mitigating the impacts of natural hazards. This survey is based on FEMA's *State and Local Mitigation Planning How-to Guide* (FEMA 386-1, September 2002), and covers the following topics: Public Information and Education, Prevention, Structural Projects, Property Protection, Emergency Services, and Natural Resource Protection.

There are several national hazard mitigation programs developed by FEMA and other agencies that are designed to help communities organize their mitigation activities to achieve tangible results in specific areas, such as flood protection and fire hazard abatement. This section looks at Tulsa's participation and progress in these national programs.

The Planning Team reviewed relevant community studies, plans, reports, and technical documents in the inventory, evaluation and planning phases of the Multi-Hazard Mitigation Plan development. The Comprehensive Plan was used to determine community growth patterns and identify areas of future development. The Capital Improvements Plan was used to determine priorities of public infrastructure improvements, and timing of potential future development. These plans were used to identify areas of future growth and development so that hazardous areas could be identified, evaluated, planned for, and appropriate mitigation measures taken.

2.1.1 National Flood Insurance Program (NFIP)

For decades, the national response to flood disasters was simply to provide disaster relief to flood victims. Funded by citizen tax dollars, this approach failed to reduce losses and didn't provide a way to cover the damage costs of all flood victims. To compound the problem, the public generally couldn't buy flood coverage from insurance companies, because private insurance companies see floods as too costly to insure.

In the face of mounting flood losses and escalating costs of disaster relief to U.S. taxpayers, Congress established the National Flood Insurance Program (NFIP). The goals of the program are to reduce future flood damage through floodplain management, and to provide people with flood insurance. Community participation in the NFIP is voluntary.

Tulsa joined the National Flood Insurance Program in 1971. All residents of Tulsa are eligible to purchase federal flood insurance. Tulsa's advances have earned its flood program one of the top ratings in the nation through the Community Rating System, which has allowed Tulsans to enjoy some of the lowest flood insurance rates in the nation. The City of Tulsa continues to maintain full compliance with the NFIP.

Community Rating System (CRS)

The CRS is a part of the National Flood Insurance Program that helps coordinate all flood-related activities of the City. Tulsa has participated in the National Flood Insurance Program (NFIP) since 1971 and in the CRS since 1991. The CRS is a voluntary program that seeks to reduce flood losses, facilitate accurate insurance rating, and promote awareness of flood insurance by creating incentives for a community to go beyond minimum floodplain management requirements. The incentives are in the form of insurance premium discounts. CRS ratings are on a 10-point scale (from 10 to 1), with residents of the community who live within FEMA's Special Flood Hazard Areas (SFHA) receiving a 5% reduction in flood insurance rates for every Class improvement in the community's CRS rating. The City takes part in the following CRS activities:

- Public information activities
- Mapping and regulatory activities
- Flood damage reduction activities
- Flood preparedness activities

Tulsa advanced from a Class 5 to a Class 3 community on October 1, 2000, and to a Class 2 community on October 1, 2003, making the City's flood insurance rates the lowest in the country. In October 2006, Roseville, CA gained the distinction of becoming a class 1 CRS community, which placed Tulsa as the second lowest flood insurance rates in the country. The Class 2 rating allows Tulsa's SFHA residents a forty percent reduction in their flood insurance premium rates. All rates are based on where the structure is located in FEMA's Flood Insurance Rate Maps (FIRMs). Current FIRMs were published April 2003, and new Digital Maps (DFIRMs) are expected to be released in the near future.

Tulsa has had 2,106 pre-FIRM flood insurance policy claims totaling $36,947,506 and 74 post-FIRM policy claims totaling $1,259,747 since 1978.

2.1.2 Firewise Community

The Firewise Community certification is a project of the National Wildfire Coordinating Group. It recognizes communities that have gone through a process to reduce the dangers of wildfires along what is referred to as the Wildland-Urban Interface. A specialist from Firewise Communities USA will work with the local community to assess wildfire dangers and create a plan that identifies agreed-upon achievable solutions to be implemented. For additional information on Firewise Communities, see Chapter 5, Section 5.2.9 or visit www.firewise.org/usa/. Tulsa does not participate in the Firewise Community program, however a major long-term care facility, St. Simeon's in North Tulsa, is considering going through the Certification process.

2.1.3 Fire Protection Rating

ISO's Public Protection Classification (PPC) program provides important information about municipal fire-protection services, which, in the past, was used by insurance companies to establish fire insurance premiums. Currently most fire insurance rates are determined by actual loss figures and history within specific zip codes. The PPC program does help communities plan for, budget, and justify improvements in order to mitigate the effects of the fire hazard.

A uniform set of criteria is used to evaluate a community's fire protection service and rate it on a scale from 1 to 10, where lower numbers indicate a better rating. These criteria incorporates nationally recognized standards developed by the National Fire Protection Association and the American Water Works Association. The evaluation inventories and analyzes the following segments of fire protection resources:

- Fire Alarm and Communication Systems – including telephone systems and lines, staffing, and dispatching systems
- The Fire Department – including equipment, staffing, training, and geographic distribution of fire companies
- The Water Supply System – including condition and maintenance of hydrants, and a careful evaluation of the amount of available water compared with the amount needed to suppress fires.

City of Tulsa Fire Protection Rating

Tulsa's fire protection rating went from a 4 to a 3 in 2007.

2.1.4 StormReady Community

StormReady is a nationwide community preparedness program that began in Tulsa in 1999, and uses a grassroots approach to help communities develop plans to handle all types of severe weather—from tornadoes to tsunamis. The program encourages communities to take a new, proactive approach to improving local hazardous weather operations by providing emergency managers with clear-cut guidelines on how to improve their hazardous weather operations. To be officially StormReady, a community must:

- Establish a 24-hour warning point and emergency operations center;
- Have more than one way to receive severe weather warnings and forecasts and to alert the public;
- Create a system that monitors weather conditions locally;
- Promote the importance of public readiness through community seminars;
- Develop a formal hazardous weather plan, which includes training severe weather spotters and holding emergency exercises.

Additional information can be found at http://www.stormready.noaa.gov/.

Tulsa has been certified as a StormReady Community since 1999.

2.1.5 Business Continuity Mitigation and Planning Programs

The shutdown or permanent loss of businesses can be particularly devastating to a community for a number of reasons.

1. Loss of a business can negatively affect the city's tax base and revenue. In 1993, a tornado struck in the area of Catoosa, Oklahoma, destroying a number of residences and a major truck stop on Interstate 44. The truck stop, and associated traffic and personnel it attracted, supported restaurants, clothing stores, motels, and numerous other businesses in the area. Overall, the loss of the one business cost the community almost 50% of its tax base until the truck stop was able to reopen.
2. Closing of a business may eliminate jobs, not only for the employees of that particular company, but also for vendors for and customers of the affected business. Following a severe tornado in Oklahoma City in 2002 that affected large parts of the community, including a General Motors plant, hundreds of workers were temporarily unemployed, putting a severe strain on the social service agencies for the area.

A great deal of the mitigation information in this document is applicable to residential, public, and commercial properties. When available, the plan will include business-specific information and strategies. For further discussion on business vulnerability and the importance of Business Continuity Planning (BCP), see Chapter 5, Section 5.2.9.

The City of Tulsa is served by the Disaster Resistant Business Council (DRBC), a coalition of a number of groups, including the Tulsa Metro Chamber, Red Cross, R.D. Flanagan & Associates, Family & Children's Services, the Oklahoma Department of Insurance, the Tulsa Health Department, State Farm Insurance, and others. The DRBC is a program of Tulsa Partners Inc., and has worked since 2004 to promote and support business continuity planning with small businesses, long term care facilities, hospitals, and non-profit agencies. For more information, see www.tulsapartners.org/DRBC.

2.2 Public Information and Education

Public information and education strategies are an important part of any successful program to mitigate the loss of life and property from natural and man-made hazards. Examples of such strategies include outreach projects, hazard information distribution, and school age and adult education programs. This section examines the existing communications infrastructure in and around Tulsa, and the programs and activities that the City currently has in place to serve this purpose. See Chapter 5 and Appendix B for discussion of potential activities and programs within this category.

2.2.1 Public Information Infrastructure

Television/Radio

Cable television is supplied by Cox Cable. Tulsa's government access Channel 23 is available to all Cox subscribers. Tulsa is served by the following TV stations:

Table 2–1: Tulsa Area Television Stations

Channel	Call sign	Network	Owner
2	KJRH-TV	NBC	E.W. Scripps Company
6	KOTV-TV	CBS	Griffin Communications
8	KTUL-TV	ABC	Allbritton Communications Company
11	KOED-TV	PBS	Oklahoma Educational Television Authority
19	KQCW-TV	The CW	Griffin Communications
23	KOKI-TV	FOX	Clear Channel
35	KRSC-TV	Educational	Rogers State University
41	KMYT-TV	MyNetworkTV	Clear Channel
44	KTPX-TV	ION Television	ION Media Networks
47	KWHB-TV	Religious	LeSea Broadcasting
51	KXAP-TV	Hispanic	Perez Broadcasting
53	KGEB-TV	Religious	Oral Roberts University

Tulsa is also served by 11 AM radio stations and 19 FM stations.**Telephone, Wireless and Cable Service**

Tulsa has an advanced telecommunications infrastructure comparable to most large metropolitan areas. The primary telecom provider is AT&T (formerly Southwestern Bell). In addition, there are a number of cellular and private telecom providers. Cox Cable also provides VOIP telephone service in the area.

AT&T offers digital DMS 100 central switch; fiber optic trunk line; 75,000 available line capacity; MCI and AT&T points of presence; and 99.9% redundancy.

Newspapers

Tulsa's morning and Sunday newspaper is the *Tulsa World.* In addition, an African American community newspaper, *The Oklahoma Eagle,* a Hispanic community newspaper, *Hispano de Tulsa*, and an American Indian newspaper, *Native American*

Times, serve the area. Tulsa is also served by two business newspapers, several suburban and metro area weeklies, and the University of Tulsa *Collegian*.

2.2.2 Outreach Programs

Outreach Programs, as the name implies, are designed to inform the community about natural hazards and measures that can be taken to protect against them. Tulsa has outreach programs through the Tulsa Fire Department, City of Tulsa Public Works, American Red Cross, Tulsa Area Emergency Management and a number of other organizations. The City also maintains a comprehensive Internet web site that posts local ordinances and agency contact information, as well as City Commission agendas and meeting minutes. Tulsa videotapes its City Commission meetings and broadcasts them over its public access Channel 23 (T-GOV).

Tulsa City government has a close relationship with the local newspaper, the *Tulsa World,* which serves as a reliable outlet for municipal news releases on hazard related issues. The *Tulsa World* provides coverage of City Council and Planning Commission meetings, and makes itself available for in-depth presentations and discussions of matters of local importance. The *Tulsa World* makes their articles available to the public via the Internet, www.tulsaworld.com.

The City of Tulsa has an outreach program for informing citizens about natural hazards, how to prevent or mitigate their impacts, and what resources the community has to assist in damage prevention, mitigation and recovery. For example, over the past three years (2003-2006) the *Tulsa World* has carried articles on family preparedness, tornado mitigation, lightning safety, house and wildfire mitigation, flooding, storm drainage, floodplain regulations, dam safety, the City's EOC, storm sirens, the Red Cross, amateur radio operators, storm spotters, and hazard mitigation planning.

Other local outreach efforts include:

- The Emergency Operations Center (EOC) and the National Weather Service Tulsa Forecasting Office offers presentations to groups interested in storm preparedness.
- The EOC has direct access to the cable television system and local radio stations to alert citizens in the event of an emergency.
- Tulsa's Mayor issues a declaration supporting September as being National Preparedness Month.
- The National Weather Service and local ham radio groups offer classes for future storm spotters.
- Tulsa Fire Department has an active Public Education Department, which includes the Fire Department Clowns.
- The Tulsa Fire Department coordinates Project Life, a program designed to inundate a high-risk square mile with free smoke detectors and battery replacements.
- The Governor declared April to be McReady Oklahoma Family Preparedness Month and Tulsa participated in the state-wide "McReady" program, distributing

hazard mitigation literature at kiosks in McDonalds restaurants and at City facilities.

- Tulsa Partners provides a number of outreach programs in the community including, but not limited to:
  - An annual conference on *Emergency Preparedness for Long Term Care Facilities*;
  - The Disaster Resistant Business Council provides opportunities for businesses to develop business continuity plans;
  - Children's workshops, developed in conjunction with the national organization *Save the Children*, are presented in elementary schools and childcare centers.

City of Tulsa Radio/TV Programs/Communications

Meetings of Tulsa's City Council are advertised on the Internet and broadcast over Channel 24 (T-Gov).

Tulsa's Emergency Manager has direct access to the cable television system and local radio to alert citizens of emergencies.

In addition, an overview of the Hazard Mitigation Plan is made available on the City of Tulsa's website.

2.3 Preventive Measures

Preventive measures are defined as government administrative or regulatory actions or processes that influence the way land and buildings are developed and built. This section contains a summary of the current ordinances and codes that relate to land use, zoning, subdivision, and stormwater management in the City of Tulsa. See Chapter 5 and Appendix B for discussion of potential activities and programs within this category.

2.3.1 Planning and Zoning Ordinances

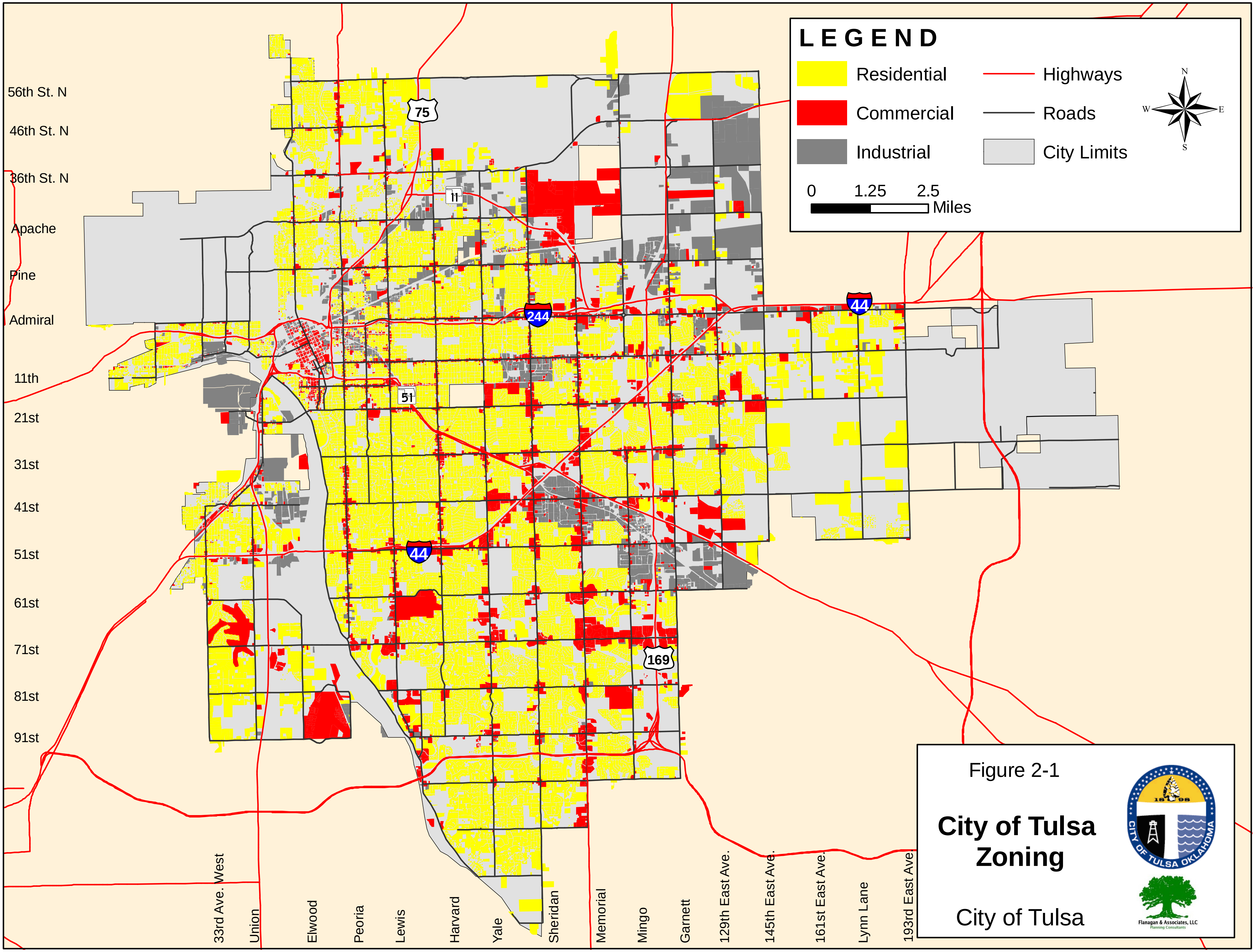
Tulsa's *Comprehensive Plan* defines policies for providing guidance and direction of the City's physical development. It covers ordinances for land use, zoning and subdivision, and the development of standards for transportation and public facilities. The original plan, adopted in 1924, contained Tulsa's first zoning ordinances. It was revised in 1960, and again in 1976, when a land use plan was added. Early in 2007, the City of Tulsa began a process to update its Comprehensive Plan.

The City's zoning ordinances and subdivision regulations are in Title 42, Tulsa Revised Ordinances, "The Tulsa Zoning Code" (1/1/1997) Zoning and Property Restrictions. The ordinances contain regulations for such things as building location and construction, mobile home location and protection, hazardous materials industries, and development in special flood hazard areas. A map of City zoning is presented as Figure 2-1.

The purpose of zoning is to:

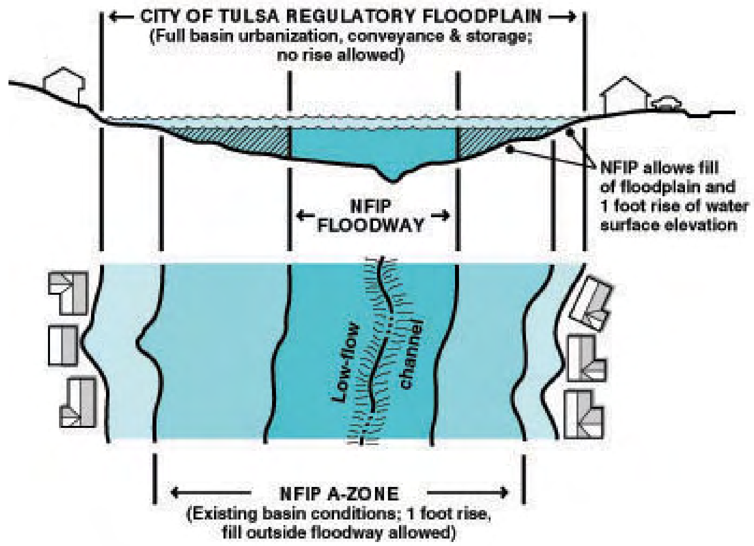
1. Encourage the most appropriate uses of land according to the policies set forth in the Tulsa Comprehensive Plan;
2. Maintain and stabilize the value of property;
3. Secure safety from fire and other damages to public health and safety;
4. Provide adequate light and air;
5. Decrease traffic congestion and its accompanying hazards;
6. Prevent undue concentration of population;
7. Create a comprehensive and stable pattern of land use upon which to plan for water supply, transportation, sewers, schools, parks, public utilities, and other facilities.

Currently the city is zoned into residential, commercial, industrial, public, agriculture and university districts. These districts regulate such things as land use, lot sizes, setbacks, parking, and landscaping requirements. Currently, there are 21 zoning districts, supplemented by special overlay districts, which assign specific criteria to the underlying zoning. These special overlay districts include planned development districts, redevelopment districts, and the downtown district.


LEGEND
Residential
Commercial
Industrial
Highways
Roads
City Limits
N
S
E
W
0
1.25
2.5
Miles
56th St. N
46th St. N
36th St. N
Apache
Pine
Admiral
11th
21st
31st
41st
51st
61st
71st
81st
91st
33rd Ave. West
Union
Elwood
Peoria
Lewis
Harvard
Yale
Sheridan
Memorial
Mingo
Garnett
129th East Ave.
145th East Ave.
161st East Ave.
Lynn Lane
193rd East Ave.
75
11
51
244
44
169
Figure 2-1
City of Tulsa Zoning
City of Tulsa
CITY OF TULSA OKLAHOMA
Flanagan & Associates, LLC

2.3.2 Flood and Stormwater Management

Tulsa has grown up with flooding. The city was settled on a major river, in a weather convergence zone with violent spring and autumn storms, on a frontier where people believed they had a right to do what they wanted with their land. After many years of repeated floods, the community instituted improved floodplain management practices that constitute one of the most respected flood programs in the nation.



Tulsa welcomes growth, so long as it does not flood or cause flooding elsewhere

Unlike many communities, the City of Tulsa regulates to a higher standard in three categories of so-called "100-year" floodplain areas:

- As a minimum standard, the FEMA Special Flood-Hazard Area is an area that has a 1% chance of flooding in any given year. FEMA SFHA floodplains are designated on FEMA's Flood Insurance Rate Maps (FIRM). The SFHA identifies the National Flood Insurance Program's (NFIP) minimum national standard, which reflects only existing development conditions at the time of the study.
- City of Tulsa regulatory floodplain areas, which are calculated by a different standard. They take into account "100-year" flooding that would occur when contributing watersheds are fully developed. Therefore, Tulsa regulatory floodplain areas may be wider than the FEMA floodplains and may extend farther up creeks and waterways.
- Floodways, generally the most dangerous center strip along a water course where water is apt to run faster and deeper. Tulsa applies more stringent regulations in floodways because of the higher risk there.

Throughout this report, "floodplain" will mean specifically the City of Tulsa regulatory floodplain, unless otherwise noted.

Because the SFHA, the national minimum standard, deals with existing conditions and does not take the impacts of future urbanization into account in its modeling or floodplain map delineations, buildings that have been permitted and built in accordance with the National Flood Insurance Program's (NFIP) minimum standards may flood in the future as the basins develop. This is why the City of Tulsa regulates to a higher standard, requiring that no insurable structure will be built that has its first finished floor less than 1 foot above the Base Flood Elevation (BFE).

Without requirements for upstream detention of excess flows and compensatory storage (both also required by Tulsa), piping and paving for future urbanization and development can cause an increase in urban stormwater runoff and flood depths. In some instances, it could cause discharges to double and can widen the floodplain and cause increases in the Base Flood Elevation (BFE).

Between 1980-2000, the City of Tulsa created master drainage plans for each of its major waterways that serve as the framework for flood management planning and programs. For the dates when those were completed, see Table 2-2.

Over the past three decades, both the frequency and severity of flooding have been greatly reduced by improved management and land use practices, but Tulsa's climate ensures that larger than 100-year rains will continue to occur over the city's future, with periodic damages. In addition, the potential for larger-than-100-year rains will continue, with a perennial risk for catastrophic floods. The first citywide master drainage plan was the *Flood and Stormwater Management Plan 1990–2005*. This plan prioritizes and coordinates the flood protection projects that are detailed in the city's 29 master drainage plans. The last revision of the plan was September 7, 2001. (Refer to Table 2–2, Master Drainage Plans and Basins.) The plan oversees the following:

- Capital Improvement Program (see next section)
- Non-Structural Mitigation/Acquisition Priority List

The City later developed the *Flood and Stormwater Management Plan 1999-2014*, published on September 10, 1998. It was developed in accordance with planning criteria from the Community Rating System (CRS), Flood Mitigation Assistance (FMA), and Hazard Mitigation Grant Program (HMGP). Although the 1999-2014 plan primarily dealt with flooding, it also addressed other natural hazards. The *Flood and Stormwater Management Plan* recommended stormwater capital improvements projects. The prioritized list of recommended stormwater projects is located in Appendix F. Tulsa has established a stormwater management fee dedicated to stormwater mitigation projects.

2.3.3 Building Codes

Tulsa has adopted the following Building Codes:

- International Building Code, 2003 Edition
- International Fire Code, 2003 Edition
- International Residential Code, 2003 Edition
- International Plumbing Code, 2003 Edition
- International Fuel Gas Code, 2003 Edition
- International Mechanical Code, 2003 Edition
- International Property Maintenance Code, 2003 Edition
- International Private Sewage Disposal Code, 2003 Edition
- National Electrical Code, 2003 Edition

Table 2–2: Master Drainage Plans and Basins

Plan Name	Creeks Watersheds	Year Completed
Bird	Bird	1993
Cherry/Red Fork	Cherry Red Fork	1982
Coal	Coal	1987
Crow	Crow Swan Travis Park	1989
Dirty Butter	Dirty Butter	1987
Downtown	Central Bus. Dist.	1993
Elm	Elm / Update	1988/2008
Flatrock	Flatrock Valley View	1987
Fred	Fred	1988
Fry Ditch #2	Fry Ditch #2	1989
Garden City	Garden City	1987
Haikey	Haikey Little Haikey	1989
Joe Mainstem	Mainstem, Joe No Study	
Joe, East & West	Upper Joe, E/W	1989
Little Joe	Little Joe (Upper)	1992
South Fork Joe	Joe, South Fork	1982
Mingo Creek	Mainstem (USACE)	No MDP
Cooley	Cooley	1980
Lower Mingo	Little Quarry Eagle Douglas	1991
Lower Mid Mingo	Tupelo Mill Jones	1980
Mingo Creek Upper Mill/Jones (Update)	Upper Mill Upper Jones Upper Audubon	1993
Upper Mid Mingo	Audubon Bell Brookhollow Fulton SouthPark Sugar	1981
Upper Tup/Brook (Update)	Upper Tupelo Upper Brookhollow	1994
Upper Mingo	Alsuma Catfish Ford Mainstem	1988
Northwest	Bigheart Harlow Parkview Oak Lower Basin	1989
Perryman	Perryman	1988
South Tulsa Basin	South Tulsa	1992
Southwest	Mooser Nickel Hager	1988
Spunky Adams	Adams Center Pond Reservoir Spunky	1989
Vensel	Vensel	1978
Vensel (Update)	Vensel	1994

2.3.4 Other Preventive Measures

All water distribution pump stations presently have backup generators with the exception of Turkey Mount, which is in the process of being backed up. Water treatment plants currently do not have generators, but a plan is being developed by the City to have generators at the plants capable of treating and distributing a minimum of 10 MGD/plant.

All sanitary sewer pump stations either have back-up generators or are on redundant electrical feeds. During the recent major ice storm in December, 2007, during which some of the pump stations on redundant feeds temporarily lost power, there were no overflows as a result.

2.4 Structural Projects

Some of Tulsa's most beautiful parks serve double-duty as flood control and detention facilities

Structural projects are usually designed by engineers and architects, constructed by the public sector, and maintained and managed by governmental entities. They typically include such projects as stormwater detention reservoirs, levees and floodwalls, channel modifications, drainage and storm sewer improvements, and community tornado safe-rooms. The following section includes measures that are already in place or included in current planning. See Chapter 5 and Appendix B for discussion of potential activities and programs within this category.

2.4.1 City of Tulsa Capital Improvements Plans

The City of Tulsa's Capital Improvements Plan lists approved street, building, water, sewer, and stormwater capital improvement needs, their costs, priority, and 5-year funding schedule. Capital improvements projects identified for hazard mitigation purposes – such as flood, tornadoes, high winds, and drought – are listed in Appendix F.

Some of the more significant projects either ongoing or planned are:

- Ongoing stormwater and drainage projects funded by the City's stormwater utility assessment;
- Development of a new Emergency Operations Center; and
- Recent completion of a new Emergency Communications (9-1-1/dispatch) Center.

2.5 Property Protection

Property protection measures are used to modify buildings or property that are subject to damage from various hazardous events. The property owner normally implements property protection measures. However, in many cases technical and financial assistance can be provided by a governmental agency. Property protection measures typically include acquisition and relocation, flood-proofing, building elevation, barriers, retrofitting, safe rooms, hail resistant roofing, insurance, and the like. The following section includes examples of property protection measures which have already been implemented within the City of Tulsa or which are part of current projects. See Chapter 5 and Appendix B for discussion of potential activities and programs within this category.

2.5.1 City of Tulsa Property Protection

Expansive Soils: Tulsa typically runs a soils report before beginning any City construction. Building elevation and meeting current 2006 IBC codes that highlight safety concerns are two other areas that are considered part of the normal business process.

Expansive Soils/Extreme Heat: For the last 25 years, water and sewer lines have been bedded in sand or gravel to reduce the risk from line breakage due to expansive soils and increased water usage during extreme heat. This is more of a problem with older pipelines, and breaks from increased demand is more common than breaks from soil movement.

Hail: Providing hail resistant roofing is considered when the project budget can accommodate the added cost. Flood proofing, SafeRooms and lightning protection are typically considered on a site-by-site basis based on the critical nature of the facility.

Lightning: Critical facilities such as telecommunications and water treatment plants have lightning protection. In addition, the airport and the Police Academy have lightning protection. All individual city of Tulsa computers have surge protection, but not robust enough to protect against a significant lightning strike, and lightning protection is not typically included in the design of new facilities unless there is considerable or sensitive electronics and computer equipment.

Tornados/High Winds: The new 911 Center is divided into zones, with the operations area designed to withstand 250 mph winds, while the administrative office area is designed to withstand an F1 or F2 level tornado.

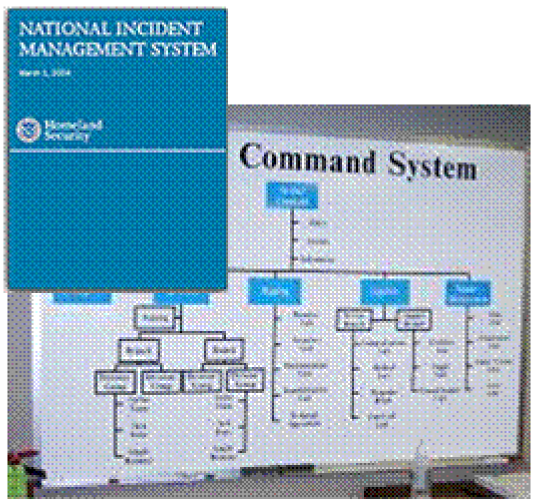
2.6 Emergency Response Procedures and Resources

In times of emergency, it is critical that a community have resources available to respond in an efficient manner to a hazard event. This section outlines Tulsa's current emergency response procedures, notification and warning systems, critical facility protection and available emergency response resources. See Chapter 5 and Appendix B for discussion of potential activities and programs within this category.

2.6.1 National Incident Management System (NIMS)

In 2004, Homeland Security Presidential Directive #5 (HSPD-5) was issued stating that, in order to be eligible for certain Federal disaster mitigation funding, state, local, and tribal jurisdictions must incorporate the use of the National Incident Management System (NIMS) into their protocols.

The NIMS incorporates a system currently used called Incident Command System (ICS), a management system developed by the fire service to provide a common language, common management protocols, and scalable incident response chains-of-command that can be applied to any emergency response, whether it be a single family fire to a major tornado event. ICS also allows for "unified command" for situations where multiple agencies may be in charge of various aspects of the operation



A typical Emergency Operations Center ICS Assignment Board

The NIMS enhances ICS by establishing a single, comprehensive system for incident management to help achieve greater cooperation among departments and agencies at all levels of government.

For further information on integrating NIMS/ICS into an Emergency Operations Plan, see the NIMS Integration Center at www.fema.gov/emergency/nims/nims.shtm. Available information includes *Local and Tribal Integration: Integrating the National Incident Management System into Local and Tribal Emergency Operations Plans and Standard Operating Procedures*, available at www.fema.gov/pdf/emergency/nims/eop-sop_local_online.pdf.

For a jurisdiction to be "NIMS Compliant," the following conditions must be met:

1. NIMS must be incorporated into existing training programs and exercises. Training will include, but not be limited to, completing FEMA course IS 700, *National Incident Management System, an Introduction.* The course is available on the FEMA website at training.fema.gov/EMIWeb/IS/is700.asp.
2. The jurisdiction must formally recognize NIMS and adopt NIMS principles and policies. State, territorial, tribal, and local entities should establish legislation, executive orders, resolutions or ordinances to formally adopt NIMS.

3. A baseline must be established by determining which NIMS requirements the jurisdiction already meets. As gaps in compliance with NIMS are identified, entities should use existing initiatives such as the Office for Domestic Preparedness (ODP) Homeland Security grant programs to develop strategies for addressing those gaps.
4. The concepts of NIMS must be incorporated into the Emergency Operations Plan (EOP).
5. A timeframe for fully implementing NIMS must be established.
6. As of FY 2007, Federal preparedness assistance became dependent upon the entity being fully NIMS compliant.

The City of Tulsa and Tulsa County have met all the preceding conditions and are both fully NIMS compliant.

2.6.2 Emergency Operation Plan

The *Tulsa Area Emergency Operations Plan,* updated in September 2007, was evaluated during the planning process to ensure that it adequately addressed the hazards identified in the Multi-Hazard Mitigation Plan, and that the Plan took the EOP into account during the planning process.

The City of Tulsa's emergency procedures are authorized by Title 8, "Civil Defense and Civil Emergencies," of the *City Ordinances*. The Tulsa Emergency Manager reports to both City and County jointly. The EM is responsible for developing written plans, and in an emergency shall enforce all emergency rules and regulations, and if necessary take control of transportation, communications, stocks of fuel, food, clothing, medicine, and public utilities for the purpose of protecting the civilian population.

In the event of a civil emergency, the mayor may proclaim a state of emergency in any part of the city affected. These emergency powers include the authority to impose curfew, limit assembly, restrict the transport of weapons and explosives, prohibit the dispensing or purchase of alcoholic beverages, and block the use of certain public streets or highways.

Tulsa's City/County *Emergency Operations Plan* (EOP) defines who does what, when, where, and how in order to mitigate, prepare for, respond to and recover from natural disasters, technological accidents, nuclear incidents, and other major incidents/hazards. The Plan is comprehensive in that it deals with mitigation and preparation activities, as well as response and recovery.

The EOP establishes the Emergency Operations Center (EOC), lays out emergency tasks and responsibilities, direction and control, continuity of government, and administration and logistics. The EOP is reviewed and tested at least once each year.

Emergency response is directed and executed by five operational groups:

- **Policy Group**, made up of the Mayor and four members of the community who, as a rule, are elected officials. This is the decision making group for all policy-level decisions. During an emergency, the Committee will advise and direct the activities of the entire response organization through the EOC emergency service coordinators.

- **Emergency Services Coordination Group**, comprised of the City department/agency heads and led by the Emergency Management Director, who acts as Chief of Operations. The Group includes the Police Chief, Fire Chief, Public Works Director, Health and Medical Coordinator, Shelter Coordinator, Resources Coordinator, and an EOC Staff Coordinator appointed by the Director.
- **Operations Staff** is composed of Officers-in-Charge of communications, damage assessment, public information, administration, transportation, warning/reporting, and shelter management/evacuation.
- **Emergency Service Coordinators**, made up of City department directors and volunteers with the functional expertise required to adequately respond to most emergencies, are responsible for the operation of their own departments and coordination with other departments and agencies.
- **EOC Support and Special Staff**, comprised of volunteers and employees with skills and training in areas essential to a total response to an emergency, assist the Emergency Service Coordinators, and perform other functions and critical tasks outside the scope of government departments.

The EOP contains procedures and responsibilities for the five operational groups, and includes report forms, contact lists and telephone numbers, damage assessment procedures, equipment sources, critical facilities, hazardous materials sites, shelter locations, volunteer groups, and other community resources, and references.

The Plan has general response procedures applicable to a wide range of natural and man-made disasters, as well as instructions for specific emergencies, such as HAZMAT events, bomb threats, and terrorism. Also included are instructions for setting up incident command posts, shelters, and staging areas and handling mass evacuations.

2.6.3 Emergency Operations Center

Tulsa Emergency Operations Center

The Emergency Operations Center (EOC), located in the basement of the Police/Municipal Courts Building in the City Hall complex, may be activated by any member of the Policy Group when it appears that any portion of Tulsa is, or may be, threatened with loss of life or extensive property damage.

During major emergencies, Tulsa's City government will be moved to the EOC. Tulsa's backup EOC is at Tulsa County Fairgrounds. The establishment and operation of the EOC is covered in detail in Tulsa's *Emergency Operations Plan*.

The Emergency Management Director (EMD) is responsible for coordinating all phases of the emergency management program, including emergency planning and training, education and warning, and communications. The EMD makes routine decisions and advises the Policy Group on alternatives when major decisions are required of that body. During emergencies, the EMD is responsible for the proper functioning of the EOC and its staff and acts as liaison with other local, county, state, and federal emergency management agencies.

The EOC has three stages of operation: Normal Peacetime Readiness, Increased Readiness, and Emergency Period.

- **Normal Peacetime Readiness.** Ensure the EOC is properly equipped and operationally ready; test warning system; review and revise *Emergency Operation Plan*; educate public as to warning signals; practice emergency operations with City officials and departments.
- **Increased Readiness.** Policy Group is advised of emergency measures; prepare EOC for activation; review EOC procedures and brief EOC staff; obtain necessary supplies; test internal and external communications; coordinate feeding of EOC staff.
- **Emergency Period.** Sound warning system; activate EOC; establish security; establish internal and external communications; move essential City functions to EOC.

The EOC is equipped with a communications center with all the necessary communications equipment. An emergency generator with fuel for a substantial period is available. During an emergency, the EOC operates on a two-shift, around the clock basis. An incident command post may be set up to coordinate activities at the site of a disaster. When necessary, offices and equipment at City Hall are available to support emergency operations.

During an emergency, the EOC may effectively become the seat of City government for the duration of the crisis. Day-to-day functions that do not contribute directly to response actions may be suspended for the duration of the emergency.

The City of Tulsa and the EOC keep an index of citizen storm shelters, so that in the aftermath of a disaster that spreads debris over shelters, emergency rescue teams will know where to begin looking for survivors.

2.6.4 Emergency Notification and Warning Systems

Warning systems may be activated from any level of government by agencies having responsibility to notify the public of imminent danger. At the local level these warnings are channeled through the Emergency Management Director in order to assign responsibility and ensure control of the warning process.

2.6.4.1 Tulsa Emergency Notification and Warning Systems

Emergency Alert System (EAS) Communication

While the Emergency Alert System (EAS) was designed to give the president a means by which to address the American people in the case of a national emergency, it has been used since 1963 by local emergency management personnel for relay of local emergency broadcasts. EAS, which is controlled by the Federal Communications Commission (FCC), utilizes FM, AM, and TV broadcast stations, as well as cable and wireless cable providers to relay emergency messages.

Table 2–3: EAS stations in or near Tulsa

Facility	Frequency	City	Facility	Frequency	City
EAS FM radio stations					
KHJM	100.3	Tulsa	**KNYD**	90.5	Broken Arrow
KXOJ FM	100.9	Tulsa	**KIZS**	92.1	Broken Arrow
KTBT	101.5	Collinsville	**KBEZ**	92.9	Tulsa
KRTQ	102.3	Sand Springs	**KEMX**	94.5	Tulsa
KJSR	103.3	Tulsa	**KWEN**	95.5	Tulsa
KJMM	105.3	Bixby	**KRAV**	96.5	Tulsa
KQLL	106.1	Owasso	**KMOD**	97.5	Tulsa
KHTT	106.9	Muskogee	**KVOO FM**	98.5	Tulsa
KWGS	89.5	Tulsa	**KXBL**	99.5	Tulsa
EAS AM radio stations					
KGTO	1050	Tulsa	**KTBZ**	1430	Tulsa
KFAQ	1170	Tulsa	**KXOJ**	1550	Sapulpa
KAKC	1300	Tulsa	**KRMG**	740	Tulsa
KTFX	1340	Sand Springs	**KCFO**	970	Tulsa
KMUS	1380	Sperry			
TV broadcast stations					
KWBT	19	Tulsa	**KPAX**	44	Tulsa
KJRH	2 (NBC)	Tulsa	**KWHB**	47	Tulsa
KOKI	23 (FOX)	Tulsa	**KOPE**	51	Tulsa
K39CW	39	Tulsa	**KGEB**	53	Tulsa
KTFO	41	Tulsa	**KOTV**	6 (CBS)	Tulsa
KTPX	44	Tulsa	**KTUL**	8 (ABC)	Tulsa
Cable TV					
Cox Cable of Tulsa (Local television override is available)					

Emergency warnings are received and disseminated through the National Warning System (NAWAS). NAWAS is a protected, full time, voice communication system interconnecting the National Warning Center and numerous warning points in each state. Oklahoma has one primary state warning point, 2 alternate state warning points, and 30 secondary warning points. The primary point is at Oklahoma Highway Patrol headquarters in Oklahoma City. Alternates are located in the Oklahoma Department of Emergency Management EOC and the National Guard EOC. The 30 secondary points are located in OHP district headquarters, sheriff/police departments, fire departments, and local EOCs throughout the state.

TAEMA is one of the in-state warning points for NAWAS. This system is answered in both the EOC and the Public Safety Response Center.

SkyWarn (Weather Spotters) is a national program designed to place personnel in the field to spot and track tornadoes. They are trained by NWS and instructed in what to report. Teams are made up of government employees and private citizens. During severe weather, storm spotters relay reports to their coordinator in the EOC. Confirmed tornado sightings are relayed to the NWS, which then disseminates appropriate warnings.

Notifications of severe weather or other serious hazard are relayed to the public through Tulsa’s siren warning system, mobile teams, and TV/Cable override, as authorized by the Mayor, Policy Group, Emergency Manager or Police or Fire Department personnel. Instructions to activate the warning system are channeled through the Emergency Management Director, if time permits, to fix a single point of responsibility for the warnings and ensure control.

Tulsa’s EOC has installed NOAA weather radios at all public buildings and schools. The EOC has the capability of overriding local radio and television stations, including cable channels. The emergency warning messages are generic, alerting the public of the danger and advising what to do or where to get further information.

Members of Tulsa’s deaf and hard-of-hearing community are served by two state programs that can facilitate alerts and warnings:

- OK-WARN is the Oklahoma Weather Alert Remote Notification program for emergency weather/situation notification service via pagers and/or E-mail addresses. The hazardous weather pager program gives deaf and hard-of-hearing Oklahoman's better access to important severe weather information. The success of a pilot program in 2001 led to the creation of OK-WARN, which now provides life-saving messages about tornadoes, severe thunderstorms, winter storms, flash floods, river floods and high wind warnings from local National Weather Service offices to deaf and hard-of-hearing people who sign up for the service. There is no cost for qualified deaf and hard of hearing persons.
- The State Department of Rehabilitation Services can (a division of Oklahoma Department of Health) provide free NOAA weather radios specially adapted to the needs of the deaf and hard of hearing community with such accessories as strobes and bed shakers.

Flood Alert System

Tulsa installed a flood alert system in 1984, with the help of FEMA and the National Weather Service. The system monitors rainfall and stream levels to provide advance warning of potential flooding. (SNP, 09-04-05)

The City is in the process of updating this system so that emergency personnel can monitor the rainfall and stream gauges from remote locations via the internet. The new system will also include a satellite modem so that it is still accessible if normal internet connections are lost.

Warning Sirens

There are 84 outdoor warning sirens serving the City of Tulsa. The sirens cover a radius of 4,100 feet, and they can also be used as an outdoor public address system. The location of the warning sirens is shown in Figure 2-2. Each of the City’s warning sirens has been installed or existing sirens upgraded since 1984. Since most sirens have a service life of approximately 20 years, a number of sirens will need to be replaced in the near future.

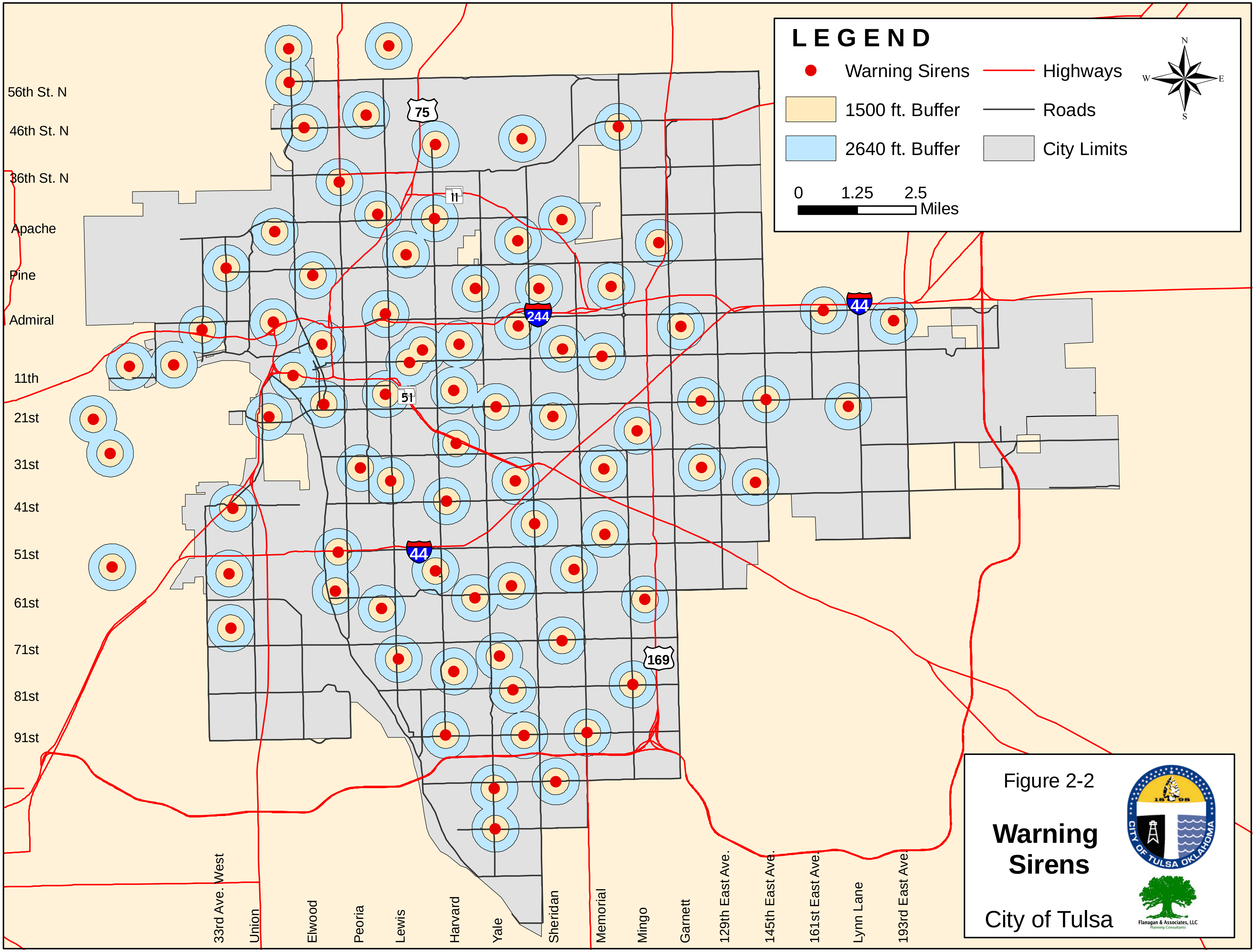


Figure 2-2

Warning Sirens

City of Tulsa

Each warning siren is radio controlled and operates off of two deep 3-cell wet cell batteries that are kept charged by a 110 VAC floating DC charger. Each siren has a two-way status, which allows it to communicate with the Tulsa EOC to report such things as loss of power, low battery voltage, or tampering.

The all clear is made over local radio stations and Cable Television and not over the warning sirens.

Warning sirens are audibly tested weekly at noon on Wednesday, weather permitting. Tulsa Area Emergency Management Agency has primary responsibility for monitoring weather information and activating warning sirens. When the sirens are activated, TAEMA staff notifies the Public Safety Response Center (PSRC) as soon as practical. If the PSRC receives a tornado warning for Tulsa via the weather alert radio when TAEMA personnel are not available and/or the EOC is not staffed, the PSRC supervisor is authorized to sound the warning system and then notify the TAEMA director and/or EOC.

Table 2–4: Alert and Siren Signals

Type of Alert	***Hazard***	***Siren Signal***
Natural Disaster Alert	Tornado Warning	3-minute straight tone
Natural Disaster Alert	Flood Warning	3-minute slow high-low siren tone
Other Disaster Alerts	Nuclear Attack	3-minute wavering tone

2.6.5 Fire Safety Resources

2.6.5.1 Tulsa Fire Department and Resources

The Fire Department, with headquarters located at 411 S. Frankfort Avenue, employs 640 firefighters, including a Fire Chief, and 17 civilian personnel. The City has 30 fire stations, including the airport station, staffed by a minimum of 3 firefighters per shift per fire company, on a 24-hour basis. All firefighters are trained at various levels as First Responders, Emergency Medical Technicians, or Paramedics. The Department provides primary fire control and suppression for the City of Tulsa and Tulsa International Airport.

The City of Tulsa *Emergency Operations Plan* lists the emergency functions of the Fire Department as follows:

- Fire suppression
- Fire investigation
- Fire prevention and education
- Rescue operations
- Medical First Response
- Hazardous material operations
- Supporting the operation of the warning system
- Hazardous material decontamination
- Assisting in damage assessment
- Communication system support

Fire Department resources for fulfilling emergency functions are listed in Table 2-5.

Table 2–5: Fire Department Resources

Resource	Quantity	Resource	Quantity
Paramedics	65	Light Rescue Truck	2
Intermediate EMT	26	4-wheel-drive SUVs	6
Fire Stations	30	Squad Hazmat Truck	2
Pump Engine 1000+ GPM	29	Portable Generator	14
Brush Pumper	8	Portable Light System	2
Ladder Truck	14	Basic EMT	457
Staff Vehicle	42	Paramedics	65

Tulsa Fire Department has mutual aid agreements with all area Departments, and frequently assists with response in areas outside the Tulsa City Limits.

The Tulsa Fire Department (TFD) along with EMSA provides pre-hospital emergency medical service to the City of Tulsa, with the number of emergency medical calls continuing to increase each year. All Department firefighters are cross-trained in rescue and emergency medical skills. The City's EMTs are licensed by the Oklahoma State Department of Health and certified by the National Registry of Emergency Medical Technicians.

2.6.6 Public Safety Resources

2.6.6.1 Tulsa Police Department and Resources

The Police Department, located at Civic Center Plaza downtown, has over 900 employees, including 812 commissioned police officers. The Department is comprised of three major divisions, including the Administration Bureau, the Investigations Bureau (with a Detective and a Special Investigations Division, and the Forensics Lab), and the Operations Bureau. Operations is comprised of three separate facilities – Uniform Divisions North, Southwest, and East – and the Special Operations Division. In addition, Uniform Support services include Air Support, Mounted Patrol, K9, Bike Patrol and Motorcycle Patrol.

The City of Tulsa's *Emergency Operations Plan* lists the emergency functions of the Police Department as follows:

- Maintain law and order
- Traffic control
- Access control of restricted areas
- Security of vital facilities
- Operation of the backup warning system
- Communication system support
- Liaison with other law enforcement agencies
- Search and rescue operation support

Tulsa Police Department resources available for fulfilling emergency functions are listed in Table 2-6.

Table 2–6: Police Department Resources

Resource	Quantity	Resource	Quantity
Total Officers	812	Ford Expedition	2
Special Operations	48	Motorcycle Patrol	14
K-9 Units	14	Auxiliary/volunteers	48
Squad Cars	650	In-car Radio	650
Portable Generators	12	In-car Computer	650
Communications Van	1	Bull Horn	4
Prisoner Transport Van	4		

2.6.7 Public Works Department Resources

2.6.7.1 Tulsa Public Works Department and Resources

Tulsa's Public Works Department is located at various locations around the City. Under Tulsa's *Emergency Operations Plan*, the Public Works Department has the following responsibilities:

- Debris clearance
- Maintaining roads and bridges
- Assisting with damage assessment of public property
- Assisting in decontamination operations

In addition, the Inspection Services section has the responsibility in Tulsa's Emergency Plan to provide damage assessment for the affected areas of Tulsa. They have 40 field inspectors that are very familiar with locating addresses throughout the City of Tulsa. They report the scope and severity of affected properties for emergency and FEMA attention. After the initial emergency response they then provide detailed damage assessment to verify what structures are habitable or uninhabitable and the amount of damage to each structure.

Tulsa's Public Works Department resources available for fulfilling emergency functions are listed in Table 2-7.

Table 2–7: Public Works Department Resources

Resource	Quantity	Resource	Quantity
Total Employees	585	Pickup Trucks	95
Office Staff	75	Bucket Trucks	10
Total Field Personnel	461	Tool trucks	162
Portable Radios	403	Dump trucks	121
Hand-held Radios	154	Bulldozers/earthmovers	30
4-Wheel Drive Vehicle	59	Portable Light systems	12
Passenger Vehicles	40	Portable generators	56
Frontend Loaders	4		

2.6.8 Tulsa County Sheriff's Department Resources

The Tulsa County Sheriff's Department is located at 303 W. 1st St. in Tulsa. Under Tulsa's *Emergency Operations Plan*, the Sheriff's Department has the following responsibilities:

- Coordinate all law enforcement in the County
- Disseminate warnings throughout the County
- Coordinate relocation traffic control
- Coordinate mutual aid agreements
- Support emergency public safety activities
- Provide for security, protection and relocation of inmates in the County Jail.

The Tulsa County Sheriff Department resources available for fulfilling emergency functions are listed in Table 2-8.

Table 2–8: Tulsa County Sheriff Department Resources

Resource	Quantity	Resource	Quantity
Deputies	220	Rescue Boat	1
Office Staff	20	Air Boat	1
Reserves /Auxiliaries	150	Communications Van	5
Detention Staff	340	Hand-held radios	100
Vehicles with Radios	155	Portable Generators	4
EMTs	2	Aircraft (reserve)	5
Bomb Disposal	0	Mobile Crime Lab	1
Scuba Trained	8	Bull Horns	3
K-9 Units	1 bomb, 1 drug		

2.6.9 Other City, County, State and Federal Response

Tulsa City Clerk is responsible for City administrative and fiscal duties.

Tulsa City Attorney is responsible for legal and emergency information services and serves as a member of an advisory committee.

Superintendent of Tulsa Schools is responsible for providing buses for transporting evacuees, and for MOUs with neighboring jurisdictions for use of buses for evacuation.

Tulsa Civil Air Patrol assists with search and rescue and crowd control.

Tulsa County office of the State Medical Examiner, when committed:

- Collects, identifies, and coordinates interment of deceased disaster victims
- Coordinates funeral home support activities

Tulsa Health Department, when committed:

- Investigates sanitation conditions and establishes safe standards for crisis location, emergency shelter, or disaster relief operations
- Coordinates medical support and epidemic control
- Inspects food and water supplies
- Provides public health education

Tulsa County Office Department of Human Services, when committed:

- Provides provisions and funds for emergency aid
- Coordinates with the Red Cross and other volunteer agencies

Oklahoma National Guard, when committed:

- Assists in radiological protection
- Assists in law enforcement and traffic control
- Assists in search and rescue operations
- Provides military engineer support and assistance in debris clearance
- Provides logistical support with supply, transportation, maintenance and food service
- Provides communication support
- Provides chemical, biological, and radiological detection services

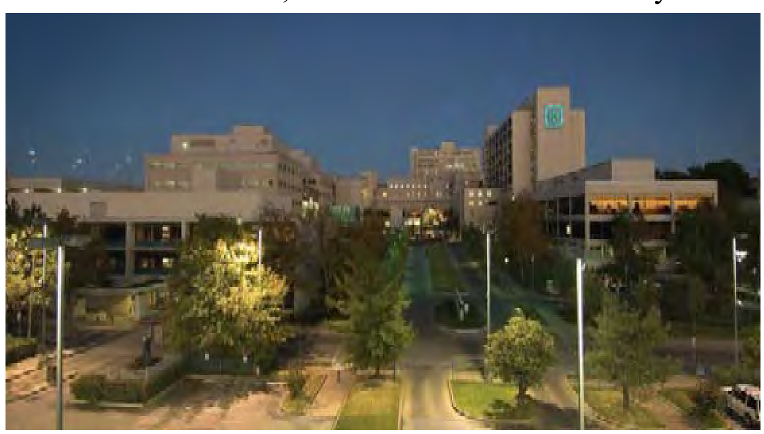
Other State and Federal agencies, when committed, assist with:

- Public welfare
- Resources
- Law enforcement
- Health and medical support and supplies
- Debris clearance
- Public information and education

2.6.10 Health Care Facilities and Shelters

Tulsa is home to four major medical centers and numerous specialty hospitals and clinics.

Hillcrest Medical Center, located in mid-town Tulsa, is a 493-licensed-bed tertiary medical center. In addition to the primary care facility, Hillcrest has facilities in Women's Healthcare, Exercise and Lifestyle, a Chest Pain Center, emergency department and trauma, cardiology unit, and a premier burn care unit.



Hillcrest Medical Center

St. Francis Medical System is a not-for-profit Catholic healthcare organization made of Saint Francis Hospital, Saint Francis Hospital at Broken Arrow, Laureate Psychiatric Clinic and Hospital, Warren Clinic, The Children's Hospital at Saint Francis, and Saint Francis Heart Hospital. It has a staff of nearly 7,000 full and part-time employees.

St. John Health System is a not-for-profit Catholic healthcare system operates hospitals in Tulsa, Owasso, Sapulpa, and Bartlesville. Other subsidiaries of St. John Health System include OMNI Medical Group primary care physicians, St. John Physicians, Inc. multi-specialty group practice, St. John Urgent Care Centers, St. John Villas Senior Living Centers and medical complexes in South Tulsa and Claremore.

OSU Medical Center, located in downtown Tulsa, is the largest osteopathic teaching facility in the country, with 15 postgraduate programs that train 126 residents each year in both primary care and sub-specialty areas. OSU Medical Center provides numerous highly specialized services, including a telemedicine program serving 35 regional hospital and clinic partners in rural Oklahoma through the OSU Center for Health Sciences. Among the other services offered are cardiology care, adolescent, geriatric and psychiatric care, and comprehensive wound care.

For locations of major healthcare facilities in the community, see Figure 1-16.

2.6.11 Medical Response and Coordination

The Tulsa County Medical Coordinator is one of the Emergency Medical Services Authority (EMSA) Directors. He will operate in accordance with the Tulsa Metropolitan Medical Response System (MMRS).

The City/County Health Director is responsible for:

- Inspects food and water to ensure safe supplies of both.
- Investigates sanitary conditions of emergency shelters and disaster relief operations to protect the health and safety of occupants and workers.
- Controls insects and rodents and employs other environmental health measures to prevent epidemics and the spread of disease.
- Provides core public health services, such as immunization programs and other related medical services.
- Disseminates public health information concerning safety issues and hazards.
- Monitors the community health status and reports identified public health problems to appropriate agencies.
- Provides limited hazardous materials emergency response capability.
- Enforces laws and regulations to protect public health and ensure safety.

The Tulsa Health Department maintains its own Emergency Operations Communications Center in the basement of the Health Department headquarters at S. 129th E. Ave. and E. 51st Street in the City of Tulsa.

TULSA HEALTH DEPARTMENT
Gary Cox, J.D. Director
5051 S. 129th East Avenue
Tulsa, OK 74134
(918) 582-9355
Web Site: http://www.tulsa-health.org/

In the event of a disaster, the Tulsa Area Chapter of the American Red Cross is responsible for identifying and managing public shelters, in cooperation with other appropriate agencies.

As of July 2008, Tulsa is home to 41 long-term care facilities with a total of 3,213 beds, including at least 131 dedicated to Alzheimer's patients. Tulsa Housing Authority maintains three high-rise facilities designed for the elderly and people with disabilities:

- Hewgley Terrace, 420 S. Lawton
- LaFortune Tower, 1725 Southwest Blvd.
- Pioneer Plaza, 901 N. Elgin

During an emergency or disaster, medical service providers are responsible for emergency medical care for victims, health care, and crisis counseling.

In the case of a disaster requiring shelters, the Superintendent of Tulsa Public Schools will assist with providing buses for transportation during disaster relief operations. The Tulsa Area Chapter of the American Red Cross will assist with shelter operation and support activities, supported by the Salvation Army, the County office of the Department of Human Services, the Tulsa Medical Reserve Corps, and the Tulsa Human Response Coalition. Emergency shelters will be drawn from a mixture of public and private resources and utilized according to the following priority: public schools first, followed by churches, government buildings, colleges/universities, and private buildings.

Ambulance service is provided by the Emergency Medical Services Authority, with support from Tulsa Fire Department. EMSA operates 30 ambulance units in its Eastern division with one basic EMT and one paramedic each, operating 24 hours a day, seven days a week staffed as needed by on-duty or off-duty personnel.

2.6.12 Volunteer and Community Support Organizations

- The **Tulsa Area Chapter of the American Red Cross** provides reception, care, food, lodging, and welfare assistance throughout northeastern Oklahoma; coordinates relief and shelter activities; and provides first aid support and blood supply, counseling, and damage assessment of private property.
- **Salvation Army** helps people in need of food, clothing, utilities, cleaning supplies, and life sustaining prescriptions. It also assists in finding missing persons and offers disaster services.
- The **United Way** provides assistance to Tulsa non-profits for such things as emergency food, clothing, shelter, utility bill assistance, counseling, literacy, advocacy and legal assistance.

- **Tulsa Community Action Program** (CAP) provides homeless services, including both emergency and transitional housing. Emergency shelter is offered to those with no resources who are in immediate need of shelter.
- **The Language & Culture Bank** is a group of people with identified proficiencies in cultural and language skills. The L&CB will support emergency response agencies during a disaster, whether single-family or catastrophic, in working with members of various cultural groups. It includes such groups as the Hispanic Chamber of Commerce, the YWCA Multi-Cultural Center, the TCC Language Center, Communication Services for the Deaf, the Jewish Federation, the Russian Golothic Church, the Islamic Foundation, and others.
- The Tulsa Red Cross maintains the **Community Emergency Response Team** (CERT) program. CERT volunteers are available to assist first responders (police, firefighters and EMS) during emergencies. CERT teams also assist in mitigation activities, including public awareness programs and other non-structural community mitigation measures. Additional information on CERT is included in Chapter 5, and is available on the Internet at www.citizencorps.gov/cert/.
- The **Tulsa Medical Reserve Corps** is a Citizen Corps program that provides licensed medical professionals (frequently retired) plus support staff for emergencies. The Tulsa group currently has over 1,000 volunteers, over 60% of whom are licensed professionals. They are coordinated out of the Tulsa Health Department.
- The **Tulsa Human Response Coalition** is a collaboration of mental health and social servce agencies, many of them faith based, culturally based, or otherwise "non-traditional" in the disaster realm, such as the National Guard Family Support Group. THRC can call upon its partners for a coordinated response to support other agencies in the area of mental health, social services, and cultural and religious support.
- The **Tulsa Amateur Radio Club** and **Tulsa Repeater Organization** provide emergency communications, storm spotting and damage assessments.
- **Tulsa Partners Inc**. is a Tulsa-based 501(c)3 organization that coordinates multiple programs, including the Disaster Resistant Business Council (see Section 2.1.5) and programs to provide preparedness and business continuity support to childcare centers, long term care facilities, and hospitals. They also assisted Tulsa Area Emergency Management Agency with developing an Emergency Operations Plan Annex for childcare facilities.

2.7 Natural Resource Protection

Natural resource protection activities are generally aimed at preserving and restoring the natural and beneficial uses of natural areas. In doing so, these activities enable the beneficial functions of floodplains and drainage ways to be better realized. This section reviews the natural resource protection activities that have already been implemented in the community or are already in the planning stages. See Chapter 5 and Appendix B for discussion of potential activities and programs within this category.

2.7.1 City of Tulsa Resource Protection

Tulsa's *Comprehensive Development Plan* states that the community seeks to conserve its natural resources through their protection and integration with compatible development. In particular, the City is committed to:

- Protecting stream corridors as wetlands, flood management and wildlife areas;
- Utilizing stream corridors, where appropriate, as linkages between activities and for recreation;
- Protecting scenic vistas;
- Protecting endangered wildlife nesting areas and preserves.

The Elm Creek Project in midtown Tulsa is an example of a flood control project existing in harmony with the natural world.

The City intends to preserve its major stream corridors as greenways, for use as community connectors and for flood management.

The City of Tulsa currently has no formal stream corridor preservation or watershed management programs. Section 9-21(b) of the *City Code* contains the City's Erosion and Sediment Control Policies. All development is required to provide appropriate erosion control facilities to minimize the amount of sediment leaving a site, under the guidelines of "no adverse impact."

The City does advocate, when possible, maintaining creeks and other small waterways in their natural state.

2.7.2 Environmentally Sensitive Areas

The following map, Figure 2-3, by the Indian Nations Council of Governments, identifies areas such as wildlife preserve or nesting areas, parkland, prime farmland, and other areas that should be included in the planning for development of certain mitigation activities such as flood control projects or other structural projects.

Looking west from Urbana Bridge

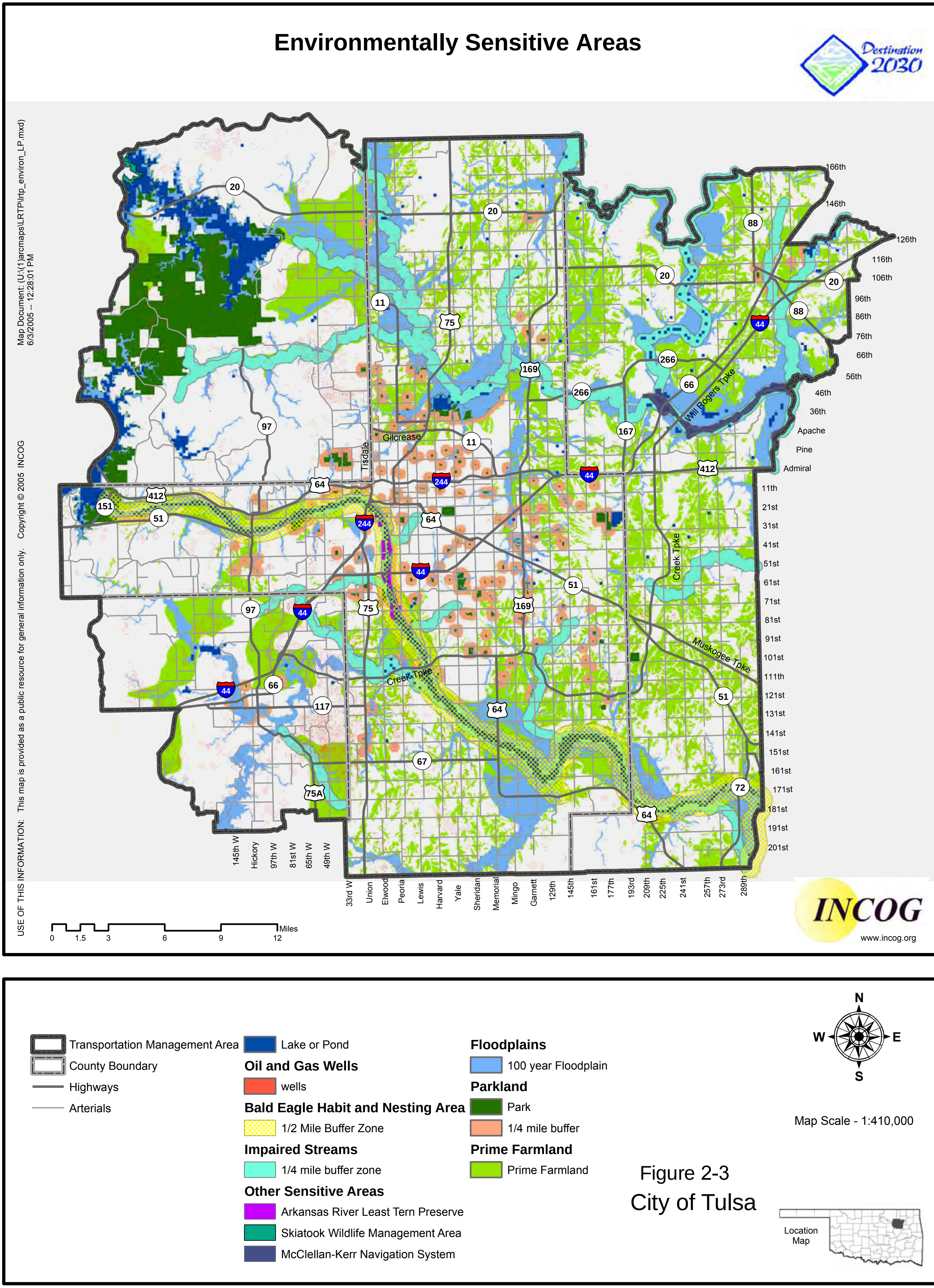


Figure 2-3
City of Tulsa

Chapter 3:
The Planning Process

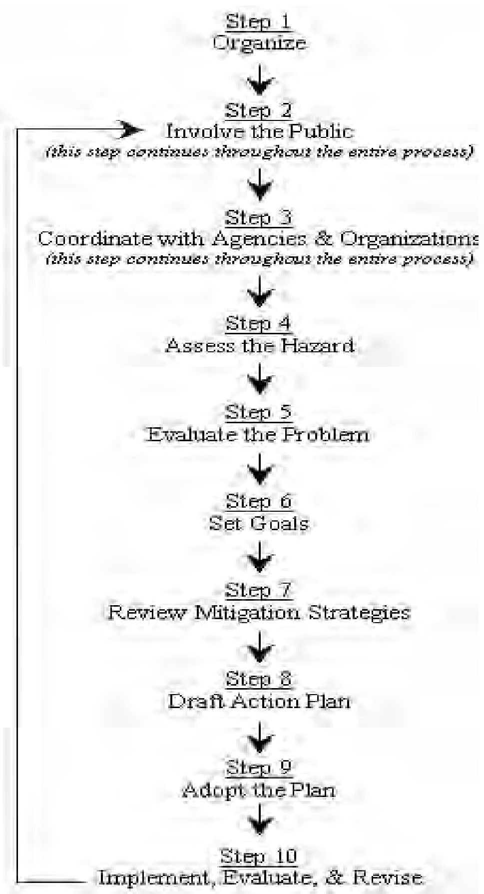
The City of Tulsa Multi-Hazard Mitigation Plan is an effort to direct the multi-hazard planning, development, and mitigation activities of the City of Tulsa. The City of Tulsa is responsible for overall coordination and management of the study.

Simply stated, a mitigation plan is the product of a rational thought process that reviews the hazards, measures their impacts on the community, identifies alternative mitigation measures, and selects and designs those that will work best for the community.

Included in this Chapter:

3.1 Step One: Organize to Prepare the Plan
3.2 Step Two: Involve the Public
3.3 Step Three: Coordinate with Others
3.4 Step Four: Assess the Hazard
3.5 Step Five: Assess the Problem
3.6 Step Six: Set Goals
3.7 Step Seven: Review Possible Activities
3.8 Step Eight: Draft an Action Plan
3.9 Step Nine: Adopt the Plan
3.10 Step Ten: Implement, Evaluate, and Revise

Mitigation Planning Process



This plan addresses the following hazards:

- Floods
- Tornadoes
- High Winds
- Lightning
- Hailstorms
- Severe Winter Storms
- Extreme Heat
- Drought
- Expansive Soils
- Wildfires
- Earthquakes
- Dam/Levee Failures

The planning for the City of Tulsa followed a ten-step process, based on the guidance and requirements of FEMA. The ten steps are shown in the graphic to the left, and are described on the following pages.

3.1 Step One: Organize to Prepare the Plan

(Oct. 2007 – Apr. 2008)
Citizens, community leaders, government staff personnel, and professionals active in disasters provided important input into the development of the plan and recommended goals and objectives, mitigation measures, and priorities for actions.

The planning process was formally created by a resolution of the City Council of Tulsa. The resolution designated the Tulsa Stormwater Drainage Advisory Board to serve as the Tulsa Citizens' Advisory Committee (TCAC) to oversee the planning effort.

City of Tulsa Citizens' Advisory Committee

The **TCAC** consists of the following members:

Gary Cheatham

Northeastern State University

Chairman of the Stormwater Drainage and Hazard Mitigation Advisory Board. Retired from US Army Corps of Engineers after 39 yrs service. Past Chief of Emergency Management/Security. Gary attended Oklahoma State University/Engineering .He also attended numerous flood response and damage assessment seminars, conducted several emergency response exercises for the corps and participated in the planning and revisions of the Federal Response Plan for FEMA.

Kyle Bierley

Executive Vice President, RotoRooter Plumbing

BS in Management and Marketing from Oklahoma State University.

Certified in individual wastewater from Department of Environmental Quality. He has an OSHA Excavation certificate of competence. Kyle is certified as a State Of Oklahoma Master Plumbing Contractor

Dr. Judith Finn

Partner, Pinkerton & Finn, P.C.

MS in Urban Studies, Focus on Systems Analysis. Chairman, Urban Study, US Corps of Engineers; Chairman of the Tulsa City-County Health Department. She has been involved with the Environmental Advisory Council 25 years and Citizen participation in flood plain mapping, zoning, and mitigation 30+ years

Robert (Bud) Fry

Ann Patton

Ann Patton Company, LLC

A Tulsa-based writer and consultant with more than 35 years' experience in journalism and government, specializing in public policy, hazard management, partnership development, and grassroots community building. Recent clients include the Department of Homeland Security, the Dept. of Health and Human Services and the National Institute for Building Sciences.

She retired from the City of Tulsa in 2004, and continues to serve as a local and national volunteer, and serves on the national Multihazard Mitigation Council.

Supporting the TCAC is the Tulsa Technical Advisory Committee (TTAC), which includes representatives of departments that have roles in multi-hazard planning, response, protection, and mitigation. Most of the detail work was done by management teams consisting of the following:

City of Tulsa Technical Advisory Committee

Bill Robison

Mitigation Plan Project Coordinator

Sr. Special Projects Engineer, City of Tulsa

BS in Civil Engineering from Oklahoma State University. Bill is a member of American Public Works Association and Oklahoma Floodplain Managers Association.

Terry Ball

City of Tulsa, Manager, Planning & Coordination

BS in Engineering from University of Oklahoma. Member of American Public Works Association.

Graham Brannin

City of Tulsa, Public Works Planning & Intergovernment Administrator

BS in Geology and BS in Petroleum Engineering from the University of Tulsa. Experience as a Safety/Environmental Consultant with Sara Services and as a Reservoir Engineer with Conoco Petroleum.

Corri Cousins

Secretary, Stormwater Drainage & Hazard Mitigation Advisory Board

BS in Criminal Justice from Troy University. Employee of Tulsa Public Works Department. Certified in global disaster response (communications restoration), refugee evacuation/relocation, and interim security for classified transport.

Amanda DeCort

Historic Preservation Officer, City of Tulsa

MS in Community Planning with a specialization in Historic Preservation from the University of Cincinnati. She worked in planning and preservation in the Ohio Valley before joining the City of Tulsa's planning team. She oversees the Certified Local Government program and is responsible for program planning and grant administration as well as providing primary staff support to the Tulsa Preservation Commission.

Roy Foster

Water Quality Assurance Manager, City of Tulsa

BS in Geology/Chemistry from the Hardin Simmons University. Chairman of the Tulsa County Conservation District. He is also an Oklahoma Delegate for the Oklahoma Water Environment Association.

Class A Water Operator, Class A Water Laboratory Operator, Class A Wastewater Laboratory Operator, Class B Wastewater Operator, and NIMS/ICS 100-400.

Richard Green

Graphic Technician II, City of Tulsa

Associates of Science in Drafting and Design from Missouri Southern State University. Richard is a Certified Floodplain Manager and a member of the Oklahoma Floodplain Managers Association.

Charles Hardt

Director, Public Works Department, City of Tulsa

Charles Hardt heads the Operations Division, which oversees Equipment Management and the Public Works Department activities including Engineering Services, Public Facilities & Property Management, Environmental Services and Policy Development.

Ken Hill

Assistant Director, Public Works Department, City of Tulsa

Mike McCool

Director, Tulsa Area Emergency Management Agency

BSBA from Tulsa University, 1970, and an MPH from Oklahoma University, 1995. He has over 2,500 hrs of emergency management-related training, just over 1,100 hrs of law enforcement training, and over 1,000 hrs of emergency medical training. He is currently an Oklahoma Certified Emergency Manager (OCEM), and a past Oklahoma Certified Floodplain Manager, and past paramedic.

Alan Rowland

City of Tulsa Public Works Financial Planning Manager

BS in Accounting from University of Central OK.

Ed Sharrer

Historic Preservation, City of Tulsa

Master's Degree in Architectural Urban Studies from the University of Oklahoma Urban Design Studio, completing an intensive level architectural survey of Tulsa's mid-century Lortondale neighborhood for his thesis project. Sharrer is a life-long Tulsan and oversees the Certificate of Appropriateness application process.

Brent Stout

Senior Special Projects Engineer, City of Tulsa

BSCE in Civil Engineering from the University of Arkansas. Continued Education in Civil Engineering with Oklahoma State University. Brent is a Board Member of the Oklahoma Floodplain Managers Association. He is a Certified Floodplain Manager. He has been a project manager for the City of Tulsa for 5 years, as well as a Damage Assessment manager. Brent is ICS trained.

Deborah Stowers

City of Tulsa, Lead Engineer, Stormwater Design

BS in Petroleum Engineering and BS in Civil Engineering from University of Oklahoma. Member of Oklahoma Floodplain Managers and American Society of Civil Engineers. Certified Floodplain Manager and Professional Engineer.

Mark Swiney

Sr. Assistant District Attorney, City of Tulsa

BA in Liberal Arts, Notre Dame; MA in Humanities, University of Tulsa; J.D from University of Tulsa. Serves as legal counsel to Stormwater Management Board since 1988.

Harold Tohlen

Development Services, City of Tulsa

Scott Van Loo

Stormwater Quality Manager, City of Tulsa

BS in Geology, with a minor in Petroleum Engineering from the University of Tulsa. 18 years working in the Environmental Field with water quality, 16 of those have been in the area of non-point source pollution (storm water pollution). Currently coordinates all storm water quality activities for the City of Tulsa, especially those dealing with Tulsa's municipal storm water discharge permit. He has been a Board Member with the Tulsa County Conservation District for 9 years.

The TTAC met periodically during the year's planning process. TTAC members also attended all meetings of the TCAC and meetings with elected officials.

Consultant:

Ronald D. Flanagan, CFM
Principal Planner

R.D. Flanagan & Associates
Planning Consultants
2745 E. Skelly Dr., Suite. 100
Tulsa OK 74105

Cathy Ambler, Ph.D
Architecture & Planning Consultant, Historic Preservation Specialist

Cathy Ambler holds a Ph.D. in American Studies from the University of Kansas and a Master's degree in historical administration and museum studies. Member of the Preservation Oklahoma Board.

Other entities involved in the development of the Mitigation Plan included:

Tulsa Partners, Inc

TPi in a Tulsa-based non-profit that has been working since 1998 to develop public / private / non-profit collaborations to help create a disaster-resistant and sustainable community and improve Tulsan's safety and well-being by reducing deaths, injuries, property damage, environmental and other losses from natural or technological hazards.

James Lee Witt Associates

Founded in 2001, JLWA is a crisis and emergency management consulting firm based in Washington, DC with experience and hands-on knowledge of public safety, disaster mitigation, continuity of operations, and emergency management issues. James Lee Witt is former Director of the Federal Emergency Management Agency (FEMA).

French & Associates, Ltd.

French Wetmore is a consultant with extensive experience in floodplain management, hazard mitigation planning, and the Community Rating System (CRS). He is former Chair of the National Association of Flood Plain Managers and has collaborated in previous Tulsa projects.

The TCAC met monthly at City Hall and the TTAC met weekly or bi-weekly at Public Works during the planning process to review progress, identify issues, receive task assignments, and advise the consultants. A list of TCAC, TTAC, and public meetings and dates is shown in Table 3-1, below. Refer to Appendix C for meeting agendas.

Table 3–1: Tulsa Hazard Mitigation Committee Meetings and Activities

Date	*Activity*
Sept. 12, 2007	City of Tulsa (CoT) Hazard Mitigation Team Staff meeting: Discuss Tulsa HM Plan Update.
September 14, 2007	City of Tulsa Multi-Hazard Mitigation Plan Update and Historical Preservation and Cultural Resources Annex Pre-Disaster Mitigation Plan Obligation Date
Sept. 18, 2007	Storm Drainage Advisory Board (SDAB) Meeting: Briefing on Hazard Mitigation Action Plan Update. SDAB designated as Hazard Mitigation Plan Update Citizens Advisory Committee.
Oct 10, 2007	CoT Hazard Mitigation Team Staff meeting.
Oct. 16, 2007	SDAB Meeting: City of Tulsa (CoT) Multi-Hazard Plan Update; Review Tulsa County Hazard Mitigation Plan.
Nov. 14, 2007	CoT Hazard Mitigation Team Staff meeting.
Nov. 20, 2007	SDAB Meeting: Multi-Hazard Plan Update.
Dec. 17, 2007	CoT Hazard Mitigation Team Staff meeting.
Dec. 18, 2007	SDAB Meeting: Multi-Hazard Mitigation Plan Review
Jan. 10, 2008	CoT Hazard Mitigation Team Staff meeting.
Jan. 11, 2008	CoT Historic Preservation Commission meeting: Presentation of HM Update Plan and Historic Preservation and Cultural Resources Annex to Commission. HM Sub-Committee formed.
Jan. 15, 2008	Storm Drainage Hazard Mitigation Advisory Board (SDHMAB) Meeting: Multi-Hazard Mitigation Plan Review
Jan. 16, 2008	CoT Hazard Mitigation Team Staff meeting.
Jan. 31, 2008	CoT Hazard Mitigation/Historic Preservation Team Staff meeting.
Feb. 8, 2008	HM Staff and Historic Preservation Staff/Sub-Committee meeting.
Feb. 13, 2008	CoT Hazard Mitigation Team Staff meeting.
Feb. 19, 2008	SDHMAB Meeting: Multi-Hazard Mitigation Plan Review.
March 12, 2008	CoT Hazard Mitigation Team Staff Meeting
March 18, 2008	SDHMAB Meeting: Natural Hazards Review. Hazard Mitigation Action Plan Review, Hazard Mitigation Grant Availability and Proposed Use of 1986 Flood Elevations.

Date	Activity
April 15,2008	SDHMAB Meeting: Natural Hazards Review. Hazard Mitigation Action Plan Review, Hazard Mitigation Grant Availability
April 16, 2008	CoT Hazard Mitigation Team Staff meeting.
May 5, 2008	Initial City of Tulsa Multi-Hazard Mitigation Plan Update Technical Advisory Committee (HMTAC) meeting:
May 7, 2008	Technical Advisory Committee (HMTAC) Meeting: Assignment of major tasks. Prepare/Review for May 12th Public Meeting. Discuss the presentation, materials and format to be used.
May 12, 2008	Multi-Hazard Mitigation Plan Update 2008 Public Meeting at Memorial High School
May 14, 2008	CoT Hazard Mitigation Team Staff meeting; TAC Meeting:
May 20, 2008	SDHMAB Meeting: Natural Hazards Review. Hazard Mitigation Action Plan Review
May 21, 2008	TAC Meeting: Discussed Mitigation Measures, Covered process on how to get information from the COT, Discussed what information is still needed and who to get information from.
May 28, 2008	TAC Meeting:
June 3, 2008	MHMP 2008 Public Meeting at the Zarrow Library.
June 4, 2008	TAC Meeting: Draft MHMP Update Review
June 11, 2008	TAC Meeting: Review/Revisions/Status of the MHMP
June 17, 2008	SDHMAB Meeting: Natural Hazards Review. Hazard Mitigation Plan Update Review and Status/Progress Report
June 18,2008	TAC Meeting:
June 25, 2008	TAC Meeting:
July 2, 2008	TAC Meeting: Review FEMA Required Revisions
July 9, 2008	TAC Meeting:
July 15, 2008	SDHMAB Meeting: Natural Hazards Review. Hazard Mitigation Plan Update and Status/Progress Review
July 16, 2008	TAC Meeting: MHMP Update Plan Approved Pending
July 23, 2008	TAC Meeting:
July 28, 2008	Public Meeting: Hardesty Regional Library
August 4, 2008	Public Meeting: Martin Regional Library
August 11, 2008	Public Meeting: Rudisill Regional Library
August 13, 2008	CoT Hazard Mitigation Team Staff meeting; TAC Meeting
August 19, 2008	SDHMAB Meeting: Natural Hazards Review. Hazard Mitigation Plan Update and Status/Progress Review
August 19, 2008	Public Meeting: City Hall, Francis Campbell City Council Chambers

Date	Activity
August 27, 2008	TAC Meeting: Review Mitigation Measures
Sept. 2, 2008	Historic Preservation Technical Advisory Committee meeting
Sept. 8, 2008	Mayor's Homeland Security Task Force meeting, City Hall
Sept. 10, 2008	Final review and Prioritize Mitigation Measures
Sept. 11, 2008	Presentation to the City of Tulsa Historic Preservation Commission
Sept. 25, 2008	SDHMAB Meeting: Briefing on status of HM Plan submittal, HMGP Grant applications.
Sept. 27, 2008	Historical Preservation Workshop, City Hall.
Oct. 6, 2008	Mayor's Homeland Security Task Force meeting, City Hall
Oct. 10, 2008	TAC Meeting: Review Final Draft HM Plan, prepare to submit to State.

3.2 Step Two: Involve the Public

(Oct. 2007 – Ongoing)
In addition to the TCAC, the management team of TTAC undertook projects to inform the public of this effort and to solicit their input. All meetings of the TCAC were publicly posted as required by ordinances and rules of the jurisdiction. Four public meetings were held in all four quadrants of the City, and one in Tulsa City Council chambers in City Hall. All meetings of the TCAC were televised over Channel 23, the Community Public Access Television Channel. In addition, opportunities for comment were provided on the City of Tulsa website.

In all public meetings, surveys were made available to the participants to review concerns and questions. These were also made available on the City of Tulsa website.

3.3 Step Three: Coordinate with Other Agencies and Organizations

(Oct. 2007 – Ongoing)
Many public agencies, private organizations, and businesses contend with natural hazards. Management team members contacted them to collect their data on the hazards and determine how their programs can best support the Tulsa Multi-Hazard Mitigation planning program. A sample letter and a list of agencies contacted are included below.

A private website was created where the draft plan was maintained so participating agencies and organizations could review and provide feedback as the plan was developed.

The Emergency Operations Plan is administered under the Tulsa Area Emergency Management Agency. The Public Works and Planning Departments play key roles during most emergencies.

Federal

Federal Emergency Management Agency, Region VI (FEMA)
Housing & Urban Development
US Army Corps of Engineers
National Weather Service (NWS)
Natural Resource Conservation Service (NRCS)
US Fish and Wildlife Service
US Geological Survey

National Non-Profit

American Red Cross, Tulsa Area Chapter
Citizen Corps Council
Salvation Army, Tulsa

State

Oklahoma Department of Emergency Management
Oklahoma Water Resources Board

- State National Flood Insurance Program (NFIP) Coordinator
- State Dam Safety Coordinator

Oklahoma Conservation Commission
Oklahoma Department of Wildlife Conservation
Oklahoma Department of Labor
Oklahoma Geological Survey
Oklahoma Department of Environmental Quality

Regional

Indian Nations Council of Governments (INCOG)

County

Tulsa County
Tulsa County Assessor
Tulsa Health Department
Tulsa Area Emergency Management Agency
Tulsa County Local Emergency Planning Committee

City

Office of the Mayor
Department of Community Development
Department of Public Works
Tulsa Public School District
Tulsa Police Department
Tulsa Fire Department

Businesses

Hillcrest Medical Center
Home Builders Association of Greater Tulsa
OSU Medical Center
St. Francis Medical Center
St. John's Medical Center
Tulsa Metro Chamber of Commerce

Education

University of Oklahoma, Schusterman Campus
Oklahoma State University, Tulsa
Oral Roberts University
Tulsa Community College
University of Tulsa
Jenks Public Schools
Union Public Schools

Neighboring Communities

City of Bixby
City of Broken Arrow
City of Collinsville
City of Jenks
City of Owasso
City of Sand Springs
City of Skiatook
City of Sperry

CITY OF Tulsa
A New Kind of Energy™

May 7, 2008

Mr. Mike McCool CEM
Emergency Manager
Tulsa Area Emergency Management Agency
600 Civic Center, EOC
Tulsa, OK 74103

Subject: City of Tulsa, Oklahoma Multi-Hazard Mitigation Plan

Dear Mr. McCool:

The Oklahoma Department of Emergency Management and the Federal Emergency Management Agency have awarded a Hazard Mitigation Grant to the City of Tulsa to update its 2003 Multi-Hazard Mitigation Plan.

Tulsa will submit a draft plan update to FEMA by June 15, 2008. The citizen-led Stormwater Drainage & Hazard Mitigation Advisory Board and a City-appointed technical advisory committee will oversee the planning process.

Hazards addressed will include:

- Flooding
- Lightning
- Drought
- Wildfires
- Earthquakes
- Tornadoes
- High Winds
- Hailstorms
- Dam Breaks
- Extreme Heat
- Dam Failure
- Winter Storms

If you would like to submit recommendations and/or receive information produced during the planning process, please respond by June 2. A preliminary schedule of the planning process is enclosed.

If you have any questions, or if I may be of further service to you, please contact me at (918) 596-9475 or brobison@cityoftulsa.org.

Sincerely,

Bill Robison

Bill Robison
Senior Special Projects Engineer
Department of Public Works
City of Tulsa

3.4 Step Four: Assess the Hazard

(Dec. 2007 – June. 2008)
The management team collected data on the hazards from available sources. Hazard assessment is included in Chapter 4, with the discussion of each hazard.

Table 3–2: How and Why Hazards Were Identified

Hazard	*How Identified*	*Why Identified*
Dam/Levee Failures	Input from US Army Corps of Engineers (USACE) Input from Oklahoma Water Resources Board, (OWRB), Dam Safety Division Input from Tulsa Department of Public Works Input from State Levee Coordinator	• Population and buildings below dam and behind levees are very vulnerable in event of major release or dam failure • Dam break/release contingency plan needs updating • Warning systems need to be updated and refined • City considering redevelopment options for areas behind levees
Drought	Historical vulnerability to drought, the “Dust Bowl” era Recent (2002) drought and water shortages in Bartlesville, just north of Tulsa Widespread Oklahoma drought of 2005-2006.	• Continuing mid-west and western drought and impacts on Oklahoma communities, including neighboring Bartlesville • Acute awareness of Oklahoma’s population to the severe results of drought • Need to ensure adequate long-term-water resources for Tulsa’s metropolitan area population
Earthquakes	Historic records of area earthquakes Input from Oklahoma Geological Survey Input from USGS HAZUS Surveys of potential damages	• Tulsa area has a history of mild earthquakes • Tulsa County has experienced earthquakes on the average of once every 5 years • Failure of the New Madrid fault could have consequences for the City of Tulsa and Tulsa County
Expansive Soils	Review of Natural Resource Conservation Service data Input from City Building Inspections Department Input from Oklahoma Department of Transportation	• Expansive soils are prevalent in the City of Tulsa. • Damage to buildings and infrastructure from expansive soils can be mitigated with public information and building code provision
Extreme Heat	Review of number of heat-related deaths and injuries from EMSA and State/Local Health Departments Review of data from National Climatic Data Center and National Center for Disease Control & Prevention	• TAEMA and local community service organizations have made heat-related deaths a high priority • High percentage of outdoor workers at risk • High percentage of poor and elderly populations at risk • 44 heat-related deaths in Oklahoma in the last 5 years

Hazard	How Identified	Why Identified
Floods	Review of FEMA floodplain maps Buildings in the floodplains Historical floods and damages (detailed in Chapter 4)	• 10% of City land is located in floodplains • 1984 flood caused $180 million in damage • 1984 flood killed 14 people • Flood damage occurs every year • Over $1 billion of property at risk
Hailstorms	Review of data from National Climatic Data Center	• 477 hail damage events in the Tulsa area over the last 5 years • Over $89.7 Million in property damage
High Winds	National Weather Service data Loss information provided by national insurance companies	• 309 thunderstorm and high wind-related events in the Tulsa area from 2003 thru 2007, and almost $8.6 Mil in damage
Lightning	National Climatic Data Center information and statistics	• Oklahoma has had 295 incidents resulting in 8 deaths, 48 injuries, and $14.8 Mil over a 10-year period. • 10 lightning events in the Tulsa area since 1997 resulting in $2.3 Mil in damage, one death and two injuries.
Severe Winter Storms	Review of past disaster declarations Input from Tulsa County Emergency Management Agency and Tulsa Emergency Management Input from Tulsa Department of Public Works Input from area utility companies	• Severe winter storms are an annual event in the Tulsa area and can produce both wide-spread economic disruption and massive public utility outages. • Tulsa has had 27 major winter storm events since 1950. • Four winter storm-related Federal Disaster Declarations in the past 3 years have required over $330 million in Federal assistance.
Tornadoes	Review of recent disaster declarations Input from Emergency Manager Review of data from the National Climatic Data Center	• Tulsa is located in “Tornado Alley” • An average of 52 tornadoes per year strike Oklahoma • Recent disaster events and damage • Oklahoma City tornado of 1999 killed 42 people and destroyed 899 buildings • All citizens and buildings are at risk • There have been 9 tornadoes in Tulsa County in the last 10 years. Two of those struck the City of Tulsa, causing $2,100,000 in reported damages.

Hazard	How Identified	Why Identified
Wildfires	Input from Tulsa Fire Department Input from surrounding county & community fire departments Input from State Fire Marshal Input from Oklahoma State University Rangeland Conservation	• Fires of the urban/rural interface threaten Tulsa properties • Several miles of Tulsa's perimeter and a number of identified critical facilities are exposed and vulnerable to wildfires • 328 wildfires in Tulsa area between 1999-2003 resulted in over $48,000 in damage • Six wildfires in 2005-2006 in Tulsa County caused 1 death, 11 injuries, and $2.05 Mil in reported damages.

3.5 Step Five: Assess the Problem

(March 2008 – July 2008)
The hazard data was analyzed in light of what it means to public safety, health, buildings, transportation, infrastructure, critical facilities, and the economy. Some of the work for Steps 4 and 5 had been initiated by the Central Oklahoma Economic Development District. They prepared several analyses using their geographic information system. The discussion of the problem assessment is addressed for each hazard in Chapter 4.

Damage Estimation Methodology

The following methodologies were used in the development of damage cost estimated for buildings and contents for flooding and tornado/high wind damage, used in the *City of Tulsa Multi-Hazard Mitigation Plan:*

HAZUS Damage Estimation Model: FEMA's HAZUS Damage Estimation Models were used to calculate damages from Flooding and Earthquakes.

Structure Value: Value of buildings within the City of Tulsa was obtained from the Tulsa County Assessor's office.

For critical facilities, non-profit properties with structural improvements, such as churches, which are tax exempt and where no county assessor valuation was available, the buildings' footprints were measured using aerial photography, GIS, and field investigation to determine size, in square feet. The value of structure was obtained by calculating the square footage times the value per square foot obtained by using FEMA publication *State and Local Mitigation Planning: Understanding Your Risks: Identifying Hazards and Estimating Losses*, August 2001, "Average Building Replacement Value per square foot," p. 3-10, source: HAZUS

Contents Value: Value of contents for all buildings was estimated using "Contents Value as Percentage of Building Replacement Value" table, page 3-11, *Understanding Your Risks*.

Depth of Damage: Flooding damage estimates for building and contents are based on actual structures' estimated flood depth determined by aerial topographic mapping and field investigations. Maps of the floodplains are included in Chapter 4.

Flood damage curves, for structures (single-family, multi-family, office, commercial, industrial), and contents were estimated using Table A-3, “Damage Factors,” Economics Branch, Tulsa District, U.S. Army Corps of Engineers.

Flood depth of damage curve estimates were used for riverine flooding and dam failures (Chapter 4).

Tornado Damage: Damage estimates for the tornado scenario were based on:

1. Structure value: Tulsa County Assessor’s office.
2. Contents: FEMA’s Contents Value, *Understanding Your Risks*.
3. Damage to structure: based on percent damage experienced during typical events, using the Fujita Scale, damage characteristics, Table 4-9.

Damage estimates were based on a “worst case” scenario, assuming about 25% of the buildings in the tornado path would experience substantial damage or total destruction; 35% would suffer 50% damage, and 40% would suffer slight to moderate or average 25% damage.

Estimation of the value of tax-exempt structures, for which no county assessor valuation is available, was done using the same methodology as for flood damaged structures, described above—that is, using FEMA publication, *State and Local Mitigation Planning: Understanding Your Risks: Identifying Hazards and Estimating Losses*, August 2001, “Average Building Replacement Value per square foot,” p. 3-10.

3.6 Step Six: Set Goals

(May 2008 – August 2008)
Project and community hazard mitigation goals and objectives for Tulsa were developed by the TCAC to guide the development of the plan. The hazard mitigation goals for the jurisdictions are listed in Chapter 5 and Appendix B.

3.7 Step Seven: Review Possible Activities

(June 2008 – August 2008)
Wide varieties of measures that can affect hazards or the damage from hazards were examined. The mitigation activities were organized under the following six categories. A more detailed description of each category is located in “Chapter 5: Mitigation Strategies.”

1. **Public Information and Education—**Outreach projects and technical assistance
2. **Preventive Activities**—Zoning, building codes, stormwater ordinances
3. **Structural Projects**—Levees, reservoirs, channel improvements
4. **Property Protection**—Acquisition, retrofitting, insurance
5. **Emergency Services**—Warning, sandbagging, evacuation
6. **Natural Resource Protection**—Wetlands and floodplain protection, natural and beneficial uses of the floodplain, and best management practices

The TTAC and the TCAC, after reviewing the potential mitigation activities, screened and selected the measures they felt were applicable, feasible, cost effective, and politically acceptable to their community. The measures specifically identified as potentially benefiting the community were combined into a new, more community-specific list for review.

To prioritize the list of possible mitigation measures, made up of over 192 identified mitigation measures, the TCAC members were given twenty votes each to select the individual measures they felt would best benefit the community's efforts to reduce or eliminate the adverse impacts of hazards on lives and property. The votes were tallied, and the Mitigation Measures were ranked in descending order. The Mitigation Measures selected and prioritized by this voting process best reflected the values and goals of the community, and the Mitigation priorities generally reflected the disaster and damage experience of the community.

The true challenge is to identify mitigation strategies and measures that represent the goals and political will of the community. Table 6-1, *Multi-Hazard Mitigation Measures, By Priority and Hazard* is the comprehensive list of Mitigation Measures receiving at least one vote from the 20-vote selection process described above. After confirming the outcome with each advisory committee, the top ten priority measures became the focus for the next phase of the plan, the "Action Plan".

3.8 Step Eight: Draft an Action Plan

(July 2008 – September 2008)
The top 29 high-priority Mitigation Measures constituted the Action Plan, and each Measure was further detailed to identify:

- A brief description of the Mitigation Measure (Action Plan Item)
- The lead agency responsible for implementation
- Anticipated time schedule for completion
- Estimated project cost
- Possible sources of funding
- The Work Product, or Expected outcome

The Action Plan items should be developed in enough specificity to respond to a Notice of Intent/Interest (NOI) from the State when HMGP Funds become available, or to provide basic information to begin to put together a Pre-Disaster Mitigation Grant Application.

3.9 Step Nine: Adopt the Plan

(December 2008)
The Draft *City of Tulsa Multi-Hazard Mitigation Plan Update 2009* was submitted to the Oklahoma Department of Emergency Management and FEMA Region VI for review and approval. The TCAC approved the final plan, adopted it as an amendment to the *Comprehensive Plan*, and submitted it to, and was approved and adopted by the Tulsa City Council.

3.10 Step Ten: Implement, Evaluate, and Revise

(January 2009 – Ongoing)
Adoption of the *Multi-Hazard Mitigation Plan* is only the beginning of this effort. Community offices, other agencies, and private partners will proceed with

implementation. The TCAC will continue to meet on a regular basis to monitor progress, evaluate the activities, and periodically recommend revisions to the Plan and Action Items. The plan will be formally updated a minimum of every five years, as required by FEMA.

Chapter 4: Natural Hazards

Introduction

Included in this Chapter:

- Introduction
- Hazards Summary
- Annual Average Damages
- Hazards Analysis
- Secondary Events
- Vulnerability Assessment
- 4.1 Floods
- 4.2 Tornadoes
- 4.3 High Winds
- 4.4 Lightning
- 4.5 Hailstorm
- 4.6 Winter Storms
- 4.7 Extreme Heat
- 4.8 Drought
- 4.9 Expansive Soils
- 4.10 Wildfires
- 4.11 Earthquakes
- 4.12 Dam & Levee Failures
- 4.13 Hazard Composite

According to the Federal Emergency Management Agency (FEMA), a hazard is defined as an event or physical condition that has the potential to cause fatalities, injuries, property damage, infrastructure damage, or agricultural loss, among other types of loss or harm. Hazards are generally defined as one of two categories based on their source: natural hazards and man-made hazards. Each hazard has its own defining characteristics, such as time of year and geographic area of probable occurrence, severity, and risk level.

Natural phenomena, such as floods, tornadoes, severe drought, and wildfires, are natural hazards because they have the potential to destructively impact human settlements and activities. When damages from a natural hazard occur, the event is generally called a natural disaster.

Man-made hazards are broadly defined as a hazard that originates from accidental or intentional human activity. They can affect localized or widespread areas and are frequently unpredictable. This category of hazard includes such events as dam breaks and hazardous material events.

While Oklahoma communities can expect disaster-related losses, hazard assessments can be used to create proactive measures against likely events, and thereby significantly decrease or eliminate their impacts. Therefore, this chapter contains a risk identification and assessment for 12 hazards. The hazards addressed are those deemed most likely to impact the City of Tulsa. The hazards include:

1. Floods
2. Tornadoes
3. High Winds
4. Lightning
5. Hail
6. Severe Winter Storms
7. Extreme Heat
8. Drought
9. Expansive Soils
10. Wildfires
11. Earthquakes
12. Dam & Levee Failures

Each hazard is covered in a separate section, which will include the following information:

- **Hazard Profile –** Causes, effects, normal frequency (how often it is likely to occur at a particular location), and available scales or methods of measuring the severity of the events, if any; the geographical extent of the hazards; and the identification of any topographic or geological conditions that would make a particular area prone to the hazard.
- **Historical Events –** Notable past occurrences of the hazard, including national, state, and local examples, if any. Where available, historical losses, in terms of lives and property, are detailed.
- **Vulnerable Population –** The people, geographic locations, and types of property subject to the particular hazard are identified. For each hazard with a definable geographic location, such as floods and dam breaks, the number, types and value of buildings and contents are identified, along with the vulnerable populations.
- **Conclusion –** The information provided on each of the hazards is condensed into a brief summary/conclusion statement.

Hazards Summary

Floods

The accumulation of water within a water body and the overflow of excess water onto adjacent lands. The floodplains are the lands adjoining the channel of a river, stream, ocean, lake, or other watercourse or waterbody that is susceptible to flooding.

From 1998-2007, Tulsa experienced 58 flood events, causing 2 deaths and a reported $3.6 Million in damages.

The City of Tulsa is at moderate risk from the effects of the flood hazard. There are 2,296 structures in the City located within the FEMA Special Flood Hazard Area (SFHA).

Tornadoes

A rapidly rotating vortex or funnel of air extending to the ground from a cumulonimbus cloud. When the lower tip of a vortex touches earth, the tornado becomes a force of destruction.

Due to the very nature of Tulsa’s climate, severe thunderstorms and the tornadoes they frequently produce will remain a threat to this community, and vulnerability should be considered “high.” Improved building technologies, advances in public communication capabilities, and opportunities for collaboration among community agencies should remain prominent in the planning and response communities’ endeavors.

High Winds

Wind is the motion of air relative to the earth's surface. Extreme windstorm events are associated with cyclones, severe thunderstorms, and accompanying phenomena such as tornadoes and downbursts.

Due to the very nature of Tulsa's climate, severe thunderstorms and the high winds they produce will remain a real threat to this community. Recent events both in Tulsa and in the surrounding areas serve as proof that while sporadic, high winds events continue to produce life and property threatening conditions. Improved building technologies, advances in public communication capabilities, and opportunities for collaboration among community agencies should remain prominent in the planning and response communities' endeavors.

Lightning

Lightning is generated by the buildup of charged ions in a thundercloud. When that buildup interacts with the best conducting object or surface on the ground, the result is a discharge of a lightning bolt. The air in the channel of a lightning strike reaches temperatures higher than 50,000˚ Fahrenheit.

Lightning is one of the most deadly and consistent hazards in the United States. In recent years, new technology has provided many opportunities for communities and individuals to provide increased warning and alerts, increased surge protection, and increased building strike protection. The threat of injury, death, or property damage in the City of Tulsa is high.

Hail

A hailstorm is an outgrowth of a severe thunderstorm in which balls or irregularly shaped lumps of ice fall with rain. Extreme temperature differences from the ground upward into the jet stream produce strong updraft winds that cause hail formation. Hailstorms are usually considered "severe" when hail is larger than ¾" and accompanied by winds greater than 60 miles per hour.

The states in the middle of the Great Plains, and particularly Oklahoma, are the most likely to have severe thunderstorms and therefore have the most hail events. Oklahoma experiences an average of 869 hailstorms each year with hailstones measuring at least 0.75" in diameter.

The City of Tulsa has high vulnerability to hailstorms.

Severe Winter Storms

A severe winter storm is one that drops four or more inches of snow during a 12-hour period, or six or more inches during a 24-hour period. An ice storm occurs when freezing rain falls from clouds and freezes immediately upon contact with earth, plants, roads, homes and other structures.

Due to the rich, moist atmosphere present in Tulsa, the entire jurisdiction should expect to be repeatedly affected by winter events. The degree of severity is dependant greatly on the temperature fluctuation between daytime and nighttime, and the duration of any extreme temperature conditions. The vulnerability to Severe Winter Ice Storms in the Tulsa area is considered High.

Extreme Heat

Extreme summer weather is characterized by a combination of very high temperatures and exceptionally humid conditions. A heat wave occurs when such conditions persist over time.

Oklahoma can expect to be hit by the hazard of extreme heat every summer. The severity of the hazard is dependent on a combination of temperature, humidity, and access to air conditioning. With July average high temperature being 93.6° Fahrenheit, and average afternoon humidity 56% resulting in a heat index of 105° Fahrenheit, Tulsa is at moderate risk to extreme heat.

Drought

Drought is a climatic dryness severe enough to reduce soil moisture and water below the minimum necessary for sustaining plant, animal, and human life systems. Drought duration and severity are usually measured by deviation from norms of soil moisture, annual precipitation and stream flows.

The severe droughts of the 1930s led to the construction of Oklahoma's numerous hydroelectric dams and reservoirs, as well as to the implementation of new farming and conservation policies. However, more recent drought response and recovery activities in Oklahoma, both at the state and local level, have not been as ambitious or successful. There is a "need to focus more on long-term water management and planning issues; to integrate the activities of numerous agencies with drought-related missions into a coherent national approach; and to achieve better coordination of mitigation, response, and planning efforts between state and federal officials."

The City of Tulsa is at low to moderate risk of drought, and moderate to high risk from a secondary impact of drought in the urban interface, wildfire.

Expansive Soils

Soils and soft rock that swell and shrink with changes in moisture content are commonly known as expansive soils. Expansive soils develop gradually and are seldom a threat to the population, but can cause severe damage to improvements built upon them.

The history of Tulsa's expansive soil hazard is difficult to track, since the City does not monitor damage to structures from expansive soils as the impact of a specific natural hazard. The City treats all such damage as a maintenance issue. According to City Engineers, the expansive soil hazard is routinely taken into account in engineering studies and construction practices for infrastructure projects, but not specifically documented.

Expansive soils develop gradually and are seldom a threat to the population, but can cause severe damage to improvements built upon them.

With 55.2% of the soils within the city limits classified as having moderate to high shrink/swell potential and less than 7.34% in the "very high" category, the City of Tulsa has a moderate to high vulnerability to the damaging effects of expansive soils. Increased damage to structures could be expected during and following a period of extended drought, particularly for structures built during a drought.

Wildfires

A wildfire is a fire that burns along the ground, moving slowly and killing or damaging trees; a fire burning on or below the forest floor in the humus layer down to the mineral soil; or a fire rapidly spread by wind and moves by jumping along the tops of trees.

Wildfires are a serious and growing hazard because people continue to move their homes into woodland areas. The value of the property exposed to wildfires is increasing more rapidly, especially in the western states.

As shown during the rash of wildfire in the winter of 2005-2006, the areas of the City of Tulsa that are in the wildland /urban interface are at moderate to high risk to wildfires, and at severe risk during times of high wind and drought. However, that vulnerable area is a relatively low percentage of the total area of the community.

The City of Tulsa's overall risk would be considered low to moderate.

Earthquakes

An earthquake is a sudden, rapid shaking of the ground caused by the fracture and movement of rock beneath the Earth's surface. Earthquakes, although seemingly trivial in Oklahoma, do occur. Although relatively safe from locally generated earthquakes, the region's underlying geology exposes Oklahoma to some risk from a severe earthquake in the New Madrid Seismic Zone. Almost all Oklahoma earthquakes are too small to be felt and cause no visible damage. Unfelt earthquakes can, however, adversely affect the integrity of local buildings, infrastructure, and lifelines.

Tulsa County experienced six earthquakes between 1977 and 2005 or 0.21 per year, none of which were "felt" earthquakes. None of the earthquakes was centered in the City of Tulsa, so a "low" probability score was awarded in the hazard analysis. As calculated using HAZUS software, an earthquake similar to the 1952 El Reno event would cause no damages to the Tulsa area.

Dam & Levee Failures

The Federal Emergency Management Agency (FEMA) defines a dam as "a barrier constructed across a watercourse for the purpose of storage, control, or diversion of water." A dam failure is the collapse, breach, or other failure of such a structure resulting in downstream flooding.

Tulsa is exposed to risk of flooding from failure of four high-hazard upstream dams. These dams are Keystone, Yahola, Warrenton, and A.B. Jewell. The dam posing the greatest threat to Tulsa is Keystone. However, the Corps of Engineers believes that the potential for failure is low because Keystone is operated by the Corps and is inspected at least once each year.

Forced releases of large amounts of water can be a significant flood hazard. This was exemplified by the 1986 Keystone Reservoir water releases that caused downstream flooding.

A related threat to Tulsa is posed by the Arkansas River levees, built in 1945 and protecting 2,271 residences, 149 commercial properties & 106 industrial parcels with improvement values ($147,453,020 in assessed improvements). Failure of the levees along the Arkansas River would have a devastating impact upon the City of Tulsa and Tulsa County. It is likely that a major Keystone Dam release could cause these levees to overtop and subsequently fail.

The worst-case event, failure of Keystone Dam and the Arkansas River levees, could impact 14,285 parcels with improvements within the city limits of Tulsa, create a severe risk for an estimated 48,000 people, cause an estimated $1,843,401,375 in damage to an estimated 14,285 buildings including 67 critical facilities. In addition, it could produce widespread power outages, and release of hazardous chemicals.

Due to the potential devastating impact, even though the likelihood of a major dam or levee failure is low, the overall risk of the Tulsa Community is rated as Medium to High Hazard.

Annual Average Damages

Although available data is limited, information on total damage to property, injuries and loss of lives for the 10-year period from 1998 through 2007 (unless otherwise indicated) has been summarized in Table 4-1 below.

Table 4–1: Sample Summary of Damages
(Damage listed in $1,000's)

Hazard	*Events*	*Events/ Year*	*Total Property Damage*	*Property Dmg/ Event*	*Property Dmg/ Year*	*Injuries*	*Injuries/ Event*	*Injuries/ Year*	*Deaths*	*Deaths/ Event*	*Deaths/ Year*
Floods	58	5.8	$3,600	$62.1	$3.6	**20**	0.35	**2.0**	13	0.22	1.3
Tornadoes[1]	9	0.9	$2,451	$272.3	**$245**	7	0.78	0.7	0	0	0
High Winds	83	8.3	$5,500	$66.3	$55	2	0.02	0.2	1	0.08	0.1
Lightning	4	0.4	$160	$40	$1.6	1	0.25	0.1	0	0	0
Hail	**86**	**8.6**	$21,655	$251.8	$21.7	0	0	0	0	0	0
Winter Storms[2]	20	2	**$50,154**	**$2,507**	$50.1	0	0	0	0	0	0
Extreme Heat[2]	4	0.4	$0	$0	$0	***Insufficient Data***			**27**	**6.75**	**2.7**
Drought[2]	8	0.8	$0	$0	$0	0	0	0	0	0	0
Expansive Soils	***Insufficient Data***										
Wildfires	6	0.6	$2,050	$341.7	$	11	**1.83**	1.1	1	0.16	0.1
Earthquakes	0	0	$0	$0	$0	0	0	0	0	0	0
Dam Failures	0	0	$0	$0	$0	0	0	0	0	0	0

Hazards Analysis: Probability and Vulnerability

The ODEM guidelines for hazard analysis provides a process for use in assessing and evaluating hazards and promotes a common base for performing the analysis by defining criteria and establishing a rating and scoring system. Table 4-2 shows the results of a sample hazard analysis for an Oklahoma community, which includes a quantification of the history, probability, vulnerability, and maximum threat for each event. Table 4-3 provides a summary of the ranking criteria and the scoring method.

[1] Number of Events are for Tulsa County
[2] Since this event covers such a wide area, figures are for the Tulsa Area.

Table 4–2: City of Tulsa Hazard Analysis

Disaster	*History* (2)*	*Vulnerability* (5)*	*Maximum Threat* (10)*	*Probability* (7)*	*Score*
Winter Storm	High	High	High	High	240
Hailstorm	High	High	High	High	240
Tornado	High	High	Low	Medium	180
Flood	High	Medium	Medium	High	165
Dam Failure	Low	Medium	High	Low	159
Extreme Heat	High	High	Low	High	150
Lightning	High	High	Low	High	150
High Wind	High	Medium	Low	High	125
Expansive Soil	High	Medium	Low	High	125
Wildfire	High	Low	Low	Medium	125
Drought	Medium	Low	Low	Medium	60
Earthquake	Low	Low	Low	Low	44

* Criteria weighted by value in column title.

Values:	
High	10
Medium	5
Low	1

Table 4–3: Summary of Hazard Analysis Ranking Criteria

Source: Oklahoma Department of Emergency Management

Criteria	*Description*	*Scoring*
History	If a certain kind of disaster occurred in the past conditions causing the event can occur again.	Number occurrences in the past 100 years: 0-1 Low 2-3 Medium 4+ High
Vulnerability	The number of people and value of property in jeopardy determine vulnerability. Vital facilities, such as hospitals, office buildings and emergency facilities, and population groups of special concern should be included in vulnerability determination.	Population exposed: < 1% Low 1%-10% Medium >10% High Property damaged or destroyed: < 1% Low 1%-10% Medium >10% High
Maximum Threat	Maximum threat is the worst-case scenario of a hazard. Its impact is expressed in terms of human casualties and property loss. Secondary events need to be factored in where necessary.	Area of town impacted: < 5% Low 5%-25% Medium >25% High
Probability	Probability is the likelihood an event will occur. History and probability are similar, however two criteria are used to distinguish between newly developing hazards and hazards with a lack of historical information.	Chance per year of disaster: < .1% Low 0.1%-10% Medium >10% High

Secondary Events

Although hazards may be individually identified and categorized, many are interrelated, and a disaster may involve multiple hazards. Severe thunderstorms, for example, may spawn high winds, lightning, hailstorms, tornadoes, and flooding. It is generally more useful to consider all secondary events as a part of the overall situation created by the primary event. These events are frequently referred to as “cascade” events. Table 4-4 identifies secondary events that are related to each of the 12 natural and technological hazards studied in this report.

Table 4–4: Secondary (Cascade) Hazard Events

Primary Event	***Dam Failure***	***Drought***	***Expansive Soil***	***Flood***	***Haz. Material Event***	***Power Failure***	***Urban Fire***	***Trans-portation***	***Water Supply Failure***	***Wild-fire***
Flood	●				●	●		●	●	
Tornado					●	●	●	●		
High Wind					●	●	●	●	●	●
Lightning					●	●	●	●		●
Hail						●				
Winter Storm						●	●	●		
Extreme Heat		●	●			●				
Drought			●						●	●
Expansive Soil									●	
Wildfire					●	●	●	●		
Earthquake	●				●	●	●	●	●	
Dam Failure				●	●	●		●	●	

4.1 Floods

Flooding is defined as the accumulation of water within a watercourse or water body and the overflow of excess water onto adjacent floodplain lands. The floodplains are the lands adjoining the channel of a river, stream, ocean, lake, or other watercourse or water body that is susceptible to flooding.

Measurements

The probable future impact of flooding can be assessed by mapping urban development, soil conditions, and the 100-year floodplains; researching the extent of past floods; looking at historical rainfall data and the condition of drainage ways and stormwater facilities; and estimating the likely contribution to flooding from recent and future development. A computerized modeling and assessment tool named HAZUS was used to estimate damages within the City of Tulsa from a 100-year flood event. Hazard rankings for floodplain lands are typically based on the frequency, depth, duration, and velocity of anticipated floods.

Floods can lead to "cascading" events increasing the damage – including power outages, health issues, and hazardous materials releases, as illustrated in the above photo of a community where the flood breached a nearby oil refinery

4.1.1 Hazard Profile

Flooding is the most common and widespread weather hazard in the United States.

Most flood dangers and deaths are caused in flash floods. Flash floods usually result from intense storms dropping large amounts of rain within a brief period. The two key elements are rainfall intensity and duration, but topography, soil conditions and ground cover play important roles also.

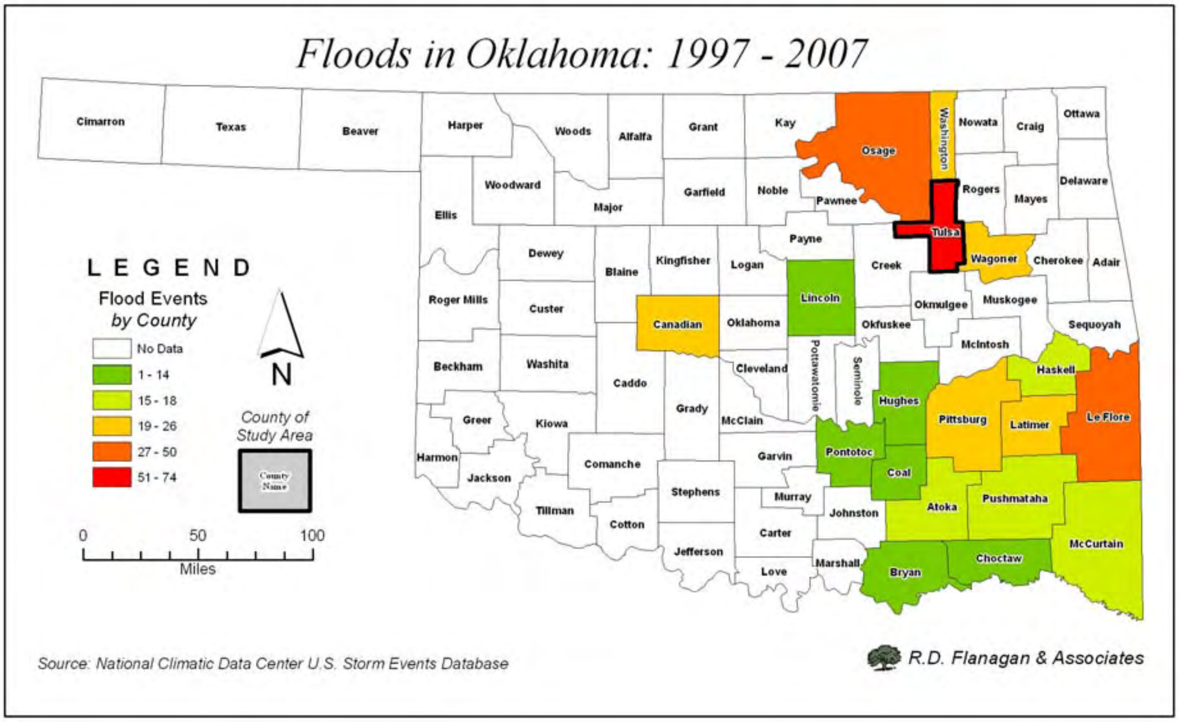
Flash floods occur with little or no warning and can reach peak flow within a few minutes. Waters from flash floods move with great force and velocity and can roll boulders, tear out trees, destroy buildings, and sweep away bridges. These walls of water can reach heights of 10 to 30 feet and generally carry large amounts of debris.

The following table lists areas identified on FEMA's Flood Insurance Rate Maps (FIRM) for use in regulating construction in the floodplain, and for determining Insurance rates for properties located in the floodplain. For information on Tulsa's existing floodplain management program, see Section 2.3.2.

Flood Zones		
Zone A	The 100-year or Base Floodplain. There are six types of A zones:	
	A	The base floodplain mapped by approximate methods, i.e., BFEs are not determined. This is often called an unnumbered A zone or an approximate A zone.
	A1-30	These are known as numbered A zones (e.g., A7 or A14). This is the base floodplain where the firm shows a BFE (old format).
	AE	The base floodplain where base flood elevations are provided. AE zones are now used on new format FIRMs instead of A1-30 zones.
	AO	The base floodplain with sheet flow, ponding, or shallow flooding. Base flood depths (feet above ground) are provided.
	AH	Shallow flooding base floodplain. BFE's are provided.
	A99	Area to be protected from base flood by levees or Federal flood protection systems under construction. BFEs are not determined.
	AR	The base floodplain that results from the de-certification of a previously accredited flood protection system that is in the process of being restored to provide a 100-year or greater level of flood protection
Zone V and VE	**V**	The coastal area subject to velocity hazard (wave action) where BFEs are not determined on the FIRM.
	VE	The coastal area subject to velocity hazard (wave action) where BFEs are provided on the FIRM.
Zone B and Zone X (shaded)	Area of moderate flood hazard, usually the area between the limits of the 100-year and the 500-year floods. B zones are also used to designate base floodplains or lesser hazards, such as areas protected by levees from the 100-year flood, or shallow flooding areas with average depths of less than one foot or drainage areas less than 1 square mile.	
Zone C and Zone X (unshaded)	Area of minimal flood hazard, usually depiction FIRMs as exceeding the 500-year flood level. Zone C may have ponding and local drainage problems that do not warrant a detailed study or designation as base floodplain. Zone X is the area determined to be outside the 500-year flood.	
Zone D	Area of undetermined but possible flood hazards.	
Source: Understanding Your Risks, identifying hazards and estimating losses, FEMA 386-2		

4.1.1.1 Location

This section contains summary information about the locations of Tulsa's creeks and floodplains. Locations of lakes and impoundments, as well as more detailed information about the Arkansas River, are contained in the section on dams and levees.



The following map shows the state of Oklahoma, with Tulsa County highlighted, and includes summary data on flood occurrences throughout the state, by county.

Creeks, rivers, watercourses, and floodplains network throughout the City of Tulsa. The City of Tulsa's 213 square miles contain 56 creeks and watersheds, which directly or ultimately drain into either the Arkansas River or Bird Creek, a tributary to the Verdigris River. A major ridgeline runs diagonally through Tulsa, from northwest to southeast. Watersheds to the southwest of that ridgeline generally flow to the Arkansas River, and watersheds to the north and east of that ridgeline flow into Bird Creek.

Figure 4-1 shows those 56 drainage basins that lie partly or entirely within Tulsa.

FEMA and Tulsa have identified those areas within the watersheds of the streams of Tulsa that have a one-percent chance of flooding in any given year. Figure 4-2 is a generalized map showing floodplains that have been identified along the major waterways and rivers.

4.1.1.2 Extent

Tulsa rainfall averages 39 inches per year, but thunderstorms can, and have, dumped more than half that amount on the city in a few hours, causing widespread flooding and devastating flash floods.

Tulsa flood problems are widely dispersed and could be divided into several categories:

- Floods along major waterways with very large drainage basins, such as the Arkansas River and Bird Creek

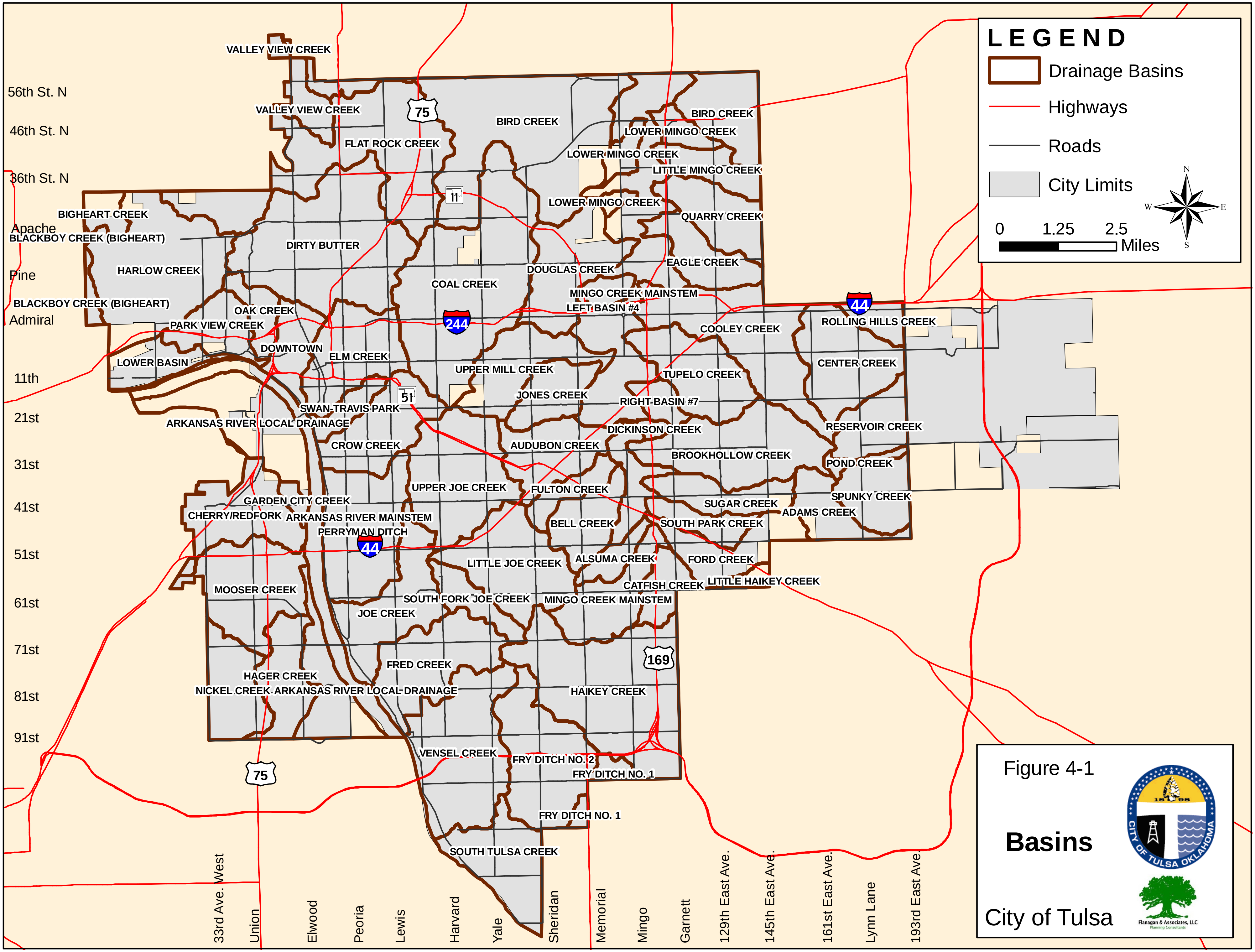


Figure 4-1

Basins

City of Tulsa

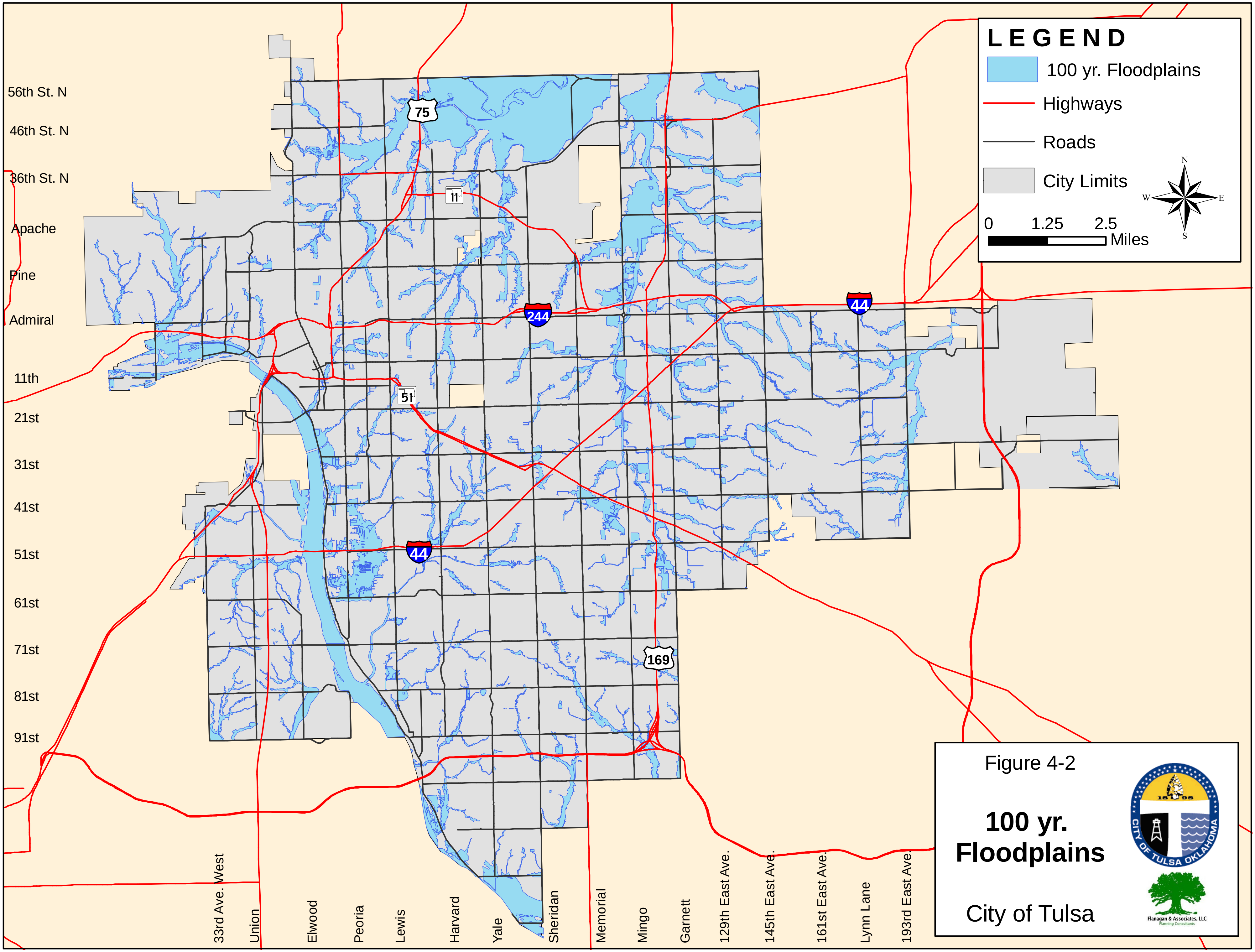


Figure 4-2

100 yr. Floodplains

City of Tulsa

- Flash floods along tributary creeks and water ways that ultimately drain into the Arkansas River or Bird Creek
- Floods that impact streets and transportation systems
- Localized drainage and nuisance flooding problems

Over the years, flooding has been Tulsa's most frequent, disruptive, and damaging disaster. Early settlers lived on a high bluff overlooking the Arkansas River, but later development spilled into lowland floodplains. Therefore, over the first 100 years of its life, Tulsa experienced some damaging flood every few years along the Arkansas River, Bird Creek, and/or their many tributary streams throughout the community. Arkansas River flooding became less frequent after partial levees were built during World War II, and after Keystone Dam was closed in 1964.

Along tributary creeks and waterways, the frequency and magnitude of flooding have been greatly reduced, but not eliminated, by significant advances in Tulsa floodplain management over recent decades. Nonetheless, the city is still prone to frequent nuisance, street, and localized flooding, remains vulnerable to larger floods along rivers and creeks, and is at risk for catastrophe along the Arkansas River.

Along Bird Creek, little change has occurred in flooding over recent years. Bird Creek continues to flood almost annually. Its floodplain is sparsely developed but includes important assets such as the Mohawk Zoo.

Arkansas River flood issues are complex for Tulsa. Building Keystone Dam and Kaw Reservoir on the Arkansas River upstream from Tulsa greatly reduced the frequency of seasonal riverine flooding. These flood control dams have not, however, eliminated the potential for catastrophic flooding on the Arkansas River and Caney Rivers, as witness the 1986 floods that were caused by forced emergency releases from Keystone, Hulah, and Copan Dams due to torrential rains.

Plans to build low-water dams on the Arkansas River at Tulsa, Sand Springs, and Jenks will spur development along the river, but also present management and development challenges, based on the river's flooding potential.

Additional information about the Arkansas River is contained in the section on dams and levees.

4.1.1.3 Frequency

Frequent floods have haunted Tulsa throughout its history. Today, the frequency and magnitude of other flood problems have been greatly reduced by better floodplain management practices. Nonetheless, relatively minor and localized flooding occurs every year, most frequently affecting the transportation systems. Some of these recent flood events are described in the following paragraphs. Although smaller floods occur much less frequently, the potential continues for catastrophic flooding -- despite a widespread community belief that flooding is a past problem.

4.1.1.4 History/Previous Occurrences

Table 4–5: Floods in Oklahoma and Tulsa for previous 10 years

Oklahoma	*Events*	*Deaths*	*Injuries*	*Damage*
1998-2007	1,213	13	20	$66.129 Mil
Tulsa	*Events*	*Deaths*	*Injuries*	*Damage*
1998-2007	58	2	0	$3.60 Mil

The following paragraphs summarize some of the major floods recorded since 1900, including historic Tulsa floods.

In Tulsa and throughout Oklahoma over recorded history, floods have accounted for many of the most frequent and most costly weather disasters. In the 15 years between 1970 and 1985, Tulsa County experienced nine major floods that were serious enough to be declared federal disasters – the most federal flood disasters on record for any community in the nation to that time. The following are among historic flooding events on record in Tulsa and Oklahoma.

Historic floods

(Dollar damages are not adjusted for inflation)

- May 28, 1908. The fourth greatest recorded flow on the Arkansas River peaked at 21.8 feet and caused $250,000 in damage in Tulsa (1908 dollars).
- June 11-13, 1923. Floodwaters destroyed Tulsa's waterworks and forced the evacuation of 4,000.
- April 6-7, 1927. Heavy rainfall in southeastern Kansas resulted in an 8- to 10-foot wall of water—with registered flows of 750,000 cubic feet per second—roaring down the Arkansas River valley below Muskogee and emptying into the Mississippi River. Nearly every levee from Fort Smith to the Mississippi was destroyed. Losses totaled $4,000,000.
- May 18-22, 1943. A deluge that dumped 24 inches of rain in six days on the area between McAlester to Muskogee resulted in the flood of record for many communities along the Arkansas River, including Tulsa.
- May 16-21, 1957. The wettest May in Oklahoma history caused widespread flooding on the Arkansas, Cimarron and Canadian Rivers.
- May 10, 1970. The Mother's Day Flood in Tulsa caused $163,000 in damages on rapidly developing Mingo and Joe Creeks.
- April, May and September 1974. April and May floods left $744,000 in damages on Bird Creek. Violent storms and tornadoes June 8 caused widespread flooding on Joe, Fry, Haikey and Mingo Creeks in Tulsa County, with more than $18 million in damages. On September 19, Mingo Creek flooded again.
- May 31, 1976. On Memorial Day, a 3-hour, 10-inch deluge centered over the headwaters of Mingo, Joe and Haikey Creeks in Tulsa caused a flood that killed three and caused $40 million in damages to more than 3,000 buildings.

- May 26-27, 1984. More than 12 inches of rain fell in Tulsa, causing extensive flooding, especially on Mingo Creek but also on many other area creeks such as Joe, Flat Rock, Dirty Butter, and Bigheart. Fourteen people were killed, 6,800 homes and more than 7,000 vehicles were damaged.
- October 1986. Keystone Reservoir filled to capacity, forcing the Corps to release water at the rate of 310,000 cubic feet per second. Downstream flooding was extensive, with $1.3 million in damage to 64 buildings in Tulsa. Garden City in West Tulsa was flooded to the rooftops, and low-lying homes along the river in northwest Tulsa were under 6 feet of water. One levee in Sand Springs was breached, but plugged with sandbags before serious damage occurred. Total damages in the Tulsa region were more than $63 million.
- May 29, 1994. Heavy rainfall resulted in flash flooding in the west and south parts of Tulsa. Hager Creek overflowed its banks, and some homes were evacuated. Some homes near 81st Street South and Elwood Avenue had 2 to 4 feet of water in them, and homes were also flooded near 71st Street South and Harvard Avenue. A total of 8 to 12 homes were flooded in the Tulsa area. Numerous roads were closed due to the flooding, including Interstate 44 from 33rd West Avenue to Union Avenue. Water was waist deep on the access road to the interstate, and 1 foot deep on the interstate itself.
- October 5, 1998. Serious flooding took place throughout Tulsa County. Major street flooding in Tulsa included the areas of 31st and Yale, 96th and Sheridan, and two feet of water over the road at 28th and 129th East Avenue. The basement of the Southwestern Bell telephone building in downtown Tulsa took on water, causing the loss of phone service across much of Tulsa for several hours and temporarily disabling 911 emergency services. Cell phones, pagers, and 911 emergency services across much of eastern Oklahoma were also affected. One woman had to be rescued from her car on a bridge near 101st and Garnett when her car stalled in four feet of water. Two other women had to be rescued when they tried to cross a swollen creek on foot on 81st Street near the Oak Creek subdivision. Damages were estimated at $30,000, not including the economic impact of the phone service interruption.
- April 26, 1999. More than 20 streets in Tulsa had to be closed. Tulsa police responded to 39 vehicles that were stalled in high water. Lower Mingo Creek overflowed, flooding undeveloped areas near 36th Street North. Lower Haikey Creek at 101st Street also overflowed its banks. Northern Tulsa County had flooding along the Bird Creek. Damages for the countywide event were estimated at $40,000.
- May 6, 2000. Over 6 inches of rain fell over Tulsa County, causing widespread flooding. Flood damage was reported in Jenks, Bixby, Glenpool, south Tulsa and Broken Arrow. Numerous roads and intersections were flooded. Damage to roads, bridges and infrastructure was estimated at $200,000, damages for the countywide event were estimated at $3Million. There was one fatality when a woman attempted crossing a street flooded by a nearby stream. Her car stalled, and with the water rising so quickly, she evacuated the vehicle and was swept away.

- May 30, 2001. Rapidly falling two inches of rain caused widespread street flooding within the city's jurisdiction. At Joe Creek on 66th Street near Lewis Ave, a police car was carried off a road. Damages were estimated at $10,000.
- May 17, 2002. Thunderstorms produced 2-3" of rain over a large portion of southern Tulsa County. Street flooding was reported in the southern part of the City of Tulsa, but more significantly caused a bridge over Snake Creek to be washed out near Bixby. Damages were estimated at $20,000.
- May 28, 2002. Up to 4" of rain fell across the southern part of the Tulsa metropolitan area just after rush hour. Lewis Avenue between 51st and 71st Streets South and Skelly Drive between Lewis and Peoria Avenues were barricaded due to high water. Two homes in south Tulsa were flooded when excessive rains overwhelmed the storm drainage system around Perryman Ditch. Damages were estimated at $10,000.
- September 8, 2007. Heavy rain caused widespread severe street flooding across the City. Numerous vehicles were stranded in the floodwaters. The worst reports of flooding were on Sheridan Avenue between 42nd and 46th Streets where water was three to four feet deep. Cars were stranded in the high water. Damages were estimated at $30,000.
- April 24, 2008. Heavy rain caused flooding in Mohawk Park, which required the zoo to be closed. No damages were reported.

4.1.1.5 Probability/Future Events

Currently flood planning is based on what are termed "100-year floods" or "500-year floods." That terminology is somewhat misleading and is changing to floods being referred to as having a 1% chance of occurring in any given year.

Depending on the extent of the rainfall, such larger storms could be expected to inundate floodplain lands and the roads, bridges, buildings, and other structures thereon. The frequency and magnitude of floods that could threaten people or property depends, in large part, on the magnitude and location of the rain and the condition of the receiving systems. For example, on-the-ground conditions such as debris in creeks could exacerbate flooding problems.

No probability has been assigned for other potential causes of Tulsa flooding, such as waterline breaks or snowmelt, because those flooding causes cannot be predicted statistically or are infrequent within the city of Tulsa.

Flooding hazards from dam or levee breaks and flooding lake releases are discussed in the report section for those hazards.

4.1.2 Existing Vulnerability

This section summarizes information about Tulsa's vulnerability to flooding problems, including problems for people, structures and buildings, critical facilities, and infrastructure. HAZUS modeling was used to help generate these data.

4.1.2.1 Population

The City of Tulsa has 13,813 residential parcels with improvement values located in or adjacent to its regulatory floodplains. In a citywide 100-year flood, more than 13,000 households, including over 30,000 individuals, could be displaced by flooding within or near the inundation area.

Those at greatest risk include persons living in residences located in repetitive flood areas for the larger events. Also at risk are those traveling by car and on foot in areas that are known to experience flooding during heavy rain. Motorists continue to ignore barricades and warnings against driving on flooded roads and become stranded in their vehicles. Just two feet of water moving at 10 mph will float virtually any car, SUV or pickup. Too often the rate of the water's rise is not appreciated and people become trapped in the vehicle – as reported in May 2000 when a woman was traveling on Sheridan Avenue between 71st and 81st Streets and crossed a road that was flooded by a nearby creek. The vehicle stalled in the rapidly rising water forcing the woman out of the car where she was swept away and drowned.

Persons being directed to evacuate an area due to rising water without appropriate transportation could be at greater risk. Likewise those being directed to evacuate, but are not willing to leave their homes for fear of looting, or not willing to leave pets behind may resist such instruction, thereby placing them at risk as well.

Additionally, for persons new to the area or for whom English is not their first language, understanding the true nature of the hazard, the necessary precautions and the accompanying warnings is a daily struggle.

4.1.2.2 Structures

In all, Tulsa has 15,459 existing buildings of all kinds located in or adjacent to the floodplain of its rivers and streams.

Information related to the 100-year flood event and flood insurance policies in force in Tulsa is shown in Table 4-6.

Structural values used in this assessment were from the Tulsa County Assessor's Office. It is estimated that the average structure will experience 2 feet of flooding, which will result in 25% damage to the structure and 25% damage to contents.

Table 4–6: Vulnerable Tulsa Floodplain Buildings

Flood Insurance as of 6/30/08	
Flood Insurance Policies in Force	1,650
Amount of Flood Insurance in Force	$253,618,300
Paid Premiums	$678,347
Total Number of Losses Paid	2,541
Total Amount of Loss Payments	$38,373,603.65

Repetitive Losses

A repetitive loss property is defined by FEMA as "a property for which two or more National Flood Insurance Program losses of at least $1,000 each have been paid within any 10-year period."

Tulsa currently has 88 properties on its FEMA Repetitive Loss list. Tulsa has developed a Repetitive Loss Plan that recommends the measures needed to solve the flooding problem of each repetitive loss property. Tulsa's strategies include:

- Construction of flood protection projects, such as channel improvements and stormwater detention ponds
- Construction of small local projects, such as storm sewers, culvert replacements, and drainage ditches
- Acquisition of the property and removal and demolition of the building

The locations of Tulsa's repetitive loss properties are shown on the map in Figure 4-3 and are listed by status category in Appendix H.

4.1.2.3 Critical Facilities

Tulsa has 30 critical facilities located in or adjacent to floodplains. Critical facilities located in the floodplains pose a problem for the community. In the event of a flood, they have impacts beyond the flooding of the facility. For example, if child care centers cannot open, parents cannot go to work to provide important community services. First responder services are hampered if flooded police and fire stations cannot operate effectively. During the 1984 flood, hundreds of police cars parked in the floodplain were flooded and unavailable for use in responding to Tulsa's worst flood disaster in modern times.

Critical facilities located in the floodplain are listed in Table 4-7 and are shown on the map in Figure 4-4. For a comprehensive list and addresses of Critical Facilities, see Appendix G.

Table 4–7: City of Tulsa Critical Facilities Located in the Floodplain

Type	Name
CC33	Mabee Red Shield Boys & Girls
CC39	Riverfield Country Day School
CC42	St. John Medical Center Chapman Learning Center
CC43	Temple Israel Day School
CC46	Victory Christian School
CC47	Victory Kids Care
CC48	Victory Mother's Day Out
CC53	YWCA Patti Johnson Wilson ELC
CF1	City Garage

Type	Name
CF8	Juvenile Delinquency Project
FD2	Fire Dept. Dog Kennel
FD17	Tulsa Fire Station #22
FD36	Tulsa Fire Dept. Supply
FD37	Tulsa Fire Dept. Training
FG13	USPS – Southeast Tulsa Post Office
ML39	Ambassador Manor
ML51	Colonial Manor
PS17	School of Saint Mary
PS24	Victory Christian School
PW3	Equipment Maintenance
PW10	Structural Maintenance
TC6	Tulsa County Deputy Sheriff
TC14	Tulsa County Juvenile Detention Center
TES26	Jackson Elementary School
TES35	Marshall Elementary School
TES39	Mitchell Elementary School
THS3	East Central High School
WW4	Sewer Lift Station
WW5	Sewer Lift Station
WW8	Southside Lift Station (Raw Sewage Pump House)

4.1.2.4 Infrastructure

Water Treatment – Most significant effect during most major events would be from loss of electrical power. Flooding in the watershed could impact water quality in the lakes accessed by the city's water system. The impact could range from minor to significant, depending on the nature of the flooding, pollutants released to the watershed, and the location of the release and the impact on the City's intakes. Deposition of sediments, nutrients and other contaminants by flooding and have a long-term effect on the City's water supply lakes.

Wastewater Treatment – Most significant effect during most major events would be from loss of electrical power. Additionally, localized flooding at or near the access road to the Apache lift station could prevent access to that facility during an emergency.

Utilities – The primary utility providers for Tulsa's jurisdiction is AEP/PSO (electricity) and ONG (natural gas). **Electricity**: The largest threat to the delivery of electrical service would be the destruction/damage of power poles/lines.

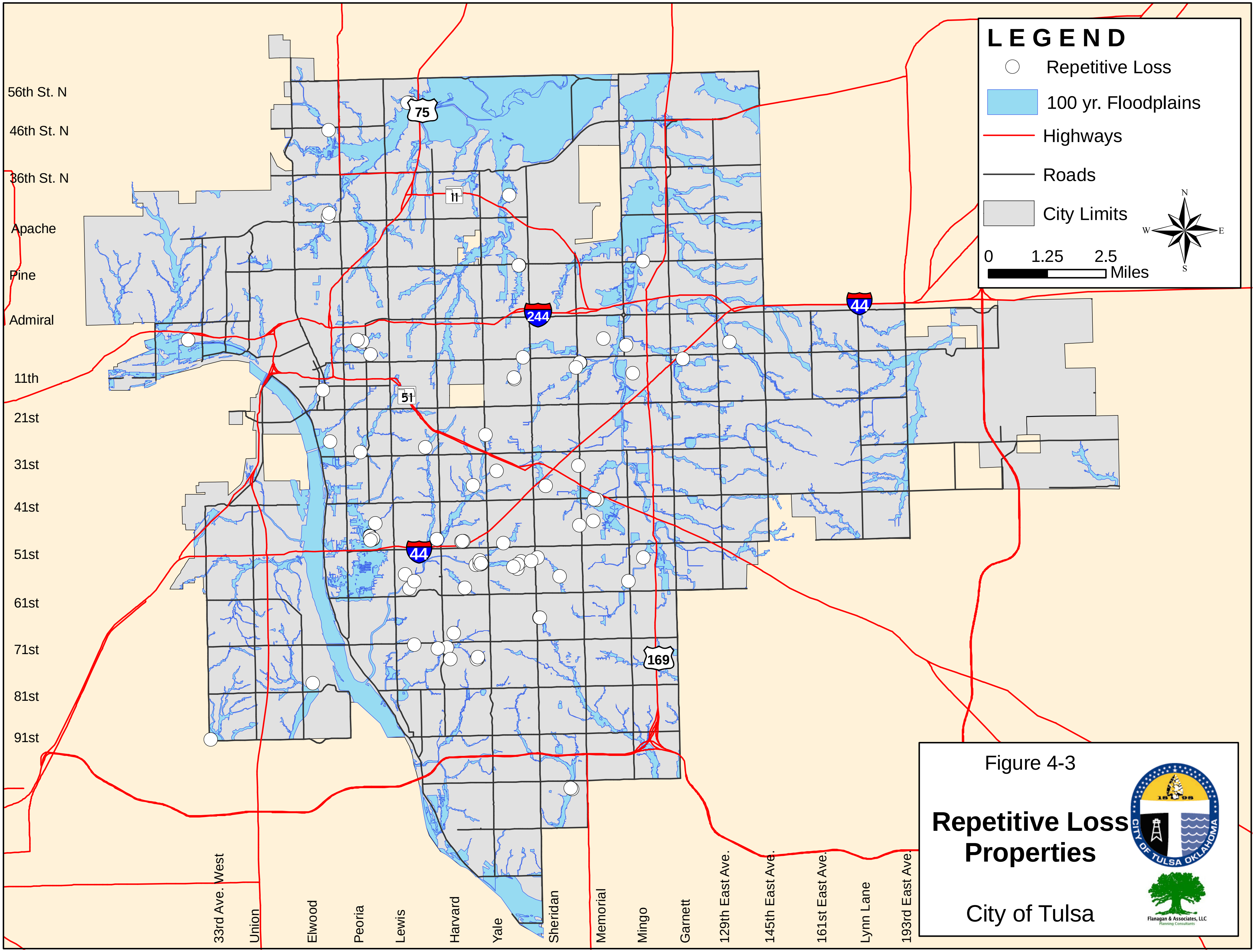
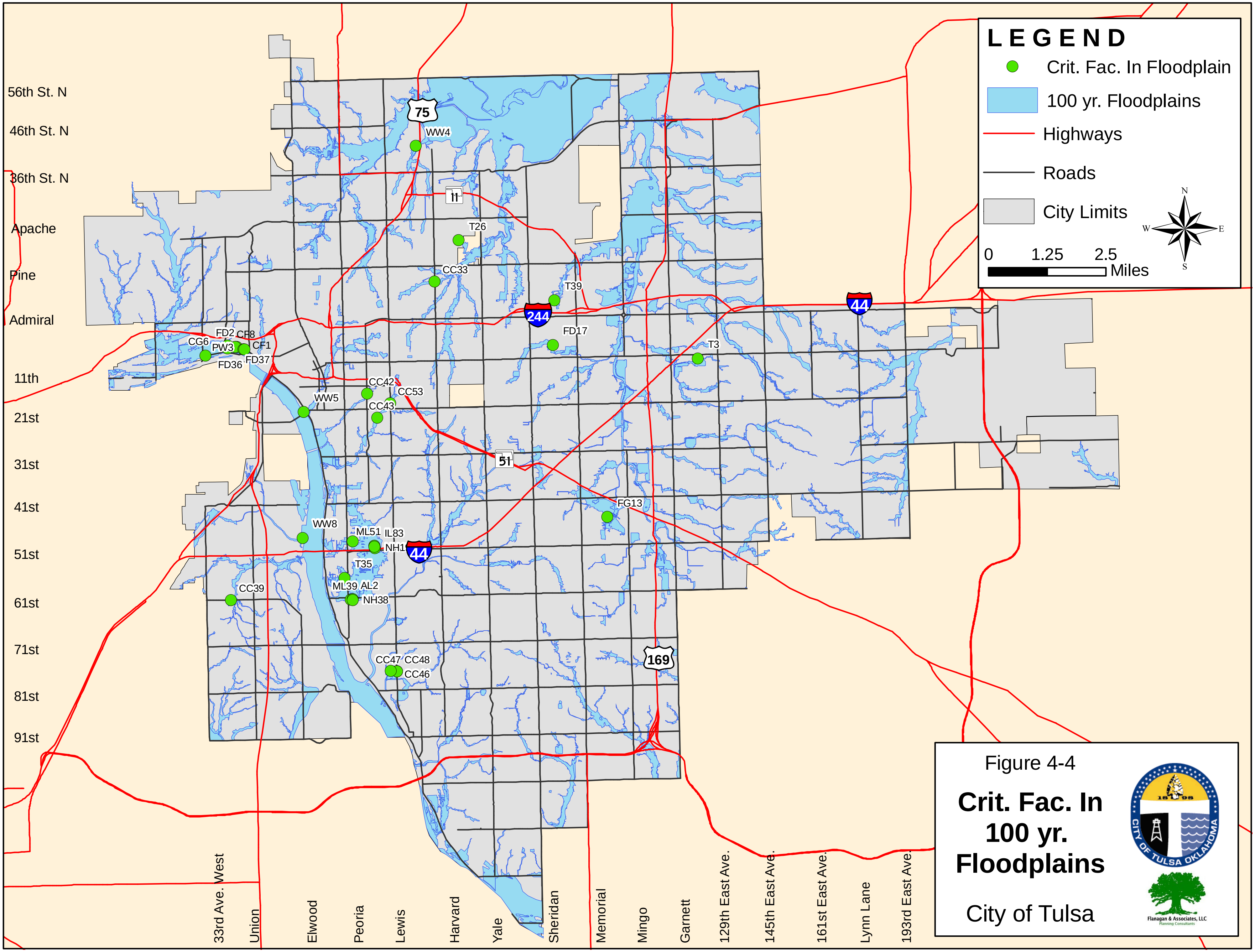


Figure 4-3

Repetitive Loss Properties

City of Tulsa


LEGEND
Crit. Fac. In Floodplain
100 yr. Floodplains
Highways
Roads
City Limits
0 1.25 2.5 Miles
N
S
E
W
56th St. N
46th St. N
36th St. N
Apache
Pine
Admiral
11th
21st
31st
41st
51st
61st
71st
81st
91st
33rd Ave. West
Union
Elwood
Peoria
Lewis
Harvard
Yale
Sheridan
Memorial
Mingo
Garnett
129th East Ave.
145th East Ave.
161st East Ave.
Lynn Lane
193rd East Ave.
75
11
244
44
51
169
WW4
T26
CC33
T39
FD17
T3
FD2
CF8
CG6
PW3
CF1
FD36
FD37
CC42
CC53
WW5
CC43
FG13
WW8
ML51
IL83
NH1
T35
CC39
ML39
AL2
NH38
CC47
CC48
CC46
Figure 4-4
Crit. Fac. In 100 yr. Floodplains
City of Tulsa
CITY OF TULSA OKLAHOMA
1898
Flanagan & Associates, LLC
Planning Consultants

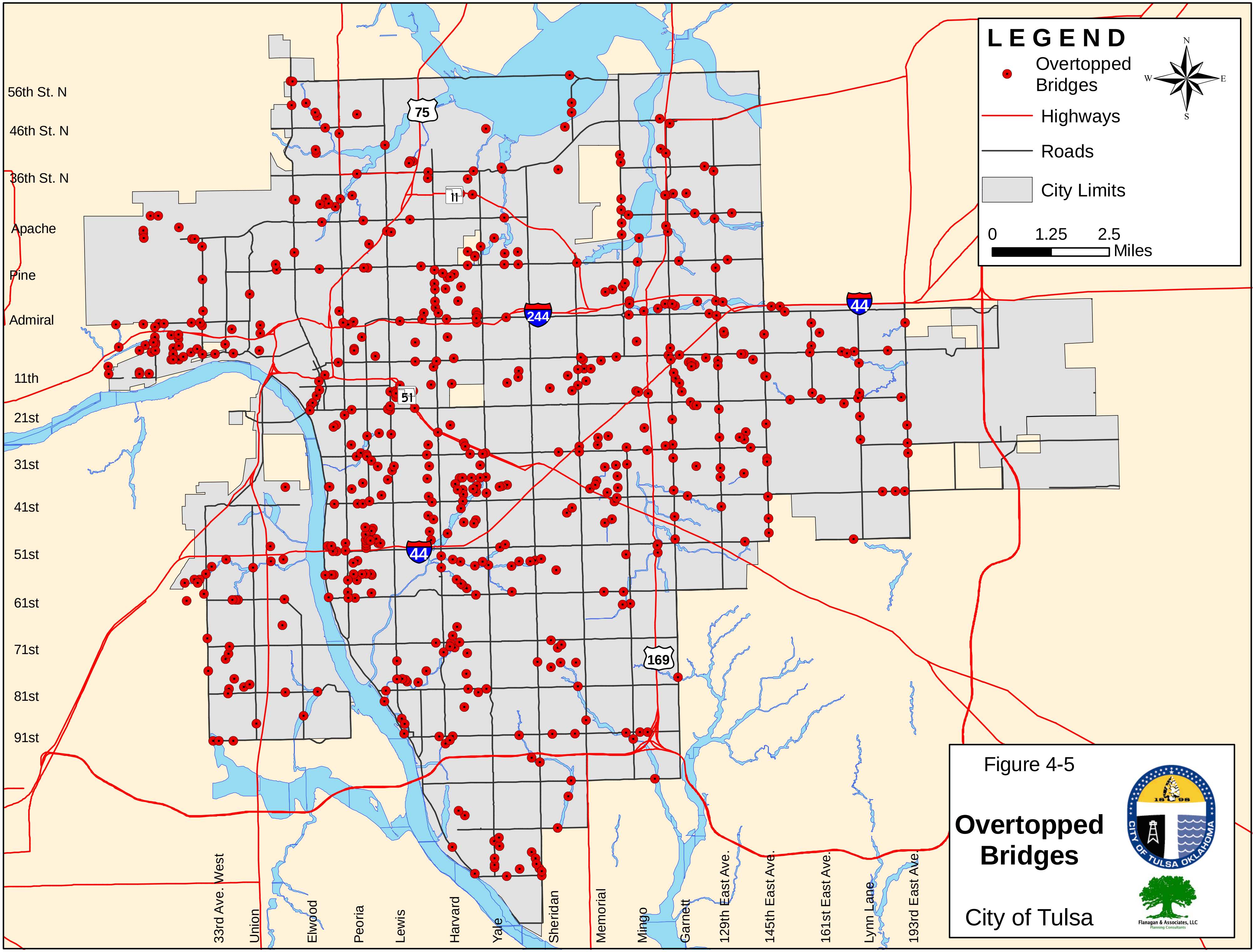


Figure 4-5

Overtopped Bridges

City of Tulsa

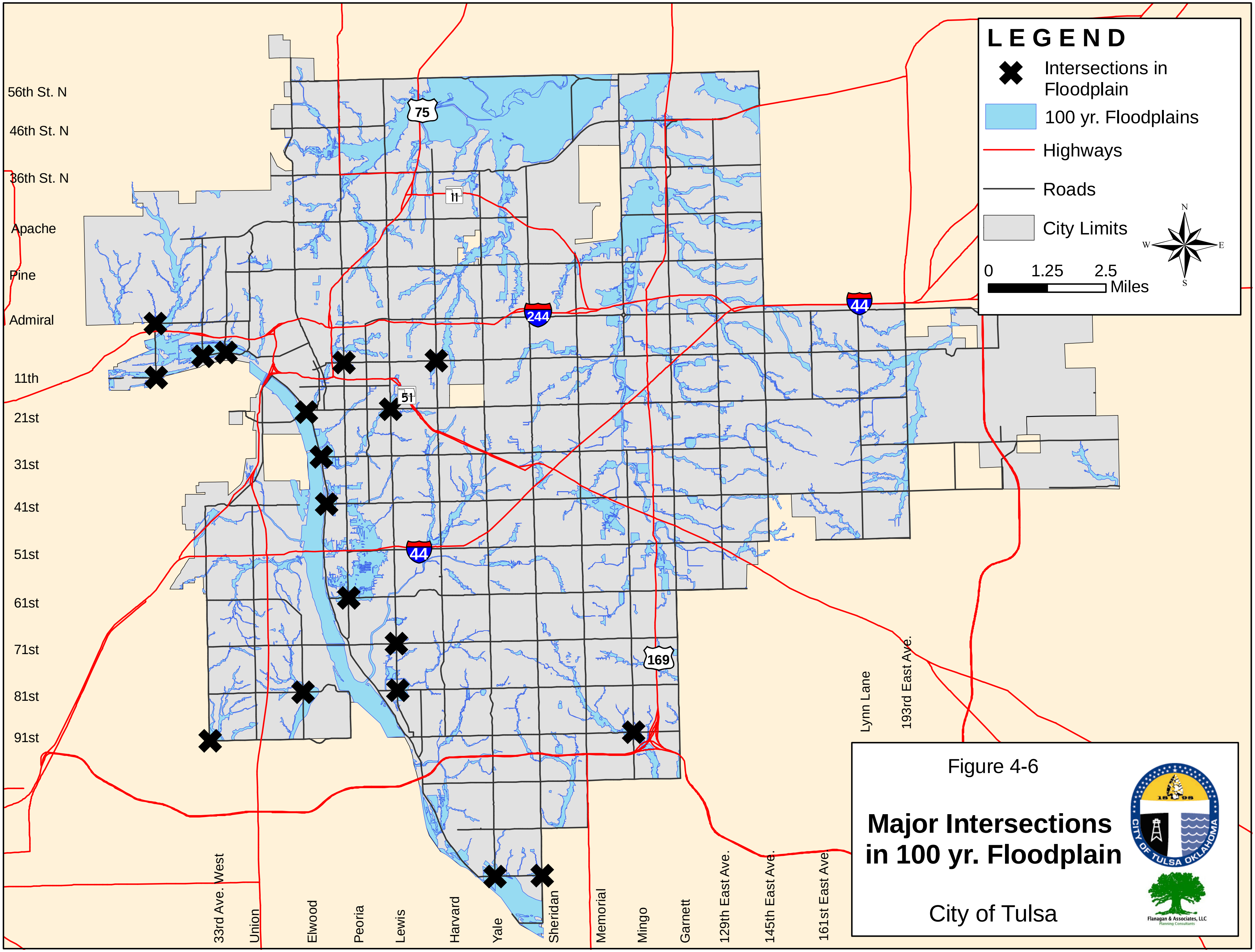
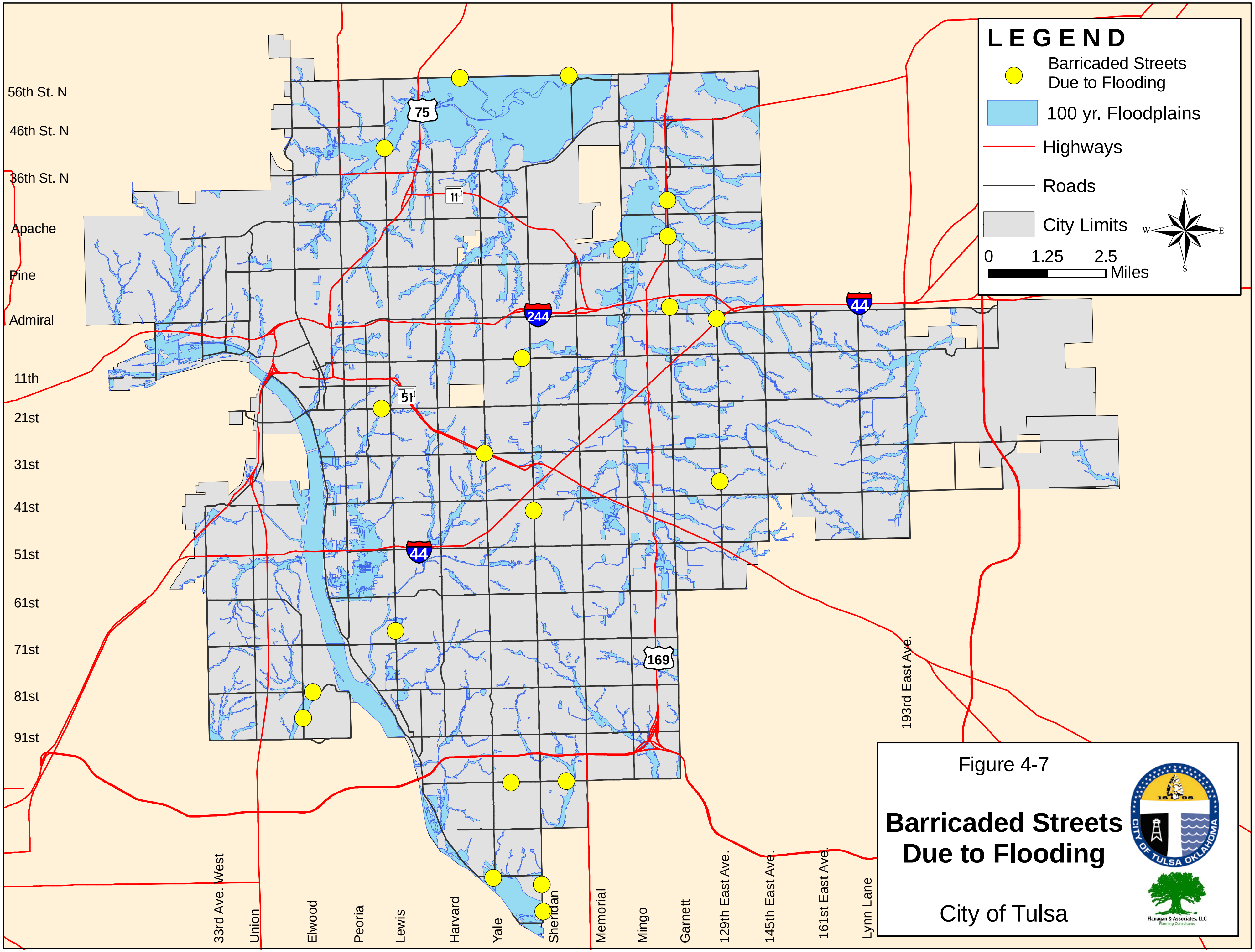


Figure 4-6

Major Intersections in 100 yr. Floodplain

City of Tulsa


LEGEND
Barricaded Streets Due to Flooding
100 yr. Floodplains
Highways
Roads
City Limits
0 1.25 2.5 Miles
N
S
E
W
56th St. N
46th St. N
36th St. N
Apache
Pine
Admiral
11th
21st
31st
41st
51st
61st
71st
81st
91st
75
11
51
244
44
44
169
33rd Ave. West
Union
Elwood
Peoria
Lewis
Harvard
Yale
Sheridan
Memorial
Mingo
Garnett
129th East Ave.
145th East Ave.
161st East Ave.
Lynn Lane
193rd East Ave.
Figure 4-7
Barricaded Streets Due to Flooding
City of Tulsa
1898
CITY OF TULSA OKLAHOMA

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Roadway inaccessibility would be the largest vulnerability posed to the transportation system during a Flood event. Several intersections within the City's jurisdiction face repeated flooding during heavy rain events. Most situations are short-lived, but do create potential life safety issues due to stranded motorists and inaccessibility to safety vehicles. Additionally, bridges in typical high water areas could be compromised in their integrity, especially if of older construction.

Emergency Services- Fire, Police and Medical Services would all be similarly at risk to effects of a Flood event. Flood/Flashflood events create a larger call load for all emergency response agencies, presenting various challenges to the agencies, in addition to the posed hazards to the agencies' personnel performing these services. During many of the events resulting in street flooding, law enforcement and fire personnel are stationed at intersections to ensure the safety of motorists who may try to enter these barricaded areas. This could potentially affect response time if the event is widespread enough requiring a large number of city resources.

4.1.3 Flood Scenario

Because of the extensive and groundbreaking flood mitigation programs that have been developed and implemented in Tulsa throughout the late 1980's and 1990's, the 1986 floods caused by forced emergency releases from Keystone, Hulah, and Copan Dams due to torrential rains are considered the worst-case scenario for the City. Damages caused by that event are reflected in the following table, and a map of the affected areas is in Figure 4-8 below.

Downstream flooding along the Arkansas River Corridor was extensive. Garden City in West Tulsa was flooded to the rooftops, and low-lying homes along the river in northwest Tulsa were under 6 feet of water. One Arkansas River levee in the City of Sand Springs was breached.

Table 4–8: 1986 Flood Scenario Damages

Parcel Count	Assessed Value	Structure Damage (25%)	Contents	Contents Damage	Total Damage
Residential Parcels					
1,096	$ 280,091,370	$70,022,842.5	$140,045,685	$35,011,421.25	$105,034,263.75
Commercial Parcels					
35	$34,082,400	$8,520,600	$17,041,200	$4,260,300	$12,780,900
Industrial Parcels					
49	$38,827,900	$9,706,975	$19,413,950	$4,853,487.5	$14,560,462.5
Tax Exempt Parcels					
1	-	-	-	-	-
Other (VP, 300)					
52	$11,523,100	$2,880,775	$5,761,550	$1,440,387.5	$4,321,162.5
Scenario Total					
1181	$353,001,670	$91,131,192.5	$182,262,385	$45,565,596.25	$136,696,788.75

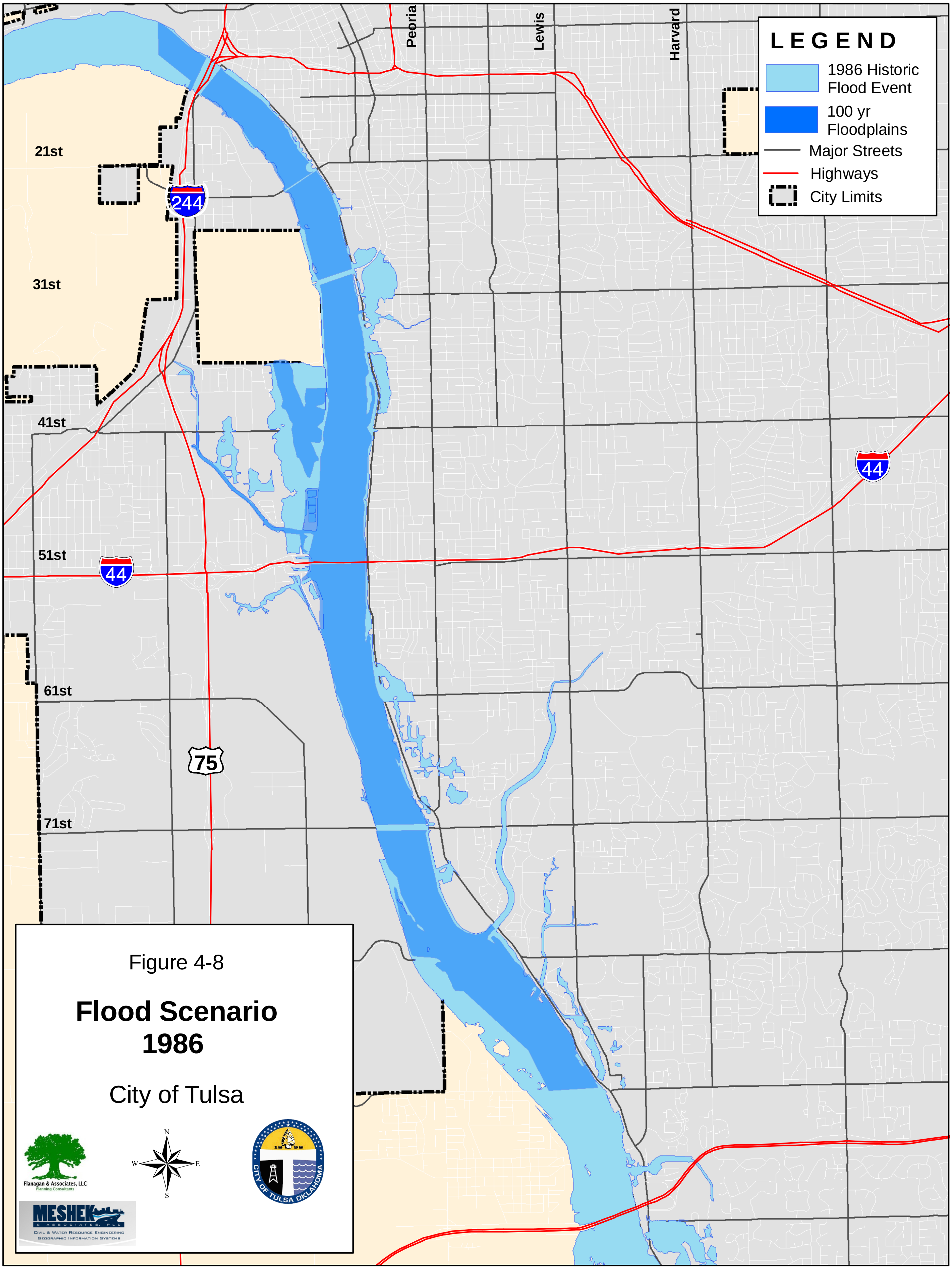


Figure 4-8

Flood Scenario 1986

City of Tulsa

4.1.4 Future Trends

For a map of future development areas, and their relationships to the floodplains, see Figure 1-13.

Table 4–9: Floodplain Property Data for Future Development Areas/Trends

County	Parcel Count	Assessed Improvement
Tulsa	364	$7,820,660
Wagoner	31	Not Available
Osage	231	$1,800,157
TOTAL	**626**	**$9,620,817**

4.1.4.1 Population

With more recreational opportunities being developed along the banks of the Arkansas River (RiverParks area) – there will naturally be an increase in population taking advantage of those areas. Many times, people who are unfamiliar with waterway recreational areas are unaware of the dangers of swiftly moving waters. In times of heavy rains and flood conditions in this Tulsa area, the Arkansas River flows at a much deeper level, producing a swifter and stronger current, even along the banks. A combination of all these factors equates to an increase in the number of those vulnerable to the secondary flood risk of wading in to or getting too close to swift moving waters.

News reports have proven that even with an aggressive campaign designed to alert people to the dangers of Flash Floods, there are those that continue to defy the odds and attempt to drive through standing water on roadways. Without stronger penalties for those disregarding road barriers and signs warning of the dangers, this is a trend that will most likely continue – therefore putting that group of drivers and their passengers at increased risk of harm during times of Flash Flood conditions.

4.1.4.2 Structures/Buildings

As development in new areas and revitalization of existing areas continues, locations and building techniques should be closely examined. The reduction of the earthen footprint in the community can potentially create water run-off to another area that was previously at low to no risk for flooding. This has been demonstrated in the Broken Arrow area that has experienced a phenomenal rate of growth. The NW portion of Wagoner County (which includes areas east of Broken Arrow) has reported more than 5,000 homes built over the last 5 years. These areas previously experienced heavy rains that pooled and caused no damage – because no homes were there at the time. Now these same areas are dotted with new homes and huge housing additions currently under construction. The Wagoner County Planning Director stated that “The more impervious the area, it’s that much less absorption you’re going to have. The more concrete poured, the less open land for some of that water to run off to.”

Additionally, development in areas along the outer perimeters of the City’s boundaries that have been identified as potential flood risk areas could have a substantial impact on the integrity and capacity of existing drainage systems. Current systems are frequently overwhelmed during events that produce slow-moving heavy volume rainfall because of shear volume or the presence of debris present in the storm drains. An aggressive and ongoing public awareness program should be maintained to ensure new and existing development comply with ordinances and policies in place that are designed to address this issue.

4.1.4.3 Critical Facilities

With Tulsa's strong commitment to maintaining current flood plain zoning guidelines, it is not anticipated that any new development of critical facilities will occur within these types of areas of currently undeveloped sections of the jurisdiction.

Any renovations or improvements made to existing critical facilities so located should be evaluated to ensure the prescribed improvements assist in the mitigation of potential damages to these facilities in the event of a flood.

4.1.4.4 Infrastructure

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Currently, the City of Tulsa's most likely ongoing threat from flooding would be a flashflood event. During a storm event that is producing a large amount of rainfall over a short period of time, it is highly likely that several roadway intersections will become impassable due to water over that roadway. With this in mind, plans being developed/implemented for street/roadway improvements within this jurisdiction should take these potential conditions into account.

4.1.5 Conclusions

Over recent years, progress has been made in protecting the lives and property of Tulsa's citizens from flooding, but much work remains to be done to make Tulsa flood-safe. It is important that Tulsans avoid being lulled into a false sense of security that could make them vulnerable to unexpected tragedy.

Because of the number of streams that run through the city, the seasonal thunderstorms that dump massive amounts of rainfall in brief time-spans, the presence of aging levees and a high Arkansas River hazard dam upstream on the Arkansas River, and the community's history of flooding, Tulsa remains vulnerable to frequent moderate flooding and the potential for infrequent catastrophic flooding.

To protect citizens, property, and the community from flooding, this study has identified several flood mitigation measures to be implemented, which are discussed in the chapter on mitigation strategies and Appendix B.

4.1.5.1 Data Limitations

While rain events and the extent of flooding produced can be reasonably predicted, other sources of floodwater, such as snowmelt, waterline breaks, or blocked storm drains cannot be as accurately defined and predicted. They are, however, relatively less common than flooding caused by rainfall.

4.1.5.2 Update Changes

Identified significant changes made from the 2003 City of Tulsa Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.1.5.3 Sources

Extreme Weather and Climate Events at National Climatic Data Center website: www.ncdc.noaa.gov/oa/climate/severeweather/extremes.html

FEMA Flood Insurance Statistics at Website: www.fema.gov/nfip/10110309.shtm

FEMA Flood Insurance Study, Tulsa, Oklahoma, Tulsa County. FEMA, Revised May 4, 1998.

4.2 Tornadoes

Each year Oklahoma has more tornado events per square mile than any other state

A tornado is a rapidly rotating vortex or funnel of air extending to the ground from a cumulonimbus cloud. When the lower tip of a vortex touches earth, the tornado becomes a force of destruction. The path width of a tornado is generally less than a half-mile, but the path length can vary from a few hundred yards to dozens of miles. A tornado moves at speeds from 30 to 125 mph, but can generate winds exceeding 300 mph.

Measurements

It should be noted that the observable size of a tornado is not an indicator of its severity. A thin "rope" tornado can have very high internal wind speeds and produce extraordinary damage, while a twister 100's of yards across might generate relatively low wind speeds. While traditionally, the Fujita scale has measured tornadoes, the National Weather Service has recently adopted an "Enhanced Fujita Tornado Scale." The new scale is based on a broader set of degrees of damage to a wider variety of structures. A description of the Fujita Scale and comparison to the Enhanced Fujita Scale (EF) are included in Table 4-10. Additional information on the Enhanced scale is available at www.spc.noaa.gov/efscale.Almost 70% of all tornadoes are measured F0 and F1 on the Fujita Tornado Scale, causing light to moderate damage, with wind speeds between 40 and 112 miles per hour. F4 and F5 tornadoes are considerably less frequent, but are the big killers. Sixty-seven percent of all tornado deaths were caused by F4 and F5 storms, which represent only 1% of all tornadoes.

Table 4–10: Fujita Scale and Enhanced Fujita Scale

Fujita Scale			EF Scale	
Category	***Wind Speed (mph)***	***Current Damage Indicators***	***Category***	***3 Second Gust (mph)***
F0	Gale (40-72)	***Light***: Damage to chimneys, tree branches, shallow-root trees, sign boards	F0	65-85
F1	Moderate (73-112)	***Moderate***: Lower limit is beginning of hurricane wind speed--surfaces peeled off roofs, mobile homes pushed off foundations or overturned, cars pushed off roads	F1	86-110
F2	Significant (113-157)	***Considerable***: Roofs torn off frame houses, mobile homes demolished, boxcars pushed over, large trees snapped or uprooted, light-object missiles generated	F2	111-135
F3	Severe (158-206)	***Severe***: Roofs and some walls torn off well-constructed houses, trains overturned, most trees in forest uprooted, cars lifted off the ground and thrown	F3	136-165
F4	Devastating (207-260)	***Devastating***: Well-constructed houses leveled, structures with weak foundations blown off some distance, cars thrown and large missiles generated	F4	166-200
F5	Incredible (261-318)	***Incredible***: Strong frame houses lifted off foundations and carried considerable distance to disintegrate, automobile-sized missiles fly through the air in excess of 100 yards, trees debarked	F5	Over 200

The F-scale and Enhanced F-scales are a set of wind estimates (not measurements) based on damage. The Enhanced Scale uses three-second gusts estimated at the point of damage based on a judgment of 8 levels of damage to the 28 indicators listed below. These estimates vary with height and exposure.

Structures Used as Damage Indicators in the Enhanced Fujita Scale	
Small barns, farm outbuildings	One- or two-family residences
Single-wide mobile home (MHSW)	Double-wide mobile home
Apartment, condo, townhouse (3 stories or less)	Motel
Masonry apartment or motel	Small retail building (fast food)
Small professional (doctor office, branch bank)	Strip mall
Large shopping mall	Large, isolated ("big box") retail building
Automobile showroom	Automotive service building
School - 1-story elementary (interior or exterior halls)	School - middle or senior high school
Low-rise (1-4 story) bldg.	Mid-rise (5-20 story) building
High-rise (over 20 stories)	Institutional building (hospital, govt. or university)
Metal building system	Service station canopy
Warehouse (tilt-up walls or heavy timber)	Transmission line tower
Free-standing tower	Free-standing pole (light, flag, luminary)
Tree - hardwood	Tree - softwood

4.2.1 Hazard Profile

Severe thunderstorms produce about 1,000 tornadoes each year in the United States. FEMA reports that 106 federal disaster declarations over the past 20 years have included tornado damage.

4.2.1.1 Location

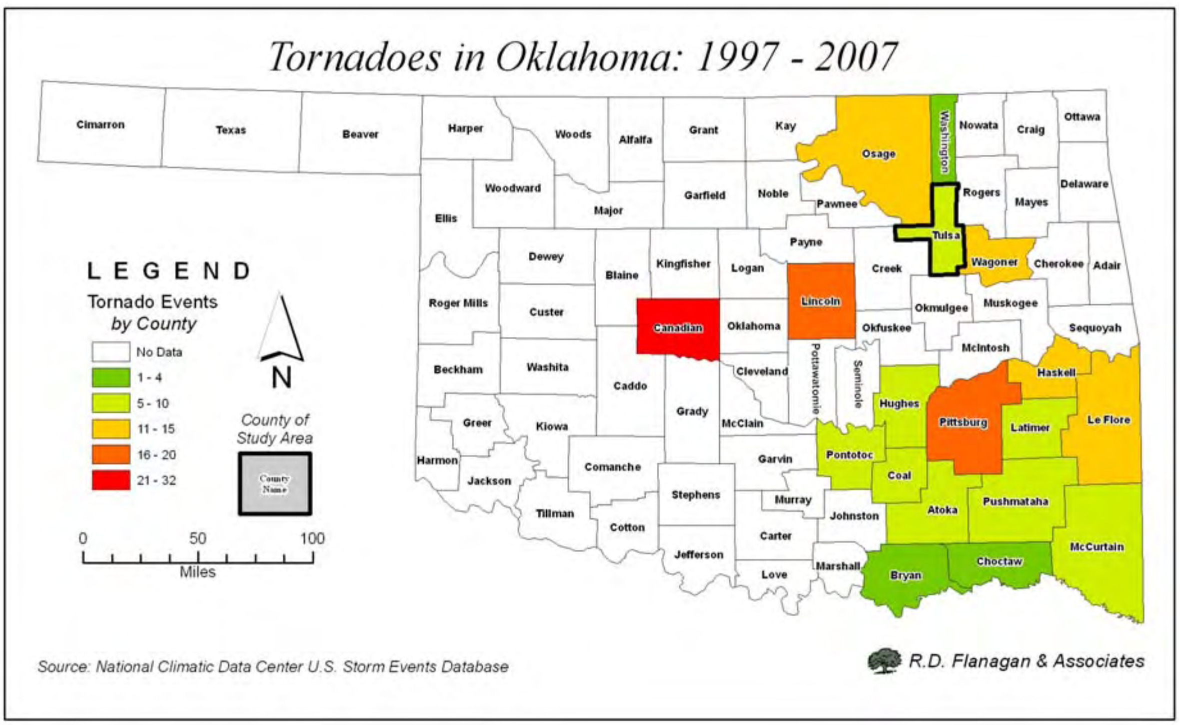
Oklahoma, along with Texas, Arkansas, Missouri, and Kansas, is located in “Tornado Alley,” the most tornado-prone area of the nation. The entire jurisdiction of the City of Tulsa is considered to be vulnerable to the effects of a tornado event. See map below for the number of tornado events per county in Oklahoma.

4.2.1.2 Extent (Magnitude/Severity)

The City of Tulsa may experience a tornado ranging from EF0 to EF5 on the Enhanced Fujita Scale shown in Table 4-10.

In a ranking of the Top Ten Costliest Oklahoma Tornadoes (1950 – 2008), Tulsa has the 6th most costly event for the April 19, 1981 tornado with damages estimated at $75-$100 Million. The top-ranking event is listed as the May 3, 1999 tornado outbreak with damages topping the $1 Billion mark.

In a ranking of the Top Ten Costliest U.S. Tornadoes (1950 – 2007), Oklahoma has two entries: May 3, 1999 ranked #3 ($1.24 Billion), and May 8, 2003 ranked #8 ($416.8 Million). These figures have been adjusted to reflect 2007 dollars.



Tulsa County experienced nine tornado events between 1990 and 2004

The Storm Prediction Center’s ranking of the 25 Deadliest U.S. Tornadoes shows two entries for Oklahoma. The Woodward Tornado of April 9, 1947 is ranked as the 6th deadliest tornado with 181 fatalities and 970 injuries, and the Snyder Tornado of May 10th, 1905 caused an estimated 97 deaths.

Oklahoma's neighbors to the north, south and east (Kansas, Texas and Arkansas) share in this rich environment for deadly and destructive events and often share the effects of the same storm systems.

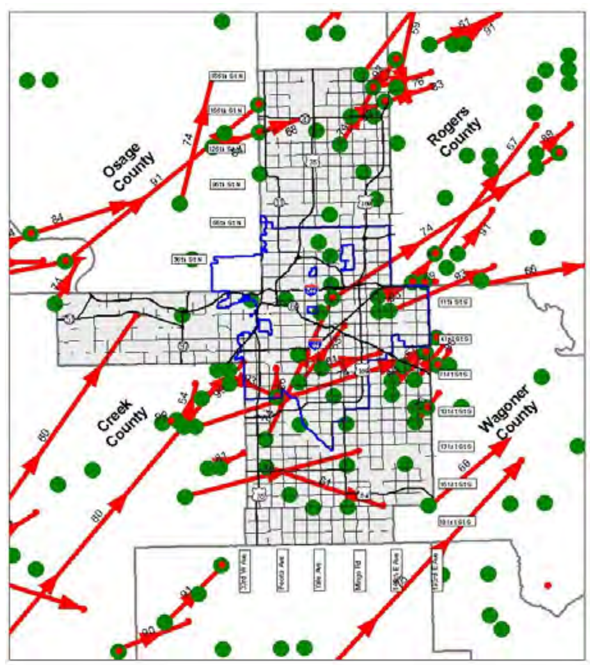
On April 21, 1996, Fort Smith, AR was hit by an F3 tornado that struck in the dead of night with no warning. 3 deaths, 89 injuries, nearly 500 homes destroyed and severe damage to the city's courthouse/jail-wing building bringing the estimated damages to over $300 million.

To the south, Fort Worth, TX experienced a devastating blow on March 28, 2000 when a low-end F3 tornado passed through the west side of the city just after 6:15pm. In all, 15 of the downtown buildings were destroyed (7 actually collapsed from the storm), 63 damaged, 93 homes destroyed – 203 suffered major damage. Two fatalities and 80 injuries were also reported. Damages were estimated at $450 million.

Just to the North, Greensburg, KS was hit by an EF5 tornado that struck at 9:45 p.m. CDT on May 4, 2007. The tornado was estimated to be 1.7 miles (2.7 km) in width and traveled for nearly 22 miles (35 km). Ninety-five percent of the city was confirmed to be destroyed, with the other five percent being severely damaged. The National Weather Service estimated winds of the tornado to reach 205 mph (330 km/h). This was the first tornado to ever be rated EF5 since the update of the Fujita scale. The Tornado had caused EF5 Damage to at least one well built home in Greensburg, and also is the first "5" classification since May 3, 1999, when an F5 tornado ripped through Moore, OK.

4.2.1.3 Frequency

Between the years 1950 – 2006, the National Weather Service reported 3,028 tornadoes (an average of 53 tornadoes each year) for Oklahoma, with 69 of these being in Tulsa County (an average of 1.2 tornadoes each year). The National Climatic Data Center reports of 57 tornadoes per year over the past 25 years. Between 1983 and 2008, there were 17 major disaster declarations for tornado related events in the state. Oklahoma experiences more tornadoes each year on average than does any other state, except Texas. Texas has twice as many, but is also more than twice the size of Oklahoma.



Historical Tornado Paths in Tulsa County

Data from the National Weather Service demonstrates that the most active months for tornadoes in Oklahoma are April and May. Of the 3,028 tornadoes reported for

Oklahoma between 1950 - 2006, reports show 1,132 occurring in May and 605 in April. It is important to point out that there are tornadoes reported in every month of the year in that period.

The City of Tulsa has been hit by a number of tornadoes in the last 58 years. Between 1950 and the end of 2007, Tulsa County experienced 62 tornado events (several of which may have had multiple tornado touchdowns), ranking 6th among Oklahoma counties in total number of tornadoes within that period.

Table 4–11: Tornadoes in Oklahoma and Tulsa County from 1950 thru 2007

Oklahoma	*Events*	*Deaths*	*Injuries*	*Damage*
1950-2007	3,321	265	4,090	$3,193,404,000
1998-2007	672	45	918	$1,651,000,000
Tulsa Cnty	*Events*	*Deaths*	*Injuries*	*Damage*
1950-2007	62	8	234	$369,445,000
1998-2007	9	0	7	$2,451,000

Since the starting point or ending point of many of the tornadoes in the area are not observed, it is not possible to accurately isolate whether tornadoes did or did not occur within the City Limits.

4.2.1.4 History/Previous Occurrences

Oklahoma has a long history of deadly and destructive tornadoes. Some of the more notable of these events include:

May 25, 1955- Attributed with the deaths of 114 people, including 20 in Blackwell, and 80 in Udall, Kansas, where the town was leveled.

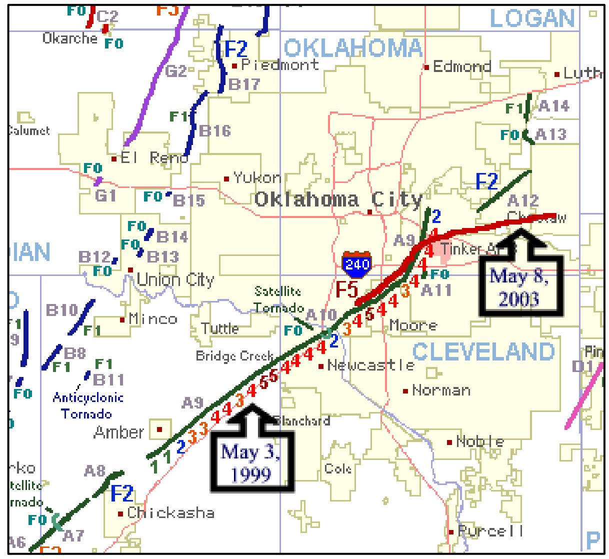
May 5, 1960- Three separate tornadoes killed a total of 26 people. An F-5 tornado reported touched down in southern Creek County, traveled 29 miles northeast crossing Sapulpa. No injuries or deaths occurred, but $2.5 million in property damages were accrued throughout the county.

May 5, 1961- Sixteen people were killed when a tornado tracked from Reichert to Howe in LeFlore County.

May 24, 1973- Six injuries, 22 homes and 18 trailers were destroyed, and 49 buildings were damaged by a tornado crossing Union City. The tornado was a quarter-mile wide and stayed on the

May 3, 1999 – Moore Tornado Path

ground for 28 minutes. Damage was approximately $2 million.



The May 3, 1999 tornadoes caused over $1 billion in damage. The May 8, 2003 tornado caused $100 million in damage

June 8, 1974- Eighteen fatalities – including three in Tulsa - and damage to 1,400 buildings occurred when 25 to 30 tornadoes formed in 19 Oklahoma counties. The same storm system spawned an F-4 tornado in southern Kansas that killed six, and injured 220.

May 3, 1999- A series of severe thunderstorms from the southwest, produced several tornadoes that intensified as they moved across the state.

One of the tornadoes in the outbreak was an F5, which occurred southwest of Oklahoma City, was measured at 318 mph, and stayed on the ground about four hours, leaving a path approximately thirty-eight miles long. This storm was the first F5 tornado to affect metropolitan Oklahoma City. The path included 6.5 miles of continuous F4 damage as well as several areas of F5 level destruction. Several homes were completely removed from their slabs.

The National Weather Service reported that 57 tornadoes were recorded in the state during the outbreak. The Oklahoma Hospital Association reported 742 people were treated at 30 hospitals, and 44 people were killed. Approximately 10,000 homes and businesses were affected by the storms, with total losses exceeding $1 billion. Oklahoma's Department of Emergency Management reported that 3,009 homes, 117 businesses, and 10 public buildings were destroyed, including 645 in Oklahoma City, 6 in Tulsa and 95% of Mulhall. Sixteen counties were declared Federal disaster areas.

May 8, 2003- At about 5 pm, the path of the estimated F-4 tornado hit Moore, Midwest City, Del City, and Oklahoma City, many of the same areas damaged by the killer tornado of May 3, 1999. The National Weather Service estimated the tornado's path to be 19 miles long. Local hospitals reported 145 injuries. Initial estimate of damage include 432 homes destroyed and another 2,457 damaged. About 20 businesses were destroyed. The 4 million square-foot Oklahoma City General Motors automobile plant sustained substantial damage and was knocked out of production, and the Xerox plant and five schools were damaged. In addition, the City of Moore reported three churches destroyed, and damage to a fire station and elementary school. The Lincoln National Bank in Oklahoma City was leveled. Oklahoma Gas and Electric reported that 4,000 customers in Oklahoma City, Moore, and Midwest City were without power. The Insurance Commissioner estimated damage at more than $100 million.

Tulsa Historic Tornado Events

NCDC data show 62 tornado events for Tulsa County between 1950 and 2007, killing eight people, injuring 234, and doing $369.4 million in damage. Of these tornadoes, 24 were recorded as F0, 16 as F1, 14 as F2, 7 as F4 and 1 as F1. Some of the events that had a direct impact on the City of Tulsa are listed below and are shown in Figure 4-9.

June 12, 1954- An F1 tornado did $300 in damage just south of Tulsa.

June 12, 1957- An F1 tornado touched down 3 miles southwest of Tulsa, moved through the southern part of the city, and lifted 3 miles to the east. Damage was $2,500.

August 9, 1963- An F2 tornado struck north of Tulsa airport, doing $25,000 in damage.

May 15, 1990- Widespread severe weather, including six tornadoes, struck northern and central Oklahoma. The worst of the tornadoes (F0) developed just west of Tulsa, and then moved through northern parts of the city. The storm heavily damaged two apartment complexes, and severely damaged or destroyed 83 homes. One person died and 12 were injured. Damage was estimated at $2.5 million.

May 3, 1999- One of the worst storms in Oklahoma history generated a total of 58 tornadoes over the western and central portions of the state (see above). Tornado B20 of this massive tornado outbreak destroyed 95% of Mulhall, in neighboring Logan County, before overturning a semi-truck and flipping two cars along I-35. The driver of one of the cars, which was parked beneath the I-35 overpass, was killed when the vehicle was picked up and dropped on its top. This particular tornado was classified as an F1 – while its more deadly counterpart that struck another portion of the Oklahoma City area was rated an F5. The tornado damaged a church and a school in West Tulsa before lifting up. This series of tornadoes was on the ground for over 100 miles. If it had continued on its track for an additional 5 miles, it would have impacted two of Tulsa's major hospitals.

February 25, 2000- An F1 tornado touched down for a minute one mile southeast of Tulsa International airport or in the vicinity of the corner of Pine and Garnett. The tornado damaged some equipment at a farm implement dealership and threw a parked car on top of another parked car. Six to eight power poles were blown down as well. Damage was estimated at $100 thousand.

April 1, 2006- National Weather Service officials reported that an F1 tornado touched down briefly just south of the Tulsa International Airport. Even though it was on the ground for just seconds, it was able to accomplish quite a bit of damage. Some windows in Terminal A were cracked, four regional jets on the ground were whipped around, the canopy over the garage's upper level was ripped apart and 75 cars were damaged. The nearby Radisson Hotel also sustained significant damage. The roof was ripped from several rooms displacing as many as 200 guests. An entire wing of the hotel and at least 10 vehicles were damaged. The hotel was closed for an extended time for repairs. Amazingly, there were no fatalities and only 7 injuries reported for the entire event. Preliminary damages were listed at $250 thousand.

4.2.1.5 Probability/Future Events

Oklahoma is vulnerable to frequent thunderstorms and convective weather patterns, and therefore its vulnerability to tornadoes is a constant and widespread threat especially during the Spring months. Tornadoes can, and do appear in nearly all months of the year at all hours of the day, so it is important that even in "light activity" years, education and preparations continue to move forward. The City of Tulsa has a high probability that a tornado will impact the city.

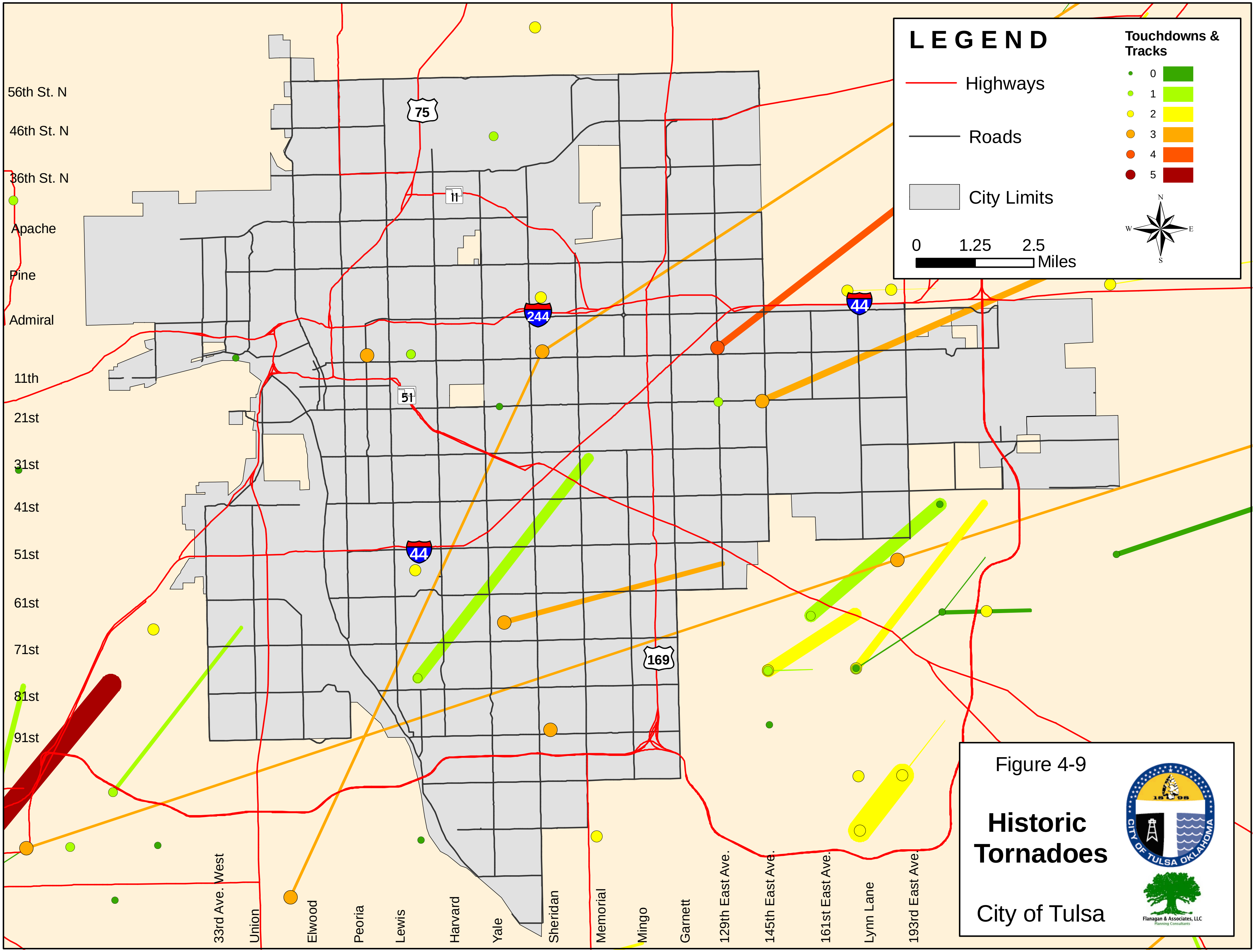


Figure 4-9

Historic Tornadoes

City of Tulsa

4.2.2 Existing Vulnerability

The National Weather Service advises that tornadoes strike at random. Therefore, all areas within the City of Tulsa, including all future development areas, have a high vulnerability to tornadoes.

4.2.2.1 Population

Table 4-12 shows the numbers of tornado-related fatalities in the United States for each year from 1997 to 2006 and where the deaths occurred. It illustrates that those living in mobile homes are significantly more vulnerable to the effects of a tornado than any other identifiable population. While the number of mobile homes is a small fraction of total residential dwellings, the number of deaths in mobile homes significantly exceeds the number of deaths associated with inhabitants of permanent homes. In fact, nearly 45% of all tornado deaths during that ten-year period occurred in mobile homes.

Table 4–12: Tornado Fatalities in the United States
Source: National Weather Service Storm Prediction Center

Year	Home	Mobile Home	Business	School	Vehicle	In the Open	Other	Total for Year
1997	38	15	3	0	3	7	1	67
1998	46	64	1	0	16	3	0	130
1999	39	36	3	0	6	9	1	94
2000	7	28	0	0	4	2	0	41
2001	15	17	3	0	3	2	0	40
2002	15	32	0	1	4	2	1	55
2003	24	25	0	0	0	3	2	54
2004	15	8	10	0	2	0	0	35
2005	4	32	0	0	1	1	0	38
2006	16	22	0	0	3	2	24	67
Totals	***219***	***279***	***20***	***1***	***42***	***31***	***29***	***621***

Not to be dismissed is the number of tornado related deaths in vehicles. While a relatively small number in recent years, 2008 is shaping up to be comparable to 1998 in numbers. According to NOAA's Storm Prediction Center in Norman, OK, by June 15, 2008, 115 deaths had been recorded for the year – making it the deadliest year since 1998. Fourteen of these individuals were killed while in their vehicle. This statistic and alarming trend places individuals traveling in their vehicles during threatening weather at increased risk.

Also at an increased risk for these events are members of the hard-of-hearing/deaf community, people for whom English is not their primary language and those without access to broadcast media messages (television or radio) alerting them of approaching severe weather. While much progress has been made in expanding communication resources for these individuals, there is still a large number of residents facing these challenges unable to receive vital warnings in a timely manner.

4.2.2.2 Structures/Buildings

Tornado damage is a factor of severity and location, both on a landscape scale – rural/urban areas – and on a structure-by-structure scale. An F4/F5 tornado in an urban area will create phenomenal damage, as experienced with the tornadoes that struck Greensburg, KS (F5, 5/4/2007) and Picher, OK (F4, 5/10/2008), but damage to structures will vary depending on how they are constructed. For example, mobile homes are more easily damaged than permanent structures, buildings with crawl spaces are more susceptible to lift, and foundation and roof construction can increase or decrease the structure's vulnerability.

Structures utilizing more modern-looking building materials (reflective glass facades, open breezeways between wings, etc.) should be considered more vulnerable to the potential damage from a tornado. Wind-driven debris (wood, metal, other larger items picked up by larger funnels) can cause catastrophic damage to buildings – as witnessed in the tornadoes that struck downtown Fort Worth in 2000 or Atlanta in May, 2008.

4.2.2.3 Critical Facilities

All critical facilities within the City of Tulsa jurisdiction should be considered vulnerable to the effects of a tornado event. Structural integrity may be compromised if in the direct path of the storm, in addition to any secondary issues presenting such as power disruption, water damage from accompanying rain, injury to workers/residents, etc. For a complete list of critical facilities for the City of Tulsa, see Appendix G.

4.2.2.4 Infrastructure

Water Treatment – Most significant effect during a tornado would be from loss of electrical power. Both of the City of Tulsa's water treatment plants would be vulnerable to these risks.

Each of the City's two water treatment plants feature dual electrical feeds, which supply power from independent substations. Additionally, these two plants are located in two different geographic areas of the city, which reduces the likelihood of both plants being affected by the same storm.

Wastewater Treatment – The most significant threat to the operation of Tulsa's four wastewater treatment plants during a tornado would be power outages. All four plants and lift stations have either double feeds or generators.

Utilities- The primary utility providers for Tulsa's jurisdiction are AEP/PSO (electricity) and ONG (natural gas). The service stations and substations for both of these providers would be vulnerable to the risks from a tornado. **Electricity:** During a tornado, providers of electrical service could experience any combination of the following challenges in meeting the needs of the Tulsa jurisdiction: Destruction of distribution and transmission poles, downed broken power lines, danger to workers derived from downed power lines, and fallen debris from trees or insufficient field and/or office staff to effectively handle the workload. **Gas:** During a tornado, providers of gas service to a community could experience a variety of challenges in meeting the needs of the Tulsa jurisdiction: falling power lines or tree debris; inaccessibility to underground gas meters from falling debris; downed power lines, extreme temperatures, insufficient field and/or office staff to effectively handle workload generated by such an event.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Flight delays cost an average of $3.2 billion annually for air carriers in the United States. Tornado conditions could result in the interruption of normal operations at Tulsa's International Airport and the private business airports.

Emergency Services – Fire, Police and Medical Services would all be similarly at risk to secondary effects of a tornado. Downed power lines or debris blocking city streets could limit or eliminate access to affected areas, as experienced after the June 2006 downburst. Excessive debris in the streets could lead to damage to emergency vehicles, potentially reducing the number of vehicles available for response. Medical Services (including treatment facilities) could be strained in responding to large numbers of injuries.

4.2.3 Tornado Scenario

A typical tornado path is reported to be approximately 600 feet in width, and 2.5 miles in length. The typical path in Oklahoma runs generally from southwest to northeast with the area of destruction being about 181 acres per event. Approximately 16 mi^2 of Oklahoma's 69,919 mi^2 are impacted by tornadoes each year. The yearly chance of a tornado of any magnitude hitting any location is roughly .0002. Bigger and more devastating tornadoes can and do occur, as evidenced by the 1999 Oklahoma City tornado, which stayed on the ground for 38 miles. However, these events are much more rare. The chance of an F4 or F5 striking an area is only about .0000024 per year.

Tulsa Tornado Scenarios

To anticipate the damage from a "worst case" tornado event, a portion of Tornado A9 from the May 3, 1999, tornado outbreak was placed through various portions of the community. Shown in Figures 4-10 through 4-13, the scenario tornado is placed through downtown Tulsa, directly south of Downtown where it strikes primarily residential areas.

The damages from each event are listed in Tables 4-13 a-d. Critical facilities that were impacted by each of the events facilities are listed in Tables 4-14 a-d. Damages in the tornado path, including buildings and contents, ranged from $650 Million to $1.1 billion. The damages, by building type, contents, and percent damage to each structure, are summarized in the following tables.

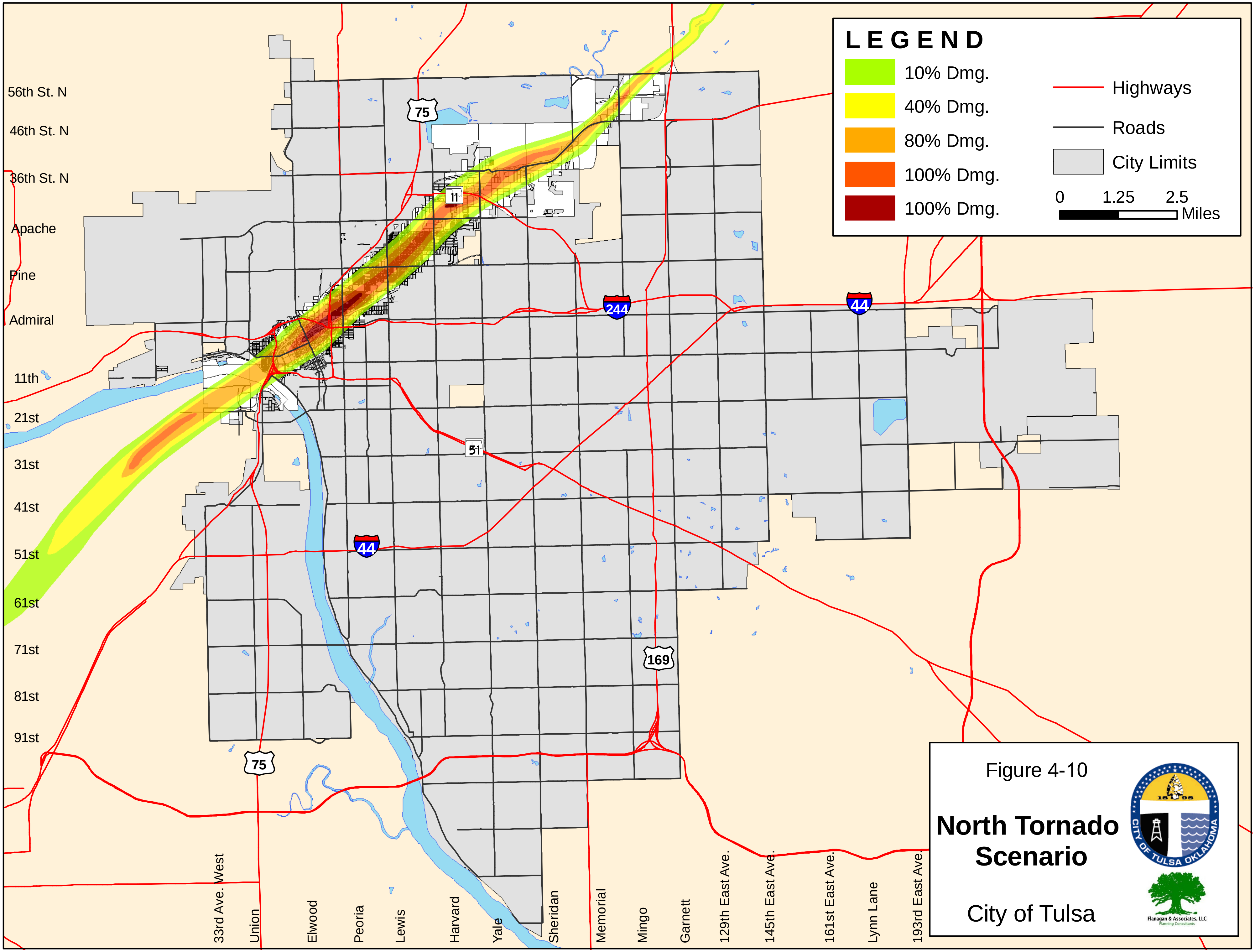


Figure 4-10

North Tornado Scenario

City of Tulsa

Table 4–13a: North Tulsa Tornado Scenario

F-Scale	Market Value	Damage Factor	Structure Damage	Contents Value	Damage Factor	Contents Damage
Residential Properties						
1	$38,871,200	.10	$3,887,120	$1,943,560	.10	$194,356
2	$23,159,500	.40	$9,263,800	$4,631,900	.40	$1,852,760
3	$32,318,500	.80	$25,854,800	$12,927,400	.80	$10,341,920
4	$22,262,100	1.0	$22,262,100	$11,131,050	1.0	$11,131,050
5	$2,583,200	1.0	$2,583,200	$1,291,600	1.0	$1,291,600
Total	$119,194,500		$63,851,020	$31,925,510		$24,811,686
Commercial Properties						
1	$61,590,000	.10	$6,159,000	$3,079,500	.10	$307,950
2	$78,194,392.5	.40	$31,277,757	$15,638,878.5	.40	$6,255,551.4
3	$170,917,600	.80	$136,734,080	$68,367,040	.80	$54,693,632
4	$59,961,400	1.0	$59,961,400	$29,980,700	1.0	$29,980,700
5	$129,697,100	1.0	$129,697,100	$64,848,550	1.0	$64,848,550
Total	$500,360,492.5		$363,829,337	$181,914,668.5		$117,105,683.4
Industrial Properties						
1	$11,478,000	.10	$1,147,800	$573,900	.10	$57,390
2	$9,252,800	.40	$3,701,120	$1,850,560	.40	$740,224
3	$29,128,000	.80	$23,302,400	$11,651,200	.80	$9,320,960
4	$13,512,900	1.0	$13,512,900	$6,756,450	1.0	$6,756,450
5	$6,529,200	1.0	$6,529,200	$3,264,600	1.0	$3,264,600
Total	$69,900,900		$48,193,420	$24,096,710		$20,139,624
Tax Exempt Properties						
1	$2,687,700	.10	$268,770	$134,385	.10	$13,438.5
2	$32,795,200	.40	$13,118,080	$6,559,040	.40	$2,623,616
3	$2,304,600	.80	$1,843,680	$921,840	.80	$737,472
4	$83,200	1.0	$83,200	$41,600	1.0	$41,600
5	$97,700	1.0	$97,700	$48,850	1.0	$48,850
Total	$37,968,400		$15,411,430	$7,705,715		$3,464,976.5
Total Damages						
	$727,424,293		$491,285,207	$245,642,604		$165,521,970

Table 4–14a: Critical Facilities in North Tulsa Tornado Scenario

ID	*Name*
CC44	Trinity Episcopal Day School
CF2	City of Tulsa – City Hall
CF3	River Parks Authority
CF4	Tulsa Convention Center
CF5	Tulsa Performing Arts Center
CF9	PSRC Tower
CG1	TAEMA Emergency Operations Center
CG5	Tulsa County Correctional Facility
CG7	Tulsa County Offices
CG8	Tulsa County Sheriff
CG10	Tulsa County Offices
FD3	Tulsa Fire Station #9
FD11	Tulsa Fire Station #16
FD35	Tulsa Fire Dept. Headquarters
FG1	USPS – Downtown Post Office
FG22	United States Attorney
HO15	Oklahoma State University Medical Center
IL75	Hewgley Terrace
JC5	Tulsa Community College – Northeast Campus
LF15	Bank of Oklahoma
LF16	BOK Financial Corp.
LF17	Energy One Federal Credit Union
LF19	Red Crown Federal Credit Union
LF20	Tulsa Federal Employees Credit Union
PD3	Tulsa Police Department – Courts Building
PD10	Tulsa Police Offices Street Level
PS14	Oklahoma Job Corps Academy
SG1	Oklahoma Air National Guard – 138th Fighter Wing
SG4	Oklahoma Dept. of Human Services
SG5	Oklahoma State Govt. Office Building
TES54	Springdale Elementary School
UV1	Oklahoma State University – Tulsa
WD13	Storm Water Pump Station
WD14	Storm Water Storage

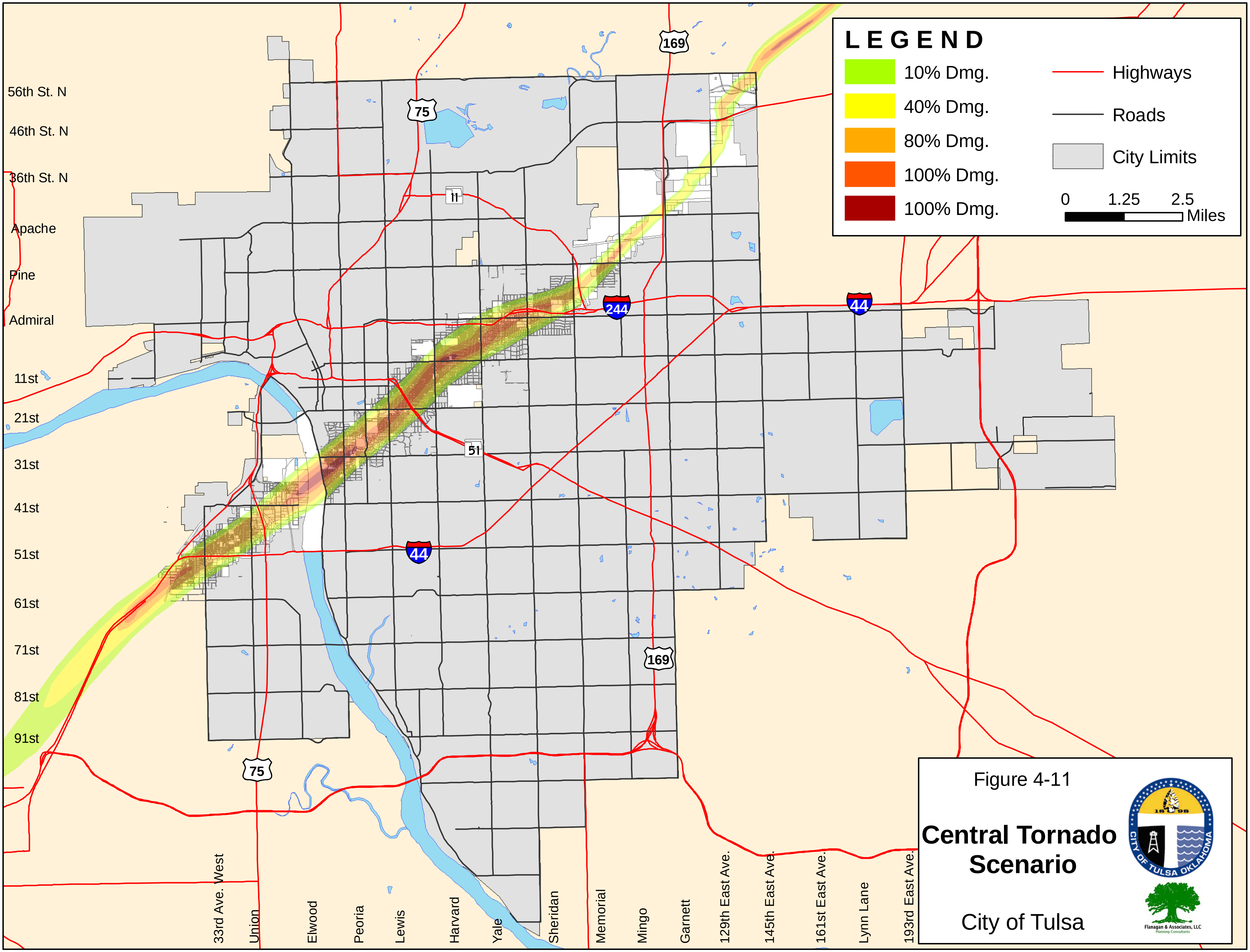


Figure 4-11

Central Tornado Scenario

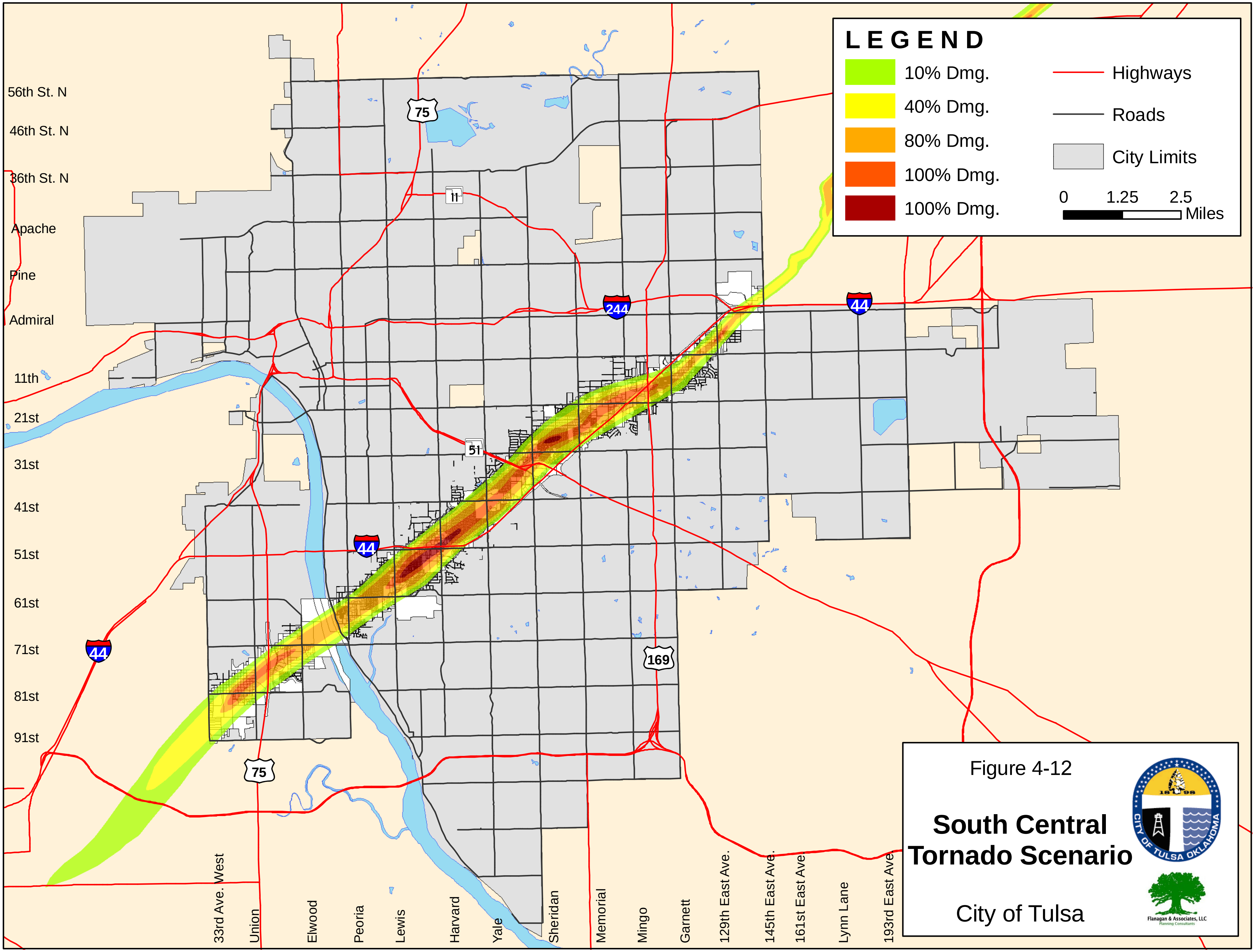
City of Tulsa

Table 4–13b: Central Tulsa Tornado Scenario

F-Scale	Market Value	Damage Factor	Structure Damage	Contents Value	Damage Factor	Contents Damage
Residential Properties						
1	$213,027,550	.10	$21,302,755	$10,651,377.50	.10	$1,065,137.75
2	$231,196,150	.40	$92,478,460	$46,239,230.00	.40	$18,495,692.00
3	$356,077,800	.80	$284,862,240	$142,431,120.00	.80	$113,944,896.00
4	$197,300,800	1.0	$197,300,800	$98,650,400.00	1.0	$98,650,400.00
5	$40,807,200	1.0	$40,807,200	$20,403,600.00	1.0	$20,403,600.00
Total	$1,038,409,500		$636,751,455	$318,375,727.5		$252,559,725.75
Commercial Properties						
1	$13,658,600	.10	$1,365,860	$682,930	.10	$68,293
2	$57,130,900	.40	$22,852,360	$11,426,180	.40	$4,570,472
3	$53,115,550	.80	$42,492,440	$21,246,220	.80	$16,996,976
4	$21,580,100	1.0	$21,580,100	$10,790,050	1.0	$10,790,050
5	$459,300	1.0	$459,300	$229,650	1.0	$229,650
Total	$145,944,450		$88,750,060	$44,375,030		$32,655,441
Industrial Properties						
1	$12,230,300	.10	$1,223,030	$611,515	.10	$61,151.5
2	$18,529,400	.40	$7,411,760	$3,705,880	.40	$1,482,352
3	$19,368,000	.80	$15,494,400	$7,747,200	.80	$6,197,760
4	$7,901,100	1.0	$7,901,100	$3,950,550	1.0	$3,950,550
5	$85,300	1.0	$85,300	$42,650	1.0	$42,650
Total	$58,114,100		$32,115,590	$16,057,795		$11,734,463.5
Total Scenario Damages						
	$1,242,468,050		$757,617,105	$378,808,552.50		$296,949,630.25

Table 4–14b: Critical Facilities in North Tulsa Tornado Scenario

ID	Name
CC37	NACT Headstart & Daycare
CC43	Temple Israel / Day Schools Inc.
CC53	YWCA Patti Johnson Wilson ELC
FD21	Tulsa Fire Station #26
LF14	F & M Bank Trust Co.
NH20	The Cottage Extended Care
NH48	Sherwood Manor
PS2	Cascia Hall Prepatory School
PS12	Monte Cassino School
PS19	Saint Catherine Catholic School
PS23	Tulsa Adventist Jr. Academy
TES5	Barnard Elementary School
TES6	Bell Elementary School
TES39	Mitchell Elementary School
TES48	Robertson Elementary School
THS8	Rogers High School



LEGEND
10% Dmg.
40% Dmg.
80% Dmg.
100% Dmg.
100% Dmg.
Highways
Roads
City Limits
0 1.25 2.5
Miles
56th St. N
46th St. N
36th St. N
Apache
Pine
Admiral
11th
21st
31st
41st
51st
61st
71st
81st
91st
33rd Ave. West
Union
Elwood
Peoria
Lewis
Harvard
Yale
Sheridan
Memorial
Mingo
Garnett
129th East Ave.
145th East Ave.
161st East Ave
Lynn Lane
193rd East Ave
75
11
51
244
44
169
Figure 4-12
South Central Tornado Scenario
City of Tulsa

Table 4–13c: South Central Tulsa Tornado Scenario

F-Scale	Market Value	Damage Factor	Structure Damage	Contents Value	Damage Factor	Contents Damage
Residential Properties						
1	$192,951,160	.10	$19,295,116	$9,647,558	.10	$964,755.80
2	$205,374,200	.40	$82,149,680	$41,074,840	.40	$16,429,936.00
3	$273,066,400	.80	$218,453,120	$109,226,560	.80	$87,381,248.00
4	$135,941,115	1.0	$135,941,115	$67,970,558	1.0	$67,970,557.50
5	$39,318,700	1.0	$39,318,700	$19,659,350	1.0	$19,659,350.00
Total	$846,651,575		$495,157,731	$247,578,866		$192,405,846
Commercial Properties						
1	$23,871,300	.10	$2,387,130	$1,193,565	.10	$119,356.5
2	$47,957,500	.40	$19,183,000	$9,591,500	.40	$3,836,600
3	$110,006,300	.80	$88,005,040	$44,002,520	.80	$35,202,016
4	$141,181,200	1.0	$141,181,200	$70,590,600	1.0	$70,590,600
5	$8,780,570	1.0	$8,780,570	$4,390,285	1.0	$4,390,285
Total	$331,796,870		$259,536,940	$129,768,470		$114,138,857.5
Industrial Properties						
1	$2,652,900	.10	$265,290	$132,645	.10	$13,264.5
2	$5,484,900	.40	$2,193,960	$1,096,980	.40	$438,792
3	$8,570,700	.80	$6,856,560	$3,428,280	.80	$2,742,624
4	$940,300	1.0	$940,300	$470,150	1.0	$470,150
5	$1,279,300	1.0	$1,279,300	$639,650	1.0	$639,650
Total	$18,928,100		$11,535,410	$5,767,705		$4,304,480.5
Tax Exempt Properties						
1	$280,900	.10	$28,090	$14,045	.10	$1,404.5
2	$4,400,100	.40	$1,760,040	$880,020	.40	$352,008
3	$15,014,700	.80	$12,011,760	$6,005,880	.80	$4,804,704
4	$7,821,500	1.0	$7,821,500	$3,910,750	1.0	$3,910,750
5	$94,700	1.0	$94,700	$47,350	1.0	$47,350
Total	$27,611,900		$21,716,090	$10,858,045		$9,116,216.5
Total Damages						
	$1,224,988,445		$787,946,171	$393,973,086		$319,965,401

Table 4–14c: Critical Facilities in South Central Tulsa Tornado Scenario

ID	Name
AL4	Brighton Gardens
AL6	Heatheridge Assisted Living Community
CC34	McClure Headstart
CC49	WABC Learning Center Inc.
FG17	USACE
FG18	Internal Revenue Service
FG19	USPS – Postage Handling Facility
IL65	The Broadmoor Retirement Community
IL82	French Villa
IL84	Heatherwood Apartments
IL97	Inhofe Plaza
JC10	Tulsa Community College – Conference Center
LF2	American TrustCorp
ML39	Ambassador Manor Nursing & Rehab. Center
NH34	Lakewood Care Center
NH40	Leisure Village
NH41	ManorCare Health Services
NH44	Tulsa Nursing Center
PS1	Bishop Kelly High School
PS8	Little Light House
PS10	Metro Christian Academy
PW7	Satellite Fuel Station – Tulsa Public Works
RC17	Heatheridge Residential Care
SG2	Oklahoma Highway Patrol – Troop B HQ
TES22	Grimes Elementary School
TES37	McClure Elementary School
TES43	Peary Elementary School
TES45	Phillips Elementary School
THS3	East Central High School
TMS13	Nimitz Middle School
VT11	Tulsa Community College – Skyline

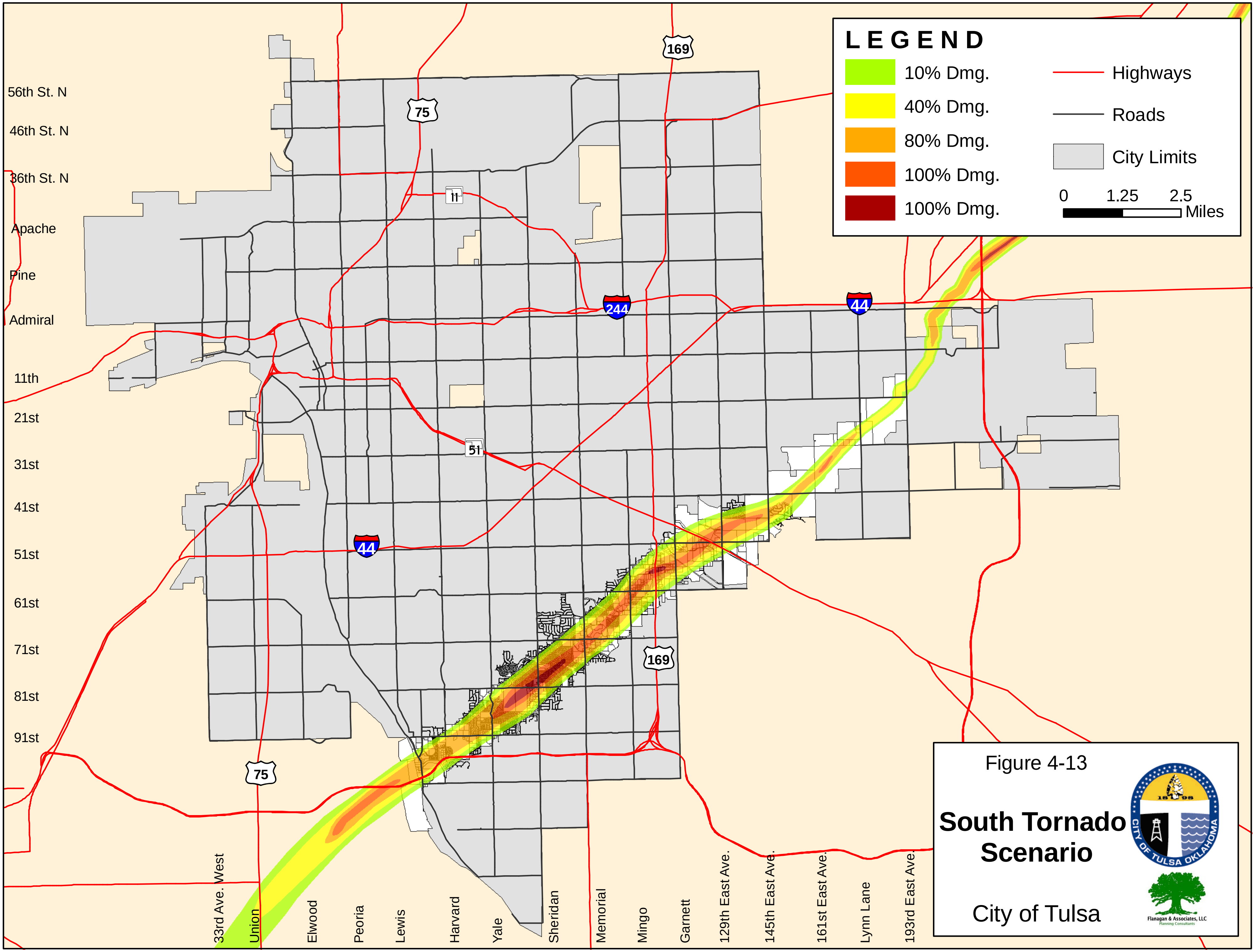

LEGEND
10% Dmg.
40% Dmg.
80% Dmg.
100% Dmg.
100% Dmg.
Highways
Roads
City Limits
0 1.25 2.5 Miles
56th St. N
46th St. N
36th St. N
Apache
Pine
Admiral
11th
21st
31st
41st
51st
61st
71st
81st
91st
33rd Ave. West
Union
Elwood
Peoria
Lewis
Harvard
Yale
Sheridan
Memorial
Mingo
Garnett
129th East Ave.
145th East Ave.
161st East Ave.
Lynn Lane
193rd East Ave.
169
75
11
244
44
51
Figure 4-13
South Tornado Scenario
City of Tulsa
CITY OF TULSA OKLAHOMA
Flanagan & Associates, LLC

Table 4–13d: South Tulsa Tornado Scenario

F-Scale	Market Value	Damage Factor	Structure Damage	Contents Value	Damage Factor	Contents Damage
Residential Properties						
1	$175,850,500	.10	$17,585,050	$8,792,525	.10	$879,252.50
2	$134,987,400	.40	$53,994,960	$26,997,480	.40	$10,798,992.00
3	$255,136,100	.80	$204,018,880	$102,009,440	.80	$81,607,552.00
4	$96,166,100	1.0	$96,166,100	$48,083,050	1.0	$48,083,050.00
5	$27,121,300	1.0	$27,121,300	$13,560,650	1.0	$13,560,650.00
Total	$689,261,400		$398,886,290	$199,443,145		$154,929,496.5
Commercial Properties						
1	$391,674,600	.10	$39,167,460	$19,583,730	.10	$1,958,373
2	$66,345,000	.40	$26,538,000	$13,269,000	.40	$5,307,600
3	$92,752,300	.80	$74,201,840	$37,100,920	.80	$29,680,736
4	$191,644,900	1.0	$191,644,900	$95,822,450	1.0	$95,822,450
5	$2,687,300	1.0	$2,687,300	$1,343,650	1.0	$1,343,650
Total	$745,104,100		$334,239,500	$167,119,750		$134,112,809
Industrial Properties						
1	$5,251,100	.10	$525,110	$262,555	.10	$26,255.5
2	$25,071,400	.40	$10,028,560	$5,014,280	.40	$2,005,712
3	$28,759,300	.80	$23,007,440	$11,503,720	.80	$9,202,976
4	$39,009,700	1.0	$39,009,700	$19,504,850	1.0	$19,504,850
5	$1,204,000	1.0	$1,204,000	$602,000	1.0	$602,000
Total	$99,295,500		$73,774,810	$36,887,405		$31,341,793.5
Tax Exempt Properties						
1	$547,400	.10	$54,740	$27,370	.10	$2,737
2	-	.40	-	-	.40	-
3	$3,649,000	.80	$2,919,200	$1,459,600	.80	$1,167,680
4	-	1.0	-	-	1.0	-
5	-	1.0	-	-	1.0	-
Total	$4,196,400		$2,973,940			$1,170,417
Total Damages						
	$1,537,857,400		$809,874,540	$403,450,300		$321,554,516

Table 4–14d: Critical Facilities in South Tulsa Tornado Scenario

ID	Name
AL10	The Parke Senior Living
CG2	Tulsa County Health Dept. – Main Office
FD23	Tulsa Fire Station #28
IL89	Quail Creek Villa
IL92	Town Village
JMS2	East Intermediate School – Jenks Public Schools
LF4	Bank South of Tulsa
LF6	ONB Bank & Trust Co.
ML52	Country Club of Woodland Hills
PW2	Equipment Maintenance – Tulsa Public Works
PW9	Street Dept. Garage / Offices – Tulsa Public Works
PW16	Water District Office / Warehouse – Tulsa Public Works
PS5	Holland Hall
TMS17	Thoreau Demonstration Academy
UES6	Robert Grove Elementary School – Union Public School
UES8	Rosa Parks Elementary School – Union Public Schools
UHS1	Tulsa Union High School – Union Public Schools
UMS1	Seventh Grade Center – Union Public Schools
WD18	Tower Site

4.2.4 Future Trends

While the direct threat from a tornado is unchanged in newly developed areas, there are issues that should be kept in mind as future development occurs in the City of Tulsa.

4.2.4.1 Population

As the “baby-boomer” population begins to move more aggressively into retirement, it could be anticipated that the number of people pursuing outdoor sports and/or social activities could also increase. Attention should be given to the task of ensuring continuing the process of educating the community of the dangers associated with tornadoes. Also adding to this increase in out-of-doors activity could be the rising cost of fuel. With more families looking for activities closer to home, parks and other outdoor recreation areas may become more attractive. These facilities, and the persons frequenting them, should be considered especially vulnerable to the effects of tornado events.

Technological advances in mobile entertainment could also factor into the increase of already escalating number of tornado related fatalities in automobiles. An ever-increasing market in the satellite radio industry is making it possible for more drivers to enjoy non-local network radio programming – thus adding to the “disconnectivity” of those driving during threatening weather conditions. Additionally, more devices allowing the interface of personal MP3 devices with automobile radios are becoming more affordable which in turn allows more drivers to listen to their own selection of music while traveling – again, decreasing the amount of localized and vital information that may be transmitted over the airwaves.

4.2.4.2 Structures/Buildings

As uninhabited areas continue to be developed and existing structures are renovated to accommodate new purposes in their use, actions to lessen the potential effects of tornado events should be considered. The inclusion of certified Safe Rooms, reinforced exterior materials (windows, doors, etc.), reinforced skeletal structure of new buildings able to withstand the effects of high winds accompanying the strongest of storms, etc. should be considered an integral part of this development. Additionally, location of outdoor warning systems (sirens) should be noted and considered when possible in any new development plans.

4.2.4.3 Critical Facilities

As the threat from the effects of tornado events themselves cannot be eliminated, any critical facilities undergoing expansion, renovation or rebuilding should consider following updated techniques for such projects. The addition of certified Safe Rooms, reinforced exterior materials such as windows, doors, siding, etc. can do much to improve the safety of these facilities. Additionally, all efforts to guard against potential secondary effects should also be implemented. These secondary effects may include, but not be limited to, compromise of structural integrity, broken windows/doors from wind-strewn debris, water damage from accompanying rains, power interruptions/surges and communication interruption from lightning or wind damage.

4.2.4.4 Infrastructure

Ensuring local government facilities are well protected against the potential effects of tornado events is an on-going endeavor. Investigating and implementing new technology as it is made available will help ensure the continuity of operations at all levels of operation – uninterrupted communications and protection of the ever-growing mountain of electronic data gathered in day-to-day operations should be considered priorities in any plans developed for future development.

4.2.5 Conclusions

Due to the very nature of Tulsa's climate, severe thunderstorms and the tornadoes they frequently produce will remain a very real threat to this community, and vulnerability should be considered "high." The absence of recent, reported "direct hits" should not be considered an indication of a reduction in that threat; but as opportunity for educating, preparing for and fortifying against such an event. Improved building technologies, advances in public communication capabilities, and opportunities for collaboration among community agencies should remain prominent in the planning and response communities' endeavors.

4.2.5.1 Data Limitations

There are many "intangibles" in tornado spotting. Low hanging "scud" clouds may be mistaken for a lowering funnel. Tornadoes are frequently reported more often near inhabited areas and major highways, due to the greater likelihood of people being present when a tornado appeared that caused little or no damage. In addition, there is frequently disagreement on whether wind damage was caused by a tornado or just severe straight-line winds or a severe downdraft. Therefore, fully accurate reports of number of tornadoes or tornado damage may be skewed by these factors.

4.2.5.2 Update Changes

Identified significant changes made from the 2003 City of Tulsa Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.2.5.3 Sources

Bohr, Gregory S. *Oklahoma Tornado Outbreak*, p. 1-2. Southern Regional Climate Center at Louisiana State University, May 1999.

Extreme Weather and Climate Events at Website:
http://www.ncdc.noaa.gov/oa/climate/severeweather/extremes.html
National Climatic Data Center.

Multi-Hazard Identification and Risk Assessment, p. 38–46. Federal Emergency Management Agency, 1997.

NCDC Storm Event Database, at Web address: www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms. National Climatic Data Center.

Situation Report #1, October 11, 2001, at Website:
http://www.odcem.state.ok.us/archives/state/2001/1009weather/1011sitreport.htm
Oklahoma Department of Emergency Management, 2001.

Talking About Disaster: Guide for Standard Messages, p. 109. National Disaster Education Coalition, Washington, D.C., 1999.

The Central Oklahoma Tornado Outbreak of May 3, 1999, at Website:
www.srh.noaa.gov/oun/storms/19990503/intro.html
National Oceanic and Atmospheric Administration.

Tornado Project Online, at Website:
http://www.tornadoproject.com/front.htm
The Tornado Project, PO Box 302, St. Johnsbury, Vermont 05819.

National Weather Service Storm Prediction Center, at Website:
http://www.spc.noaa.gov/climo/index.html and www.spc.noaa.gov/faq/tornado/killers.html

www.srh.noaa.gov/tsa/weather-events/may10_2008/PicherTornado.htm

National Weather Service, Norman OK, at website: www.srh.noaa.gov/oun/tornadodata/ok/

Wikipedia report, authored by the Storm Prediction Center, at website:
http://en.wikipedia.org/wiki/Greensburg,_Kansas

4.3 High Winds

Wind is defined as the motion of air relative to the earth’s surface. Extreme windstorm events are associated with cyclones, severe thunderstorms, and accompanying phenomena such as tornadoes and downbursts. Winds vary from zero at ground level to 200 mph in the upper atmospheric jet stream at 6 to 8 miles above the earth’s surface.

The mean annual wind speed in the mainland United States is reported by FEMA to be 8 to 12 mph, with frequent speeds of 50 mph and occasional wind speeds of greater than 70 mph. Tropical cyclone winds along coastal areas from Texas to Maine may exceed 100 mph.

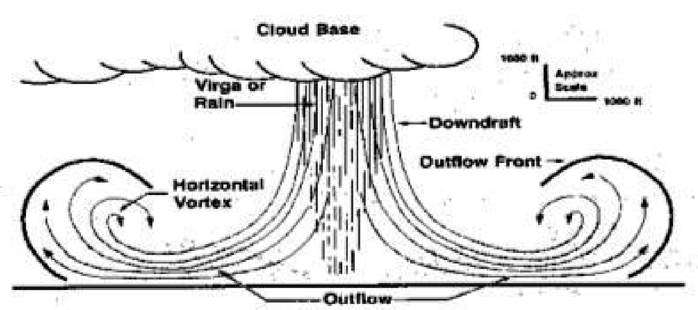
Table 4–15: Beaufort Scale of Wind Strength

Force	*Wind Speed (mph)*	*Damages*
9	47-54	**Strong gale:** Chimneys blown down, slate and tiles torn from roofs
10	55-63	**Whole gale:** Trees broken or uprooted
11	64-75	**Storm:** Trees Uprooted, cars overturned
12	75+	**Severe Storm:** Devastation is widespread, buildings destroyed

4.3.1 Hazard Profile

4.3.1.1 Location

The entire United States is at risk from damaging winds. Winds are always part of severe storms, such as hurricanes, tornadoes, and blizzards, but do not have to accompany a storm to be dangerous.



A Microburst is a particularly violent type of downburst that can generate winds up to 168 mph

Down-slope windstorms, straight-line winds, derechoes (a widespread and long-lived, violent straight-line windstorm that is associated with a fast-moving band of severe thunderstorms), and microbursts (a very localized column of sinking air, producing damaging straight-line winds that are similar to but distinguishable from tornadoes) can all cause death, injury, and property and crop damage.

4.3.1.2 Extent (Magnitude/Severity)

Wind is the fourth-leading cause of property damage. From 1981 to 1990, the insurance industry spent nearly $23 billion on wind-related catastrophic events. Out of the primary sources of high winds (hurricanes, tropical storms, severe thunderstorms, and winter storms), severe local windstorms accounted for 51.3% of the expenditures. See Table 4-16 for data related to casualties and damages caused by high wind events.

Cladding damage, especially glass damage, is not only costly but also threatens pedestrian safety, increases damage to interior contents, and lengthens business downtime.

In Oklahoma, wind events are generally associated with the huge convective thunderstorms that move through the region in the spring and fall months generating tornadoes, downbursts and high winds. It is not unusual for winds produced by these storms to reach speeds of 80-100 mph, with winds of 50-70 mph being commonplace. Downbursts, like the one that struck Tulsa on June 6, 2006, can topple trees, damage houses and power lines, and break up sidewalks and streets

The City of Tulsa may experience a wind force of 9-12 as measured on the Beaufort Scale shown in Table 4-15.

4.3.1.3 Frequency

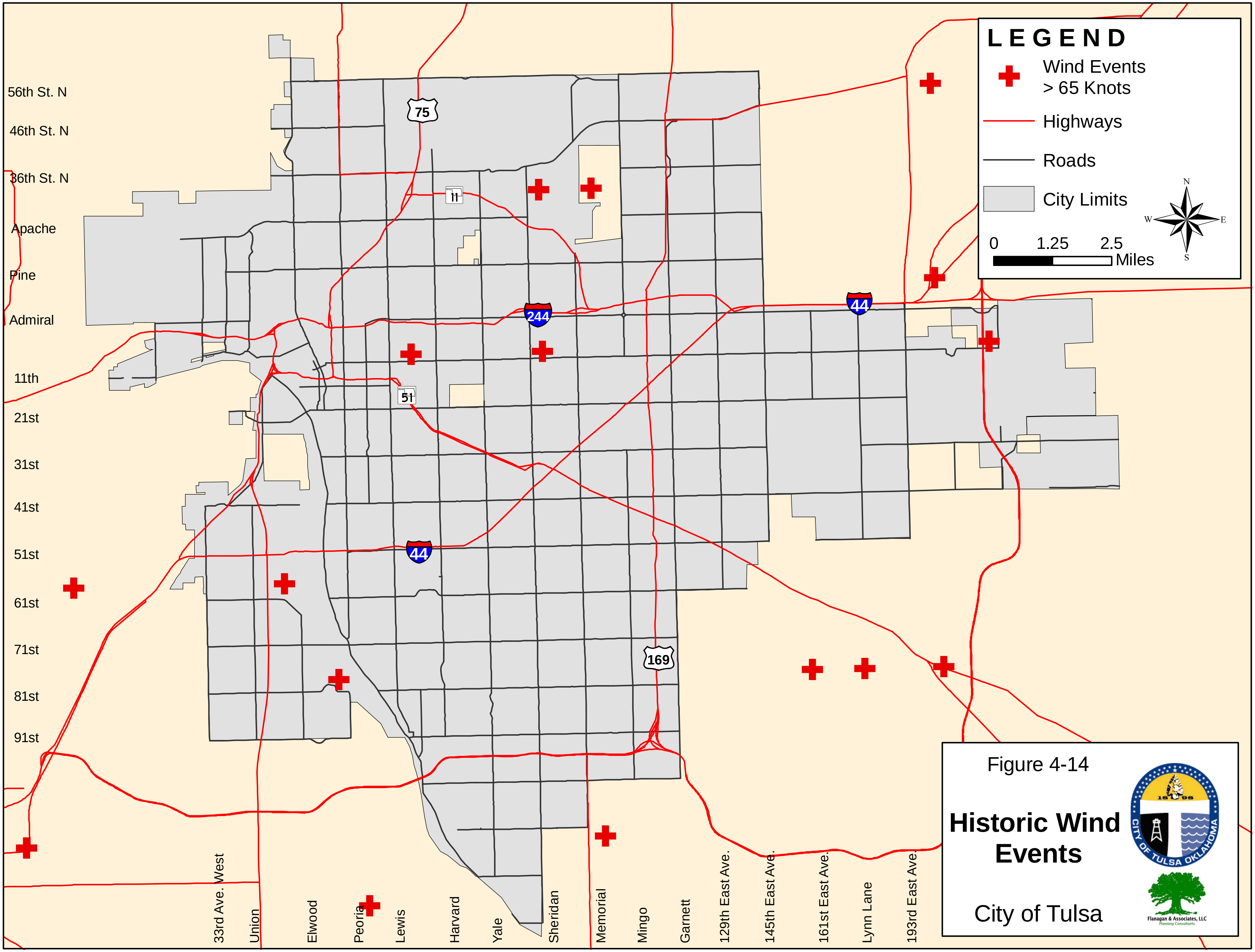
Over the past 20 years, 193 Federal disaster declarations involved wind-induced damage. From 1975 to 1994 in the United States, there were a total of 649 deaths and 6,670 injuries from disastrous winds. In that 20-year period, deaths from winds were highest in 1975 with 103 deaths, 31 of them occurring on November 10 in Michigan. The second highest number was in 1983 with 98 deaths. There was also the highest number of wind-related injuries in 1983, totaling 622.

High winds generated by Oklahoma's spring and autumn storms can be devastating to older homes and mobile homes

4.3.1.4 History/Previous Occurrences

Since 1956, Tulsa County has experienced 182 high wind events, almost all connected to thunderstorm activity. Since 1993, Tulsa has had 49 reported thunderstorm/high wind events. Wind speeds ranged between 85-100 mph. Some of the more notable of these events include the following and are mapped in Figure 4-14:

June 2, 2004- At approximately 1:40pm CDT, thunderstorm winds of nearly 80 mph blew glass windows out of the Adams Mark Hotel in downtown Tulsa, and caused structural damage to the NE façade of the nearby Wiltel (now called One Technology Center) building. One person was injured by the breaking glass. AEP estimated approximately 70,000 customers were without power at the peak of the outage, with the company estimating repairs in the Tulsa area to cost several million dollars. NCDC reports show property damages estimated at $4 Million.


LEGEND
Wind Events > 65 Knots
Highways
Roads
City Limits
0
1.25
2.5
Miles
N
S
E
W
56th St. N
46th St. N
36th St. N
Apache
Pine
Admiral
11th
21st
31st
41st
51st
61st
71st
81st
91st
75
11
244
44
51
169
33rd Ave. West
Union
Elwood
Peoria
Lewis
Harvard
Yale
Sheridan
Memorial
Mingo
Garnett
129th East Ave.
145th East Ave.
161st East Ave.
Lynn Lane
193rd East Ave.
Figure 4-14
Historic Wind Events
City of Tulsa
CITY OF TULSA OKLAHOMA
1898
Flanagan & Associates, LLC
Planning Consultants

August 12-13, 2005- Thunderstorms with winds as high as 70 mph blew down 3 to 4 inch diameter tree limbs on the west side of Tulsa on August 12, while on the following day winds tore the roof off part of a house on East 11th Ave., exposing 3 bedrooms, a bathroom, and a stairwell.

April 6, 2006- 64-mph winds were reported at Tulsa airport.

April 24, 2006- A pole barn under construction, near the intersection of 6th St. and Country Club Rd. was lifted and thrown over 8 city blocks.

June 6, 2006- A microburst with winds estimated at 85 mph occurred at approximately 4:45am CDT. The Tulsa County Fairgrounds received an estimated $2.5 Million in damages – most notably the destruction of an 80-year old Ferris Wheel, and major damage to the roofs at the Trade Center and the Exchange Center. Two nearby churches experienced substantial roof damage, an estimated 1,420 homes experienced varying degrees of damage, primarily from damage to roofs/roofing material, and trees were uprooted destroying sidewalks/driveways. 13,000 customers were without power at the peak of the event; four people were transported to the hospital for treatment of minor injuries.

A downburst did extensive damage in Midtown Tulsa on June 6, 2006

October 17, 2007- At approximately 7:23 pm, straight-line winds clocked in excess of 80 mph accompanying an energetic upper-level system caused 2 large and several smaller tents to collapse at the local Oktoberfest celebration. More than 7,000 people were in attendance at the time of the storm – a light attendance as it was the preview "corporate night". EMS crews arriving on scene treated 29 people with 24 being transported to local hospitals – 3 in critical condition. Authorities estimate that an additional 20-30 people self-transported to medical facilities seeking treatment. Damages were estimated at $100,000.

June 1, 2008- At approximately 10:50 am, Tulsa National Weather Service confirmed a downburst packing winds of 70 mph hit the TownWest Shopping Center located in West Tulsa. The shopping center sustained damage to a sizable section of the roof, and several cars in the parking lot were damaged. AEP reported damage to 24 power poles in the area, and power outages to approximately 6,200 customers. Gas leaks were also suspected around the shopping center, so gas service was shut off for investigation.

In addition, twenty windows on the south side of downtown BOk Tower and six glass panes on the west side of the 15-story One Technology Center also were damaged. Most of the damage occurred between the 8th and 14th floors on the BOk Tower, and to the unoccupied 5th floor of the One Technology building. Some of the glass from the BOk tower fell into nearby Second Street.

Table 4–17: High Wind Events in Tulsa from 1998 thru 2007

Location	Events	Fatalities	Injuries	Damages
Tulsa	83	1	2	$5.500 Million
Tulsa County	183	1	56	$7.807 Million
Oklahoma	6,302	6	107	$185,253,000
United States	124,854	524	5,063	$9.75 Billion

4.3.1.5 Probability/Future Events

With 83 events recorded within the City of Tulsa in a 10-year period, and 26 of those producing reported economic damages, it is apparent that this is a very common event, and we can expect on the order of 8-9 events a year, with multiple events potentially producing economic loss. Deaths and injuries are more likely in tornadoes, the most severe wind events, but with 3 casualties recorded, deaths and injuries are a very real likelihood in future events.

4.3.2 Existing Vulnerability

The highest wind speeds other than tornadoes occur in coastal regions in connection with hurricane-related storms. However, the Midwest is also at risk from high winds because of the powerful thunderstorms that frequent the region

4.3.2.1 Population

The people most vulnerable to high wind-related deaths, injuries, and property damage are those residing in mobile homes and deteriorating or poorly constructed homes. Refer to Figure 1-11 for Mobile Home Park Locations. However, as demonstrated by the October 17, 2007 Oktoberfest event, those participating in outdoor activities in high-risk weather conditions are particularly at risk from wind-driven debris and falling or collapsing structures. Also facing increased risk are those operating motor vehicles during high-wind events. Higher profile vehicles (RV's, full-sized vans, semi's, etc.) are at greatest risk for turn-overs during these fast moving, strong wind events; smaller, lower profile vehicles are not as high risk, but can be moved from their designated lane of travel. It should be noted that anyone operating a vehicle at highway speeds during a sudden burst of high winds is at risk for losing control of their vehicle.

4.3.2.2 Structures/Buildings

Property damage and loss of life from windstorms are increasing due to a variety of factors. Use of manufactured housing is on an upward trend, and this type of structure provides less resistance to wind than conventional construction. Not all states have uniform building codes for wind-resistant construction. Inferior construction practices result in buildings particularly susceptible to high winds.

The deteriorating condition of older homes and the increased use of aluminum-clad mobile homes will likely cause the impacts of wind hazards to increase. The general design and construction of buildings in many high wind zones do not fully consider wind resistance and its importance to survival. Near-surface winds and associated pressure effects exert pressure on structure walls, doors, windows, and roofs, causing the structural components to fail.

The glass-clad Bank One Tower, Fort Worth TX, following the March 2000 storms. (Photo by Doug Smith, AAWE)

In particular, certain types of buildings, such as glass-clad office buildings, present increased vulnerability, as reported in the Source reference, *Performance of Glass Cladding of High Rise Buildings in Hurricane Katrina.*

4.3.2.3 Critical Facilities

Critical facilities are defined differently by different organizations and agencies, but are usually classified as those facilities that, if put out of operation by any cause, would have a broadly adverse impact on the community as a whole.

Some of these facilities may include (but not be limited to); Structures or facilities that produce, use or store highly volatile, flammable, explosive, toxic and/or water-reactive materials; Hospitals, nursing homes, and housing units for vulnerable populations, Police stations, fire stations, vehicle and equipment storage facilities, and emergency operations centers; Public and private utility facilities. Since 9/11, FEMA has also added banks and other financial institutions to their critical facilities list. The City of Tulsa's critical facilities are listed in Appendix G, and are mapped in Figure 1–14.

All critical facilities within the City of Tulsa jurisdiction should be considered vulnerable to the effects of a high wind event. Structural integrity may be compromised if in the direct path of the storm, in addition to any secondary issues presenting such as power disruption, water damage from accompanying rain, injury to workers/residents, etc.

4.3.2.4 Infrastructure

Water Treatment – Most significant effect during a high wind event would be from loss of electrical power. Both of the City of Tulsa's water treatment plants would be vulnerable to these risks.

Each of the City's two water treatment plants feature dual electrical feeds which supply power from independent substations. Additionally, these two plants are located in two different geographic areas of the city, which reduces the likelihood of both plants being affected by the same storm.

Wastewater Treatment – The most significant threat to the operation of Tulsa's 4 wastewater treatment plants during a high wind event would be power outages. All four plants and lift stations have either double feeds or generators.

Utilities – The primary utility providers for Tulsa's jurisdiction is AEP/PSO (electricity) and ONG (natural gas). The service stations and substations for both of these providers would be vulnerable to the risks from a high wind event. **Electricity:** During a high wind event, providers of electrical service could experience any combination of the following challenges in meeting the needs of the Tulsa jurisdiction: Destruction of distribution and transmission poles, downed broken power lines, danger to workers derived from downed power lines, and fallen debris from trees or insufficient field and/or office staff to effectively handle the workload. **Gas:** During a high wind event, providers of gas service to a community could experience a variety of challenges in meeting the needs of the Tulsa jurisdiction: falling power lines or tree debris; inaccessibility to underground gas meters from falling debris; downed power lines, extreme temperatures, insufficient field and/or office staff to effectively handle workload generated by such an event.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Flight delays cost an average of $3.2 billion annually for air carriers in the United States. High Wind conditions could result in the interruption of normal operations at Tulsa's International Airport and the private business airports. At least eight fatal aircraft incidents since 1975 have been attributed to microbursts.

Emergency Services- Fire, Police and Medical Services would all be similarly at risk to the secondary effects of a High Wind Event. Downed power lines or debris blocking city streets could limit or eliminate access to affected areas, as experienced after the June 2006 downburst. Medical Services (including treatment facilities) could be strained in responding to large numbers of injuries such as those from the October 2007 high winds at Oktoberfest.

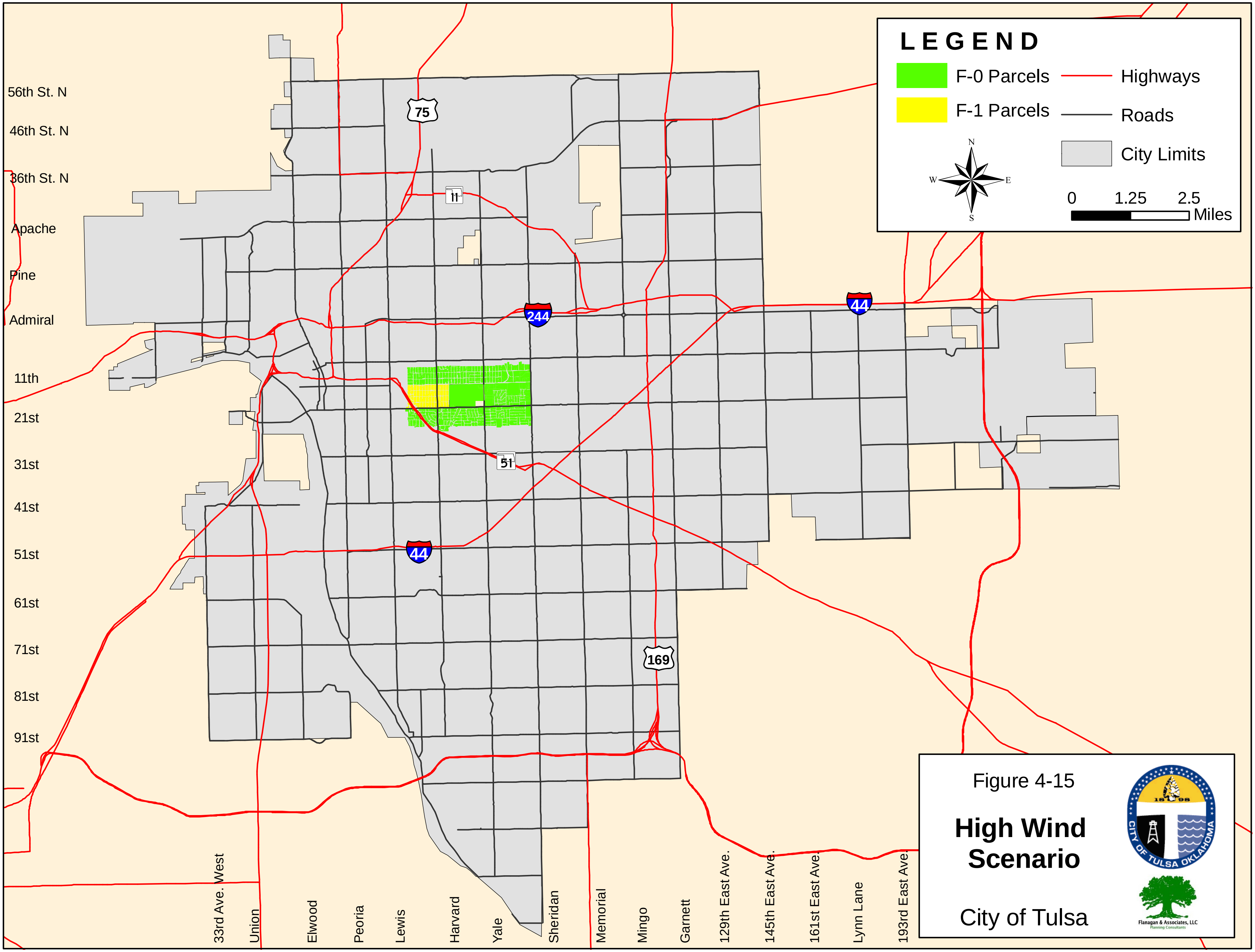
4.3.3 High Wind Scenario

The microburst of June 6, 2006, at 4:45 am, with winds estimated at 85 mph, could be considered a worst-case scenario for a high wind event.

In that event, the Tulsa County Fairgrounds received an estimated $2.5 Million in damages. Two nearby churches experienced substantial roof damage, an estimated 1,420 homes experienced varying degrees of damage, primarily from damage to roofs/roofing material, and trees were uprooted destroying sidewalks/driveways. 13,000 customers were without power at the peak of the event, and four people were transported to the hospital for treatment of minor injuries.

Wind speeds in this event would have been the equivalent of an F-1 tornado with winds in the F-0 range on the perimeter. Damages encompassed approximately 2 sq. mi. with the following borders: E. 12th St. to the North, E. 25th St. to the South, S. Columbia Ave. to the East, and S. Sheridan Rd. to the West. Damages were greater in the area of 15th to 21st Streets between Louisville and Columbia. Residential properties affected consisted predominately of 1930's – 1950's construction.

By laying this storm footprint on a predominantly residential area, damages detailed on Table 4-19 could be expected. In addition, expenses on infrastructure in the scenario would be similar to the following listed in Table 4-18:



LEGEND
F-0 Parcels
F-1 Parcels
Highways
Roads
City Limits
N
S
E
W
0
1.25
2.5
Miles
56th St. N
46th St. N
36th St. N
Apache
Pine
Admiral
11th
21st
31st
41st
51st
61st
71st
81st
91st
33rd Ave. West
Union
Elwood
Peoria
Lewis
Harvard
Yale
Sheridan
Memorial
Mingo
Garnett
129th East Ave.
145th East Ave.
161st East Ave.
Lynn Lane
193rd East Ave.
75
11
244
44
51
169
Figure 4-15
High Wind Scenario
City of Tulsa

Table 4–18: City of Tulsa Infrastructure Expenses from High Wind Scenario

Department	Expenses
Tulsa Police Department	$3,000 (overtime)
Tulsa Fire Department	$15,662 (overtime for 108 personnel logging 533 overtime hours) + $1,000 (equipment and materials)
Public Works	$99,400 (vegetation & drainage)
Street Maintenance	$104,720 (labor and equipment)
Traffic & Engineering	$3,115
TOTAL	**$226,897**

Approximately 6,786 cubic yards of debris was picked up by the city.

For an estimated 1,420 homes affected by the event, this breaks down to approximately $159.68 per affected home in infrastructure expense and 4.77 cubic yards of debris per affected home.

Four minor injuries were reported for this event, none requiring hospitalization. This places the economic value of those injuries at $6,240, or $4.39 per affected residence.

At the height of the event, an estimated 13,000 customers were without power; by late in the day of the event, that number was down to 10,000; approximately 700 the following day, and full restoration expected two days after the event. Based on this rate of restoration, the economic value of the loss of power for these customers would be estimated at $1.639Million. (Records for the actual Rate of Restoration for the actual event were unavailable, so this was estimated based on periodic reports located in different sources.)

Based on these calculations, the infrastructure damages in the proposed scenario would be as follows: ($159.68 x total houses affected) in expenses from various City Departments, and (4.77 cubic yards x total affected houses affected) cubic yards of debris to be collected.

Table 4–19: High Wind Worst Case Scenario Damages

F-Scale	Parcel Count	Damage Factor	Averaged Damage	Parcel Count	Debris Factor	Averaged Debris (yds.)
Residential Properties						
0	4,289	$159.68	$684,867.5	4,289	4.77	20,458.53
1	971	$159.68	$155,049	971	4.77	4,631.67
Total	5,260	$159.68	$839,916.5	5,260	4.77	25,090.2
Commercial Properties						
0	159	$159.68	$25,389.12	159	4.77	758.43
1	82	$159.68	$13,093.76	82	4.77	391.14
Total	241	$159.68	$38,482.88	241	4.77	1,149.57

Industrial Properties						
0	56	$159.68	$8,942.08	56	4.77	267.12
1	2	$159.68	$319.36	2	4.77	9.54
Total	58	$159.68	$9,261.44	58	4.77	276.66
Tax Exempt Properties						
0	68	$159.68	$10,858.24	68	4.77	324.36
1	14	$159.68	$2,235.52	14	4.77	66.78
Total	82	$159.68	$13,093.76	82	4.77	391.14
Totals						
	5,641		$900,754.88	5,641	4.77	26,907.57

4.3.4 Future Trends

All potential development areas for the City are equally at risk from high-wind events, with the following considerations.

4.3.4.1 Population

As fuel costs continue to rise, more people may turn to lighter-weight vehicles for transportation both in the city and on the highways. Studies have yet to correlate the increase in risk associated with driving these more fuel efficient yet lighter vehicles in dangerous weather conditions, but that possibility certainly merits close monitoring.

With increased discussion of development along the River Parks area for public use, an increase in people participating in activities conducted in these new facilities could also be anticipated. An increase in such outdoor activities would also increase those vulnerable to the dangers of high wind events, much like that in October 2007, or the more recent wind event in Pryor, OK during the *Rocklahoma* Concert (July 13, 2008), where two tents were downed during the event and one person suffered a broken arm after slipping in the mud while running to safety.

4.3.4.2 Structures/Buildings

In the continuing development and revitalization of downtown and currently undeveloped areas, areas experiencing large volume of construction debris should be considered at high risk for wind-strewn debris during a high-wind event. Construction companies and crews should be cautioned to exercise great care in securing apparatus and supplies that could become wind-borne during inclement weather. Following Hurricane Alicia, a group of glass distributors determined that more than 80% of glass breakage was caused by wind borne debris. Sources of debris include roof gravel, construction debris, broken glass and insufficiently secured rooftop appurtenances.

According to a report on “Performance of building cladding in urban environments under extreme winds”, close observation often reveals large areas of pits, nicks, and scratches indicative of wind borne debris impact. Although some abraded windows remain completely intact, they are eventually replaced as it is very likely that their decreased glass strength would lead to poor performance in future storms.

4.3.4.3 Critical Facilities

As the threat from the effects of high wind events themselves cannot be eliminated, any critical facilities undergoing expansion, renovation or rebuilding should consider following updated techniques for such projects. The addition of reinforced exterior materials such as windows, doors, siding, etc. can do much to improve the safety of these facilities. Additionally, all efforts to guard against potential secondary effects should also be implemented. These secondary effects may include, but not be limited to, compromise of structural integrity, broken windows/doors from wind-strewn debris, water damage from accompanying rains, power interruptions/surges and communication interruption from lightning or wind damage.

4.3.4.4 Infrastructure

Ensuring a minimized effect on the delivery of utility service requires forethought and planning while in the development stage. Any plans for areas currently under development or consideration of development should include the provision for underground utility supply when possible, well trimmed vegetation (to limit creation of falling debris) and multiple access routes for emergency services vehicles.

4.3.5 Conclusions

Due to the very nature of Tulsa's climate, severe thunderstorms and the high winds they frequently produce will remain a very real threat to this community. The probability and accompanying risk of events occurring is "high." Recent events both in Tulsa and in the surrounding areas serve as proof that while sporadic, high winds events continue to produce life and property threatening conditions. Improved building technologies, advances in public communication capabilities, and opportunities for collaboration among community agencies should remain prominent in the planning and response communities' endeavors.

4.3.5.1 Data Limitations

In many cases, tornadoes and high wind events occur during the same storm incident. For example, a 2006 storm event produced damage at Tulsa International Airport from both a downburst and a tornado. In some cases, unless there is direct observation, it may never be known whether damage was produced by a tornado or a downburst. This Section should be read and analyzed in conjunction with the Tornado section.

4.3.5.2 Update Changes

Identified significant changes made from the 2003 City of Tulsa Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.3.5.3 Sources

NCDC Storm Event Database, at Web address: www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms. National Climatic Data Center.

National Weather Service: Office of Climate, Water, and Weather Services, at Web address: http://www.nws.noaa.gov/om/hazstats.shtml.

Mighty Thunderstorm hits town (6/7/06) Tulsa World at www.tulsaworld.com

"Performance of building cladding in urban environments under extreme winds" by Tiphaine Williams and Ahsan Kareem of NatHaz Modeling Lab, University of Notre Dame

Bashor, Rachel and Kareem, Alisan. *Performance of Glass Cladding of High Rise Buildings in Hurricane Katrina.* Newsletter of American Association for Wind Engineering, December 2006. Also on Website: www.aawe.org.

4.4 Lightning

Lightning is generated by the buildup of charged ions in a thundercloud. When the buildup interacts with the best conducting object or surface on the ground, the result is a discharge of a lightning bolt. Thunder is the sound of the shock wave produced by the rapid heating and cooling of the air near the lightning bolt. The air in the channel of a lightning strike reaches temperatures higher than 50,000 degrees Fahrenheit.

4.4.1 Hazard Profile

Lightning is the most constant and widespread threat to people and property during the thunderstorm season. According to National Oceanic and Atmospheric Administration (NOAA) studies, an average of 44 people per year were killed by lightning between 1998 and 2007 in the United States. From an article in the *TMCNET Newsletter* dated September 14, 2006, “Lightning is responsible for more than $5 billion in total insurance industry losses annually, according to Hartford Insurance Co.”

When a person is struck by lightning, serious burns or deaths are obvious outcomes. According to *Storm Data* (NWS Publication),

Lightning can strike 10 miles out in front of an advancing rain column

Fire is a potential outcome from a cloud-to-ground lightning strike. During 2002-2004 U.S. fire departments responded annually to about 31,000 fires caused by lightning with $213,000,000 in direct property damages.*(*Source: NFPA Report, January 2008.) The period 2000-2006 showed 12,000 wild land fires started by lightning per year. This amounts to an average of 5.2 million acres annually. *(*Source: National Interagency Fire Center, 2007).

Lightning strikes can also cause high-voltage power surges that have the ability to seriously damage equipment and valuable data if surge protection devices are not installed. Property damage from power surges and resulting fires can destroy not only the electronics in private homes, but also unprotected equipment located in the business sector and critical facilities in a community. Some 30% of all power outages annually are lightning-related, on average, with total costs approaching $1 billion dollars. *(Source: Ralph Bernstein, EPRI; Diels, et al (1997))*

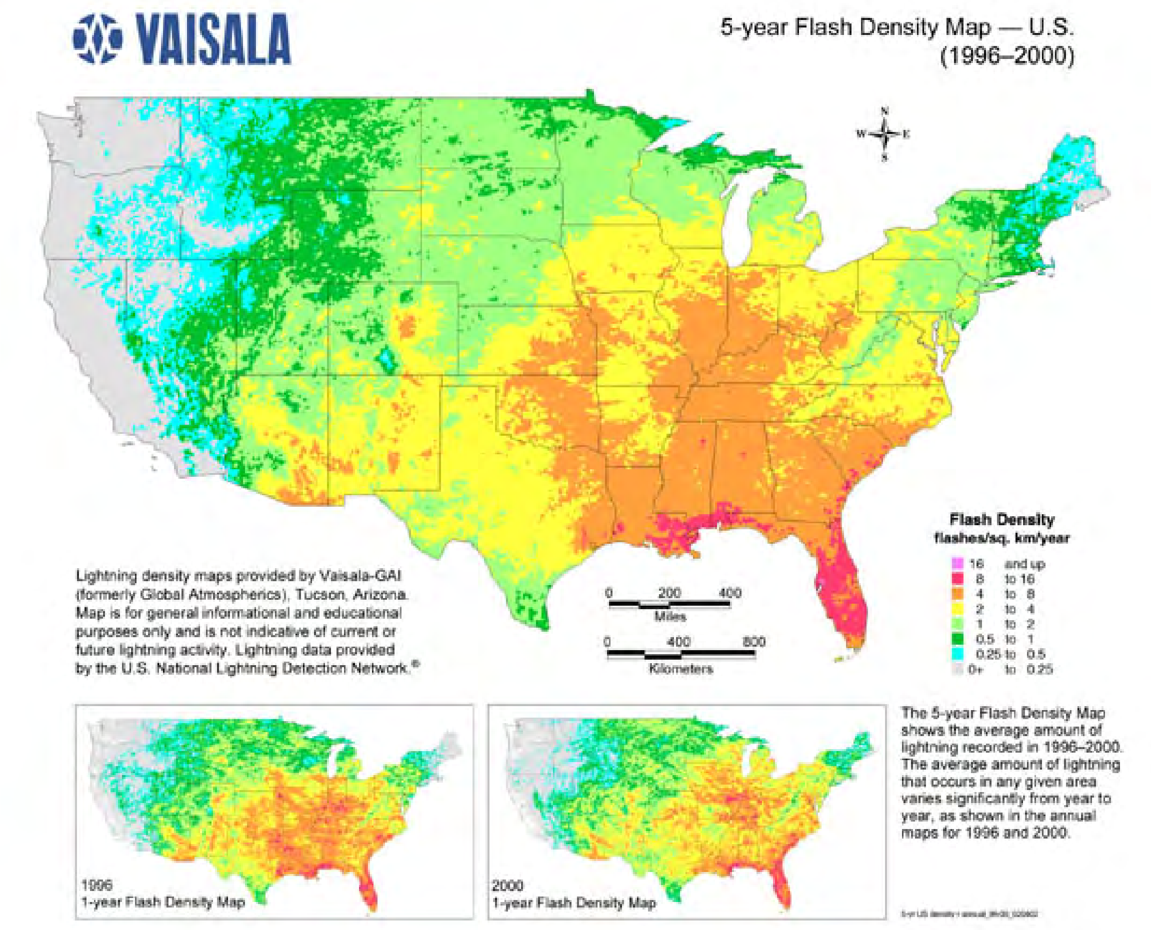
4.4.1.1 Location

Lightning can strike ten miles out from the rain column, and lightning deaths often occur under a clear sky ahead of the storm. This is largely because people wait until the last minute to seek shelter – not fully comprehending the true danger of lightning.

As lightning is a by-product of thunderstorms, the entire jurisdiction of the City of Tulsa is subject to the exposure and effects of lighting events.

4.4.1.2 Extent (Magnitude/Severity)

Tulsa County has reported 10 lightning events between 1998 and 2008 that resulted in $2.265 Million in damages, 1 death and 2 injuries. This data demonstrates that Tulsa County could anticipate one significant lightning strike each year, with damages averaging $226,500. Although the entire community of Tulsa is at risk from lightning, the probable extent of a damaging strike depends upon the type of structure that is hit, the age, condition and density of structures in the strike area, the community's fire response capability and the presence or absence of lightning warning and protection systems.

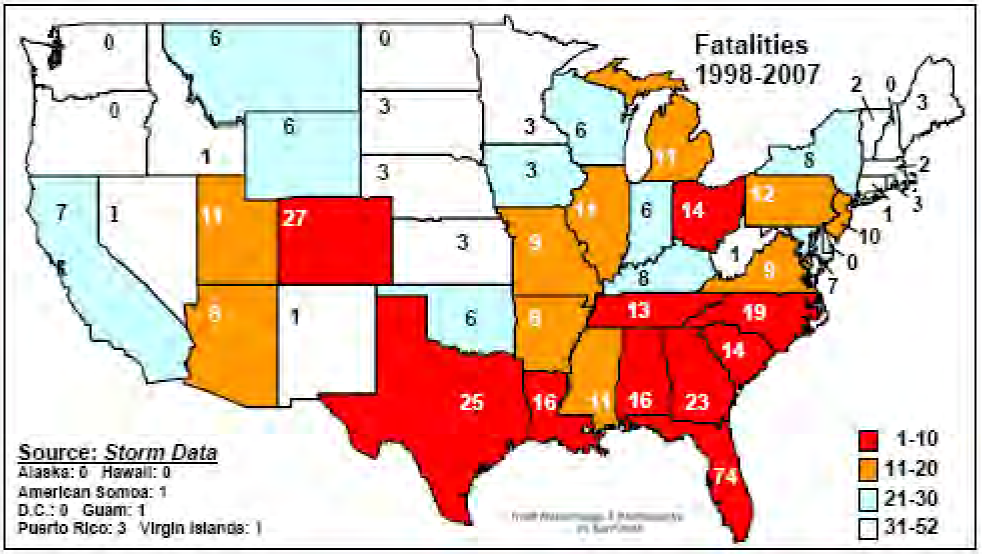


The City of Tulsa may experience Lightning flashes between 4 and 8 per Sq Km per year as shown on the Vaisala Scale

4.4.1.3 Frequency

National Geographic claims that lightning strikes the surface of the earth approximately 100 times every second. The National Lightning Detection Network states researchers have typically defined a flash as consisting of all cloud-to-ground discharges which occur within 10km of each other within a one second interval. In a report released by the NLDN in 2006, for the time period between 1996 and 2005, Oklahoma was ranked 9th in

Lightning Deaths by State, 1998 to 2007



the country for Average Lightning Flashes per Year (966,295 flashes/year), which represents an average of 13.8 Lightning Flashes per Square Mile.

Lightning casualties and damages increase gradually through the spring when thunderstorm season begins for most of the country, and peak during the summer months. The months most notorious for lightning incidents were June (21%), July (30%) and August (22%). The most injurious lightning strikes have been shown to occur on Sundays, Wednesdays and Saturdays between the hours of 12:00noon and 6:00pm.

4.4.1.4 History/Previous Occurrences

In 2007, there were 43 deaths from lightning strikes in the United States. Florida was hardest hit with 10 deaths, followed by Texas with 7. Other states experiencing fatalities were Georgia (3), New Jersey, Missouri, South Carolina, Colorado (2 each) and 15 additional states with 1 each.

Between 2000-2006 it was reported that an average of 12,000 wildland fires were started by lightning each year. This amounts to an average of 5.2 million acres annually. In 2005, a lightning-caused methane gas explosion in West Virginia killed twelve miners.

Between 1998 and 2008, there have been 263 lightning events recorded for the state of Oklahoma, with 6 deaths, 45 injuries and $14.128Million in damages. In that same time period, Tulsa County experienced 10 events with 1 death, 2 injuries and $2.265Million in damages; the City of Tulsa experienced 4 events with no deaths, 1 injury and $160K in damages.

Other significant events in Oklahoma include:

Cushing, OK (4/19/1992) – In Cushing, lightning struck a propane gas company, and the resulting explosion ripped the roof off the building. Lightning also struck the antenna system of Cushing City Hall, destroying the Fire and Police Department's radio dispatch and antenna system.

Tulsa County (9/7/1999) – Lightning ignited a fire at Mid-Continent Pipeline, located 7 miles east of Cushing in Tulsa County, where two tank batteries were damaged.

Tulsa, OK (5/17/1999) – House near 111th Street between Yale & Sheridan struck by lightning, sparking structural fire. Entire roof of home was destroyed. Estimated damages $150K. No injuries, no deaths.

Broken Arrow, OK (5/17/1999) – House in 800 block of East Mason Drive struck by lightning sparking structural fire. Fire destroyed entire second level of the home. Estimated damages $50K. No injuries, no deaths.

Tulsa County (5/9/2000) – One mile to the east of Tulsa, lightning strikes burned out 2 power pole phases causing power outages to approximately 550 residents.

Tulsa, OK (6/10/2003) – Seventeen-year-old boy struck by lightning while outside in a residential area. Transported to local hospital for treatment of injuries.

Broken Arrow, OK (7/23/2005) – Two teenagers struck by lightning while playing under a tree. Both went into cardiac arrest as a result of the strike but were revived on scene and transported to a nearby hospital. One teenager later died from his injuries. The other teenager was eventually released from the hospital, but will be require lengthy rehabilitation as a result of his injuries.

Glenpool, OK (6/12/2006) – Fuel tank containing 5 million gallons of fuel struck by lightning igniting a fire. 800,000 gallons of fuel burned with much of the rest being pumped out. 5 homes were voluntarily evacuated, and Hiway 75 was rerouted for a time. No deaths, no injuries. Estimated damages - $2Million

While the most significant of these events did not occur within the city limits, they were located in nearby communities that rely on the City of Tulsa for mutual aid in times of disaster.

Table 4–20: Casualties and Damages Caused by Lightning from 1998 thru 2007
Source: Storm Data

Location	*Events*	*Fatalities*	*Injuries*	*Damages*
Tulsa	4	0	1	$160,000
Tulsa County	10	1	2	$2,265,000
Oklahoma	263	6	45	$14,128,000
United States	8,705	484	3,130	$370,978,000

4.4.1.5 Probability/Future Events

Oklahoma is vulnerable to frequent thunderstorms and convective weather patterns, and therefore its vulnerability to lightning is a constant and widespread threat during the thunderstorm season. Tulsa City and County jurisdictions are no exception, as demonstrated by the deadly and damaging lightning strikes in 2005 (death of one teenager and lingering disability of another) and 2006 (a victim of a lightning-caused petroleum tank farm fire). The City of Tulsa has a high probability of a lightning strike.

4.4.2 Existing Vulnerability

4.4.2.1 Population

Anyone out-of-doors during a thunderstorm is exposed to and at risk from lightning. More people are killed by lightning strikes while participating in some form of recreational activity than any other incident, source, or location. The next largest group of fatalities involves people located under trees, then those in proximity to bodies of water. Other common incidents are related to agricultural activity, telephone users, and people in proximity to radios and antennas.

Table 4–21: Locations of Injurious Lightning Strikes

Location	Percent
Not reported	40
Open fields and recreation areas (not golf courses)	27
Under trees (not golf courses)	14
Water related (boating, fishing, swimming)	8
Golfing and on a golf course under trees	5
Heavy equipment and machinery related	3
Telephone related	2.4
Radio, transmitter and antenna related	0.6

4.4.2.2 Structures/Buildings

Oklahoma is vulnerable to frequent thunderstorms and convective weather patterns, and therefore its vulnerability to lightning is a constant and widespread threat during the thunderstorm season. The City and County of Tulsa jurisdictions are no exception, as demonstrated by the 1 death, 2 injuries and $2+ Million in damages between the years of 1998 and 2008. The entire community is at risk to lightning-caused fires, damages and casualties.

4.4.2.3 Critical Facilities

All critical facilities within the jurisdiction of the City/County of Tulsa should be considered vulnerable to the effects of a lightning event. Power disruption and potential destruction of electronic equipment (computers, vital medical equipment, communication equipment, data storage, etc.) should be considered a primary threat to critical facilities. A list of the Critical Facilities in the City of Tulsa can be found in Appendix G.

4.4.2.4 Infrastructure

Lightning-caused problems are one of the most common troubles faced by American business today. A recent Carnegie-Mellon study showed that 33% of U.S. businesses are affected by lightning – and that more businesses are affected by lightning storms than by floods, fires, explosions, hurricanes, earthquakes, and violence.

Electronic equipment from computers to enterprise-level communications systems can be seriously damaged by power surges from lightning. Surge protection should be included in any electronic system to minimize the risk of damage from lightning. In addition, lightning warning/detection systems (such as ThorGuard© which is utilized by Northeastern State University) should be included in protection plans for critical components of the City/County of Tulsa's infrastructure. For additional information about lightning detection/alert systems, see Appendix B, Section B.2.10 and B.4.8.

Water Treatment – Most significant effect during a lightning event would be from loss of electrical power and damage to electrical equipment. The water plants experience power outages related to lightning and thunderstorms on a regular basis. Outages are usually short in duration and affect only a portion of the facility. Both of the City of Tulsa's water treatment plants have sustained equipment damage in the past that required repair or replacement are at continued risk to this type of event.

Wastewater Treatment – The most significant threat to the operation of Tulsa's 4 wastewater treatment plants during a lightning event would be power outages. All four plants and lift stations have either double feeds or generators.

Utilities- The primary utility providers for Tulsa's jurisdiction is AEP/PSO (electricity) and ONG (natural gas). The service stations and substations for both of these providers would be vulnerable to the risks from a lightning event. Electricity: During a lightning event, providers of electrical service could experience any combination of the following challenges in meeting the needs of the Tulsa jurisdiction: Damage to transformers or other transmission components, downed broken power lines, danger to workers derived from downed power lines, and fallen debris from trees or insufficient field and/or office staff to effectively handle the workload. Gas: During a lightning, providers of gas service to a community could experience a variety of challenges in meeting the needs of the Tulsa jurisdiction: falling power lines or tree debris; inaccessibility to underground gas meters from falling debris; downed power lines, insufficient field and/or office staff to effectively handle workload generated by such an event.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Transportations systems would experience the same vulnerability to lightning events as other city facilities.

Emergency Services- Fire, Police and Medical Services would all be similarly at risk to the secondary effects of a lightning event. Downed power lines or debris blocking city streets could limit or eliminate access to affected areas. A potential secondary effect on these services would be interruption of communication capabilities due to a lightning strike.

4.4.3 Lightning Scenario

A graphic scenario demonstrating the effects of a major lightning event for this jurisdiction would be difficult to assemble, and even more difficult to analyze due to the sporadic and erratic behavior of lightning itself. However, it is possible to examine recent major events including lightning strikes and parallel those to similar situations found in this jurisdiction.

On October 14, 2007 the city of Holdenville, OK (est. 2007 population 4,582 - located in Hughes county) experienced a thunderstorm that was accompanied by lightning that struck the City Hall building crippling the community's 911 system. While repairs were being made, those requiring emergency assistance were asked to call a local 7-digit phone number.

In addition to the 911 system, the Holdenville Police Department reported major damage to its radio system. Damages reported were approximately $26,600. This was not the first time Holdenville has had to contend with lightning damages. Over a period of 14 months (March 29, 2007 through May 27, 2008), the city experienced three different strikes resulting in damages in excess of $36,000.

The City of Tulsa's 911 Dispatch Center currently handles an average of 1,050,000 emergency calls each year. In the planning and construction of this facility, many disaster resistant techniques were utilized to strengthen the integrity of this vital part of Tulsa's infrastructure. City records show that state of the art lightning and electrical surge protection systems have been installed to protect the operational equipment within this facility. Additionally, the interior spaces of the 911 Call Center were built in accordance with FEMA 361 standards for Community Safe Rooms and the exterior aligned offices were built to withstand an FE-F3 tornadic event. By employing such techniques, it is highly improbable that the city's 911 Call Center would experience an outage as extensive as that seen in Holdenville. However, should a catastrophic event result in the prolonged disabling of this system for even a 4-hour time frame, it would mean the disruption of nearly 480 emergency calls.

This figure is based on an annual average of calls handled, and would not account for a spike in 911 calls in the event of a major disaster/emergency affecting a large portion of the city. In such a catastrophic event, the volume and the critical nature of the incoming calls would increase dramatically, therefore demonstrating the criticality of providing such protection measures for the city's vital infrastructure components.

The most frequently reported incidents involving injuries and/or deaths from lightning strikes occur during common outdoor activities such as hunting, swimming, and other outdoor team events such as soccer and football. According to the website "struckbylightning.org", at the time of the writing of this plan, there have been 24 fatalities and 288 injuries attributed to lightning strikes in the United States.

One of these events occurred at a football game in Bonaire GA on September 11, 2008 at approximately 3:30 p.m. Officials had a hand-held lightning detector in use, and when it sounded an alarm, decided to call the game because of the approaching thunderstorm. They were in the

A similar lightning detector in use at a Bonaire GA football game had prompted officials to begin moving people off the field when lightning struck

process of moving players off the field when lightning struck. Thirteen individuals were injured, twelve sent to local hospitals, and one of the coaches remained in critical condition for several days.

A second event took place in Dorchester MA on July 20, 2008, also at approximately 3:30pm. This time, the sporting event was a local soccer game. There were 10 injuries reported, four of these were critical. Seven or eight of the players were knocked unconscious, and the injuries reported ranged from burns to cardiac conditions. The victims ranged in age of 13 – 41yrs old, all were males.

These two events are particularly pertinent to the Tulsa area, as there are a large number of gatherings centered around both of these sports as well as others.

In the Tulsa area, there are at least five organized soccer clubs, with 7 major soccer fields / complexes listed on their various websites. This does not account for the numerous school/community based soccer teams whose information is not readily available. There are children as young as 5yrs old on teams – and players well into their adult years participating in this very popular sport. Add to this list the usual range of spectators – parents, grandparents, schoolmates, friends, co-workers, siblings, etc. – and the number of those placed in an extreme situation of vulnerability increases dramatically.

The other sport activity mentioned above was football. In the Tulsa area, football is a most popular and widely promoted activity for all ages. Again, youth leagues begin at a very young age with flag football, with the demographics going up in age from there. High School football is a competitive and highly attended social activity – again placing an extremely large number of people at a very high risk during a lightning event.

As with many reports pertaining to lightning events, specific numbers of people in attendance were not available in the above mentioned situations. So for this discussion it will be assumed that the same number of players would be on the field(s) for a similar event in the Tulsa jurisdiction.

In the case of the football game described in the above incident, there were thirteen people injured, with twelve of those people being transported to the hospital - nine by ambulance and three by personal vehicle. Assuming that those transported to the hospital would have been admitted overnight for observation (at the minimum) the economic value of those hospitalizations, according to “What is a Benefit”, would be a total of $187,200 (12 patients x $15,600 each). The economic value for lost wages according to the same source is $21.16/hour per person. If it is assumed that one coach and one teacher were among those injured, and their time off work totaled 10 working days (the time frame noted for the injured coach in Georgia), total economic value of those lost wages would be $3,385.60. These two considerations represent a total loss of $190,585.60. This does not take into account the cost to the school for additional counselors working with the students the following week, or property damages (if any) sustained from the strike.

Reviewing the information available from the soccer match incident, it is noted there were ten people injured, four of which were critical. Injuries ranged from burns to cardiac related issues. Utilizing the same calculation method for economic values, the value of related hospitalizations for a similar event would be $156,000. There were several adult males injured, so the time lost from work would also be a factor. The economic value for lost wages is $21.16/hour per person. If it is assumed that one-half of those injured were employed, and the time away from their jobs averaged 10 days each, that would amount to a total of $8,464.00 in lost wages, bringing the total to $164,464. This figure does not factor in a lengthier hospitalization for a critically injured victim.

4.4.4 Future Trends

4.4.4.1 Population

As the "baby-boomer" population begins to move more aggressively into retirement, it could be anticipated that the number of people pursuing outdoor sports and/or social activities could also increase. Priority should be given to continuing the process of educating the community of the dangers associated with lightning. Also adding to this increase in out-of-doors activity could be the rising cost of fuel. With more families looking for activities closer to home, parks and other outdoor recreation areas may become more attractive.

With any future development comes construction. An increase in new construction or even large renovation projects would also increase the number of outdoor workers in a wide variety of functions. These groups should also be included in the continuation of education to the public on the above-discussed dangers.

4.4.4.2 Structures/Buildings

As uninhabited areas continue to be developed and existing structures are renovated to accommodate new purposes in their use, actions to lessen the potential effects of lightning strikes should be considered. Installation of surge protectors for electricity and phone lines should be actively encouraged as well as working with utility companies to facilitate the relocation of above-ground utility lines to underground.

4.4.4.3 Critical Facilities

As technology continues to advance, the need to protect power sources supporting that technology should advance as well. Working with local utility companies to coordinate the relocation of above-ground utilities (phone, electricity, etc.) to underground should be considered a top priority in the construction of new facilities, or the renovation of facilities to accommodate the updating of current systems.

4.4.4.4 Infrastructure

Ensuring local government facilities are well protected against the potential effects of lightning strikes is an on-going endeavor. Investigating and implementing new technology as it is made available will help ensure the continuity of operations at all levels of operation – uninterrupted communications and protection of the ever-growing mountain of electronic data gathered in day-to-day operations should be considered priorities in any plans developed for future development.

4.4.5 Conclusions

Lightning is one of the most deadly and consistent hazards in the United States. People outside can have a false sense of security, thinking that they are safe because a storm front has not yet reached their location. In fact, lightning can strike ten miles out from the rain column, putting people that are still in clear weather at risk. The general rule of safety is that anyone outside during a thunderstorm should take cover.

Electronic equipment, from personal computers to enterprise-level communications systems, can be seriously damaged by power surges from lightning. Surge protection should be included in any electronic system to minimize the risk of damage from lightning.

In recent years, new technology has provided ample opportunities for communities and individuals to provide increased warning and alerts, increased surge protection, and increased building strike protection. The threat of injury, death, or property damage in the City of Tulsa is high.

4.4.5.1 Data Limitations

Accurate data on the effects of lightning events is difficult to obtain for multiple reasons. *Regarding injuries* – many survivors do not seek immediate medical care and only come to the attention of medical personnel when they seek care for effects of the shock that have not resolved by a few days after their injury. In addition, many lightning deaths and injuries are attributable to nervous system disruption with no visible signs of injury, so in some cases, injuries or deaths may be misdiagnosed as heart attacks or other ailments.

Regarding property damages – home and business owners often choose not to submit insurance claims in connection with their damages. Typically, the events that are documented are the more widespread occurrences affecting several business/residential locations.

Regarding data collection – much of the data utilized is taken from newspaper accounts, so if budgets are cut or if people/structures affected by lightning do not make the news, they are not included in the larger pool of statistics.

4.4.5.2 Update Changes

Identified significant changes made from the 2003 City of Tulsa Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.4.5.3 Sources

eMedicine – Lightning Injuries: Article by Mary Ann Cooper at www.emedicine.com/emerg/TOPIC299.HTM

Lightning Fatalities, Injuries, and Damage Reports in the United States from 1959-1994. NOAA Technical Memorandum NWS SR-19, 1997 and at Web Address: http://www.nssl.noaa.gov/papers/techmemos/NWS-SR-193/techmemo-sr193.html.

Mulkins, Phil. "If you can hear thunder—find cover now!" *Tulsa World*, May 23, 2002.

Multi-Hazard Identification and Risk Assessment, p. 30. Federal Emergency Management Agency, 1977.

National Lightning Safety Institute, at Web address: http://www.lightningsafety.com/.

National Weather Service: Office of Climate, Water, and Weather Services, at Web address: http://www.nws.noaa.gov/om/hazstats.shtml.

NCDC Storm Event Database, at Web address: www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms. National Climatic Data Center.

"Securing the Supply of Electrical Services" by Jay Apt, Carnegie Mellon University

4.5 Hailstorm

A hailstorm is an outgrowth of a severe thunderstorm in which balls or irregularly shaped lumps of ice fall with rain. Extreme temperature differences from the ground upward into the jet stream produce strong updraft winds that cause hail formation. Hailstorms are usually considered “severe” when hail is larger than ¾” and accompanied by winds greater than 60 miles per hour.

Table 4–22: Common Sizes and descriptions of Hail
Source: National Weather Service

Hail Size	Description	Hail Size	Description
0.25 inch	Pea Size	1.75 inch	Golf Ball Size
0.50 inch	Mothball Size	2.00 inch	Hen Egg Size
0.75 inch (Severe Criteria)	Dime/Penny Size	2.50 inch	Tennis Ball Size
0.88 inch	Nickel Size	2.75 inch	Baseball Size
1.00 inch	Quarter Size	3.00 inch	Teacup Size
1.25 inch	Half Dollar Size	4.00 inch	Grapefruit Size
1.50 inch	Walnut or Ping Pong Ball Size	4.50 inch	Softball Size

Combined NOAA/TORRO Hailstorm Intensity Scales

Size Code	Intensity Category	Typical Hail Diameter (inches)	Approximate Size	Typical Damage Impacts
H0	Hard Hail	up to 0.33	Pea	No damage
H1	Potentially Damaging	0.33-0.60	Marble or Mothball	Slight damage to plants, crops
H2	Potentially Damaging	0.60-0.80	Dime or grape	Significant damage to fruit, crops, vegetation
H3	Severe	0.80-1.20	Nickel to Quarter	Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored

Combined NOAA/TORRO Hailstorm Intensity Scales

H4	Severe	1.2-1.6	Half Dollar to Ping Pong Ball	Widespread glass damage, vehicle bodywork damage
H5	Destructive	1.6-2.0	Silver dollar to Golf Ball	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries
H6	Destructive	2.0-2.4	Lime or Egg	Aircraft bodywork dented, brick walls pitted
H7	Very destructive	2.4-3.0	Tennis ball	Severe roof damage, risk of serious injuries
H8	Very destructive	3.0-3.5	Baseball to Orange	Severe damage to aircraft bodywork
H9	Super Hailstorms	3.5-4.0	Grapefruit	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open
H10	Super Hailstorms	4+	Softball and up	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open

4.5.1 Hazard Profile

Hail can occur in any strong thunderstorm, which means that hail is a threat ubiquitously within the United States. Hail is one of the most destructive hazards to agricultural crops and animals, and the major natural cause of automobile damage.

4.5.1.1 Location

The states in the middle of the Great Plains, and particularly Oklahoma, are the most likely to have severe thunderstorms and therefore have the most hail events. Oklahoma experiences an average of 869 hailstorms each year with hailstones measuring at least 0.75” in diameter. All buildings and agricultural areas in the City of Tulsa are at risk.

4.5.1.2 Extent (Magnitude/Severity)

The damages expected from a hail event are a function of the diameter of the hailstones and the wind speed, or hailstone velocity. There have been numerous instances of hailstones reaching four inches in diameter, or softball size. The largest hailstone ever measured in the United States fell at Coffeyville, Kansas, on September 3, 1970. It weighed 1.67 pounds and measured 17.5 inches in circumference. When hailstones reach such dimensions, they can be extremely dangerous to property, agriculture and the vulnerable populations of the jurisdiction.

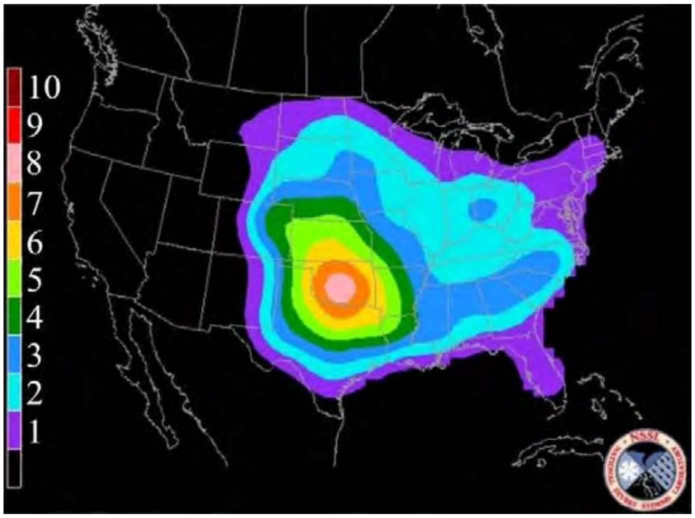
The size of hailstones is a direct function of the severity and size of a storm. High velocity updraft winds keep hail in suspension in thunderclouds. The greater the intensity of heating at the Earth's surface, the stronger the updraft will be. Higher temperatures relative to elevation result in increased suspension time, allowing hailstones to grow in size.

When hail hits, it can damage cars, shred roof coverings, and lead to water damaged ceilings, walls, floors, appliances, and personal possessions. Large hailstones can also cause serious bodily injury.

Based on historical records, the City of Tulsa can receive up to 3 inch hail in any area of the city or even the entire city.

4.5.1.3 Frequency

Most localities within the United States from the Great Plains eastward experience hailstorms at least two or more days each year. The Great Plains, particularly the states of Oklahoma, Kansas and Texas, are most frequently affected by hailstorms. These states can expect to receive hail between four and eight days per year.



Hailstorm days per year from 1980 to 1999

Any specific location in the Tulsa metropolitan area can expect to receive hail an average of two to three times each year, with the entire city averaging up to eight events per year. Hail has been reported in every month, with the highest frequency during the transitional months in the spring. The peak time of year falls right in the middle of that transition period from mid-April to mid-May. Another small peak occurs in November as the weather pattern transitions back into winter.

Multiple impacts of concurrent severe thunderstorm effects (high winds, tornadoes and hail) are very likely within the Great Plains region. About 2% of United States' crop production is damaged by hail each year, and in the Great Plains states, damages have sometimes reached 20%. In total, hail causes nearly $1 billion in property and crop damage each year. In 2005, there were more than 13,000 hail storms in the United States. According to Swiss Re, four out of the top 20 most costly insurance losses of 2005 were hail related.

4.5.1.4 History/Previous Occurrences

In the state of Oklahoma, there were 725 severe hail events in 2006 (largest reported hailstone was 4.25" in Harmon County) with $832 K in Property Damages and $176 K in Crop Damage; 470 severe hail events in 2007 (largest reported hail was 4.25" in Harper

County) with $167K in Property Damage; and for the first two months of 2008 there were 72 severe hail events reported with Property Damage reported of $45K.

On June 1, 2008, a large storm system moved across a large portion of the state, resulting in large hail reported in several locations. Perhaps the most devastating reports came from the small rural community of Mannford (Creek County), where City Officials were estimating that every home in the community (approximately 1,100 homes) sustained some form of damage from hail ranging in size from golf balls to tennis balls. It was reported that approximately 600 homes had windows broken out and that every home suffered roof damage – with hailstones actually tearing through some of the roofs and landing in the homes. Additionally, between 1,000 and 1,500 vehicles also sustained heavy damage. Two non-life threatening injuries were also reported in this community because of the hail event.

Tulsa County has reported 326 severe hail events from 1996 through 2005, with $89.3 Million in reported damage. Based on data from the National Climatic Data Center, 129 of these events were reported for the Tulsa jurisdiction, with $23.5 Million in reported damages.

Table 4–23: Reported Casualties and Damages Caused by Hail from 1996 to 2005

Location	Events	Fatalities	Property Damage	Crop Damage
Tulsa	86	0	$21,655,000	$0
Tulsa County	227	0	$89,506,000	$0
Oklahoma	8,688	0	$44,371,000	$1,093,000
United States	114,402	34	$7,455,167,000	$1,525,597,000

4.5.1.5 Probability/Future Events

As hail is a direct by-product of thunderstorm activity, and Oklahoma enjoys a climate-rich environment most suitable for this weather activity, it is accepted that the entire Tulsa jurisdiction will continue to experience thunderstorms of varying severity with hail present in many of those events.

Based on history and previous occurrences from the past 10 years, the Tulsa jurisdiction can expect to experience an average of 8.3 severe hail events each year.

4.5.2 Existing Vulnerability

Hailstorms occur in every state of the continental Unites States, but most frequently in the Great Plains during the late spring and early summer when the jet stream migrates northward. This period coincides with the Midwest's peak agricultural seasons for wheat,

Hailstones can cause widespread damage to crops and automobiles and serious bodily injury

corn, barley, oats and rye, tobacco and fruit trees. Long-stemmed vegetation is especially vulnerable to damage by hail impacts and winds.

4.5.2.1 Population

Given the climatic environment in this jurisdiction, all demographic groups located within the Tulsa jurisdiction are vulnerable to the effects and potential damages of hailstorm events. Those of particularly high vulnerability are those pursuing farming and/or ranching activities within this jurisdiction, as crop damage is the highest percentage of reported hail damages. In addition, people engaging in outdoor recreational activities, such as camping, may find themselves in a situation where sufficient shelter is unavailable.

4.5.2.2 Structures/Buildings

Severe hailstorms also cause considerable damage to buildings and automobiles but rarely result in loss of life.

Oklahoma has significant exposure to hailstorms, and virtually all buildings and crops in the storms are at risk. The City of Tulsa is no exception. The entirety of each jurisdiction is vulnerable to the damaging effects of hail.

4.5.2.3 Critical Facilities

Since all buildings would be vulnerable to damage, all critical facilities would fall into this category (for a complete list of City of Tulsa critical facilities, see Appendix G). Hail, however, is unlikely to render a building non-operational.

4.5.2.4 Infrastructure

Water Treatment – It is not anticipated that a hail event would cause a major disruption in the normal operation of the water treatment systems for the City of Tulsa.

Wastewater Treatment – It is not anticipated that a hail event would cause a major disruption in the normal operation of the wastewater treatment systems for the City of Tulsa.

Utilities – The primary utility providers for Tulsa’s jurisdiction is AEP/PSO (electricity) and ONG (natural gas). Neither of these services would suffer a major disruption of service delivery in the event of a hail storm.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – During a hail event, public transportation vehicles may sustain damage. If severe enough (such as the hail event on June 1, 2008 in Mannford, OK) there could be some risk of loss of use of these vehicles, possibly disrupting normal operation of city routes. During a major storm that is producing hail, it is reasonable to assume that flights leaving and arriving at Tulsa International Airport could be delayed. Aircraft on the runway during a significant event could potentially experience some damage if the hailstones were of a substantial size, and the event were prolonged.

Emergency Services – Fire, Police and Medical Services would all be similarly at risk to the secondary effects of a hail event. Response vehicles in the open during a hail event would all face the same risk of damages, most likely to be window and/or windshield damages. A secondary effect could be an increased call volume related to traffic accidents should the hail event occur during a heavy traffic period during the work week.

If a major hail event were to occur between 7:30 – 8:30am or 5 – 6pm on any weekday, the risk of commuters being caught in that event are substantially higher. The daytime population of Tulsa increases by over 74,000 people due to commuters from neighboring communities. Additionally, the majority of workers in the city have a commute time of 15-20minutes; thus creating a high volume of traffic on the city streets in these time periods.

4.5.3 Hail Scenario

4.5.3.1 Overview

On Sunday June 1, 2008, Mannford OK (Creek County, approximately 30 miles west of Tulsa) experienced a major hail event. The storm struck at approximately 9 am, and lasted for nearly 20 minutes. Reports from the local City Manager revealed that every home (approximately 1,100 homes) was affected by this event. Nearly 600 homes sustained broken windows, and every home reportedly suffered roof damage – some so severe that the accompanying rain leaked inside causing further damage. Also damaged were between 1,000 and 1,500 vehicles. Two injuries were reported – neither requiring hospital admission.

The City of Mannford encompasses approximately 6.9 sq. miles, with an estimated housing density of 165 houses-condos/square mile (according to 2005 housing demographics). Considering the number of housing units reporting damage, this would indicate that the storm blanketed the entire city limits ground area.

4.5.3.2 Tulsa Comparison

By using these storm coverage figures, and applying them to housing density figures from the same period for the City of Tulsa, certain conclusions regarding the projected impact of a similar event on this jurisdiction may be drawn.

According to 2005 housing demographics, the City of Tulsa contained 983 houses-condos per square mile. Based on this information, a storm the size and severity of the June 1, 2008 event could be calculated to affect 6,783 residential structures in a major residential area within the city limits of Tulsa. With an estimated average repair cost of $4,500 per structure (damages ranging anywhere from a couple of windows damaged with minor damage to shingles, to several windows damaged and/or destroyed and total roof replacement), this would result in total housing damages of $30,523,500.

Comparing the housing density of Mannford to that of Tulsa (165 vs 983 units per square mile), it is noted that Tulsa's density is approximately 5.95 times that of Mannford. Applying that same rate of increase to the number of vehicles potentially affected could mean that approximately 7,437 vehicles would sustain some form of damage. By applying an average repair cost of $500 to each vehicle (mostly broken out windows/windshields, some with very heavy body damage), an average vehicular damage cost of $3,718,750 could be expected.

Utilizing these same comparison methods, Tulsa could expect to see 15 injuries of like nature reported. When applying the values provided in the publication “What is a Benefit?” the total cost of 15 minor injuries (not requiring hospitalization) amounts to $23,400 ($1,560 per injury).

Table 4–24: Hail Scenario Damages

Damage Type	Number of Units	Damage $
Housing	6,783	$30,523,500
Vehicles	7,437	$3,718,750
Injuries	15	$23,400
TOTAL		**$34,265,650**

4.5.3.3 Scenario Conclusions

This methodology, and the data it is applied to, provides a conservative indication of the damages that could be seen in the City of Tulsa should it experience a hail event of the same scope and duration as the one seen in Mannford. The total for the damages theorized above approaches $34.27 Million. This analysis does not include the economic value of time lost working with cleanup, insurance companies, etc. nor does it include estimated damages for businesses in the area.

Hail events historically do not receive the depth of reports and information sharing seen with other natural hazards. Many homeowners do not report minor claims to their insurance companies, and detailed reports are generally unavailable from insurance carriers as a result of proprietary information concerns. These factors create a true challenge in accurately analyzing the cost and true economic impacts of such widespread and sporadic events.

4.5.4 Future Trends

For maps of Tulsa’s potential future development areas, see Figure 1-13.

4.5.4.1 Population

Since deaths or injuries from hail events are extremely rare, and since all areas of the city are equally at risk of exposure to hailstorms, the vulnerability of populations in newly developed areas will be low, and will be similar or equal to the vulnerability of already established populations.

4.5.4.2 Structures/Buildings

In all areas being considered for future development, the construction of any new structures/buildings should include plans to utilize impact resistant materials and components when available on initial plans. As more buildings are being considered for renovation and converted from one purpose to another, strong emphasis should be placed on utilizing these same materials whenever possible in the reconstruction process. The two primary areas of concern would be roofing and window systems.

4.5.4.3 Critical Facilities

Any future development and renovation should also include the improvement of existing critical facilities to help ensure the community's sustainability. Hail resistive materials utilized in construction should become standard in this class of facility and the construction of protective screens for external equipment (i.e. air filtration/conditioning systems, backup generators, communication terminals, etc.) to assist in protecting them from damaging weather events should be included in any future plans.

4.5.4.4 Infrastructure

As research and development of alternative fuel sources evolves, it is anticipated that "bio-fuels" will begin to play a much larger role in energy resources. As this technology evolves, strong consideration should be paid to the planning of the planting and development of crops supporting this technology. Since crops are potentially very vulnerable to hail damage, this could produce a potentially high economic impact.

4.5.5 Conclusions

The states in the middle of the Great Plains, and particularly Oklahoma, are the most likely to have severe thunderstorms and therefore have the most hail events. The peak season for hail events is in the late spring and early summer. Oklahoma experiences an average of 869 hailstorms each year with hailstones measuring at least 0.75" in diameter. All buildings and crops in the State are at risk.

The City of Tulsa has high vulnerability to hailstorms.

4.5.5.1 Data Limitations

The property losses due to hail are not well defined and conflicting information exists. For example, in 1992 the Property Claims Service declared, "Hailstorms across the country (in 1992) ran up a bill of $1.57 billion." Yet, their data on all weather catastrophes shows that hail plus other conditions caused $3.9 billion in insured losses in 1992, and only one storm was a hail-only event, and it caused losses listed at $275 million. This is just one demonstration of the lack of good data on the property losses due to hail. In addition, since a hailstorm is seldom a nationally declared disaster, there may be no agency gathering aggregate data across a region on losses.

4.5.5.2 Update Changes

Identified significant changes made from the 2003 City of Tulsa Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.5.5.3 Sources

The Weather Channel Storm Encyclopedia at Website:
www.weather.com/encyclopedia/thunder/hail.html

National Weather Service Forecast Office – Tulsa, OK at
www.srh.noaa.gov/tsa/climate/tulhail.html

"Trends in Hail in the United States" by Stanley Changnon, Chief Emeritus & Principla Scientist at Illinois State Water Survey – Mahomet, IL at http://sciencepolicy.colorado.edu/socasp/weather1/changnon.html

National Climatic Data Center at www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

Tulsa World (Vol. 103, No 262) at www.tulsaworld.com

City-Data.com at www.city-data.com/city/tulsa-oklahoma.html

4.6 Winter Storms

A severe winter storm is one that drops four or more inches of snow during a 12-hour period, or six or more inches during a 24-hour period. An ice storm occurs when freezing rain falls from clouds and freezes immediately upon contact.

The National Weather Service (NWS) issues winter storm advisories when at least five inches of snow or any amount of ice is projected to occur over a 24-hour period. A winter storm warning means forecasters expect at least seven inches of snow or ½ inch of ice.

4.6.1 Hazard Profile

A winter storm can range from moderate snow over a few hours to blizzard conditions with blinding wind-driven snow that lasts several days. Many winter depressions give rise to exceptionally heavy rain and widespread flooding. Conditions worsen if the precipitation falls in the form of snow because it occupies seven to ten times more space than the same quantity of rain. The aftermath of a winter storm can impact a community or region for weeks, and even months.

Tulsa is vulnerable to ice storms produced by warm, moist Gulf air colliding with arctic air from the Canadian Shield

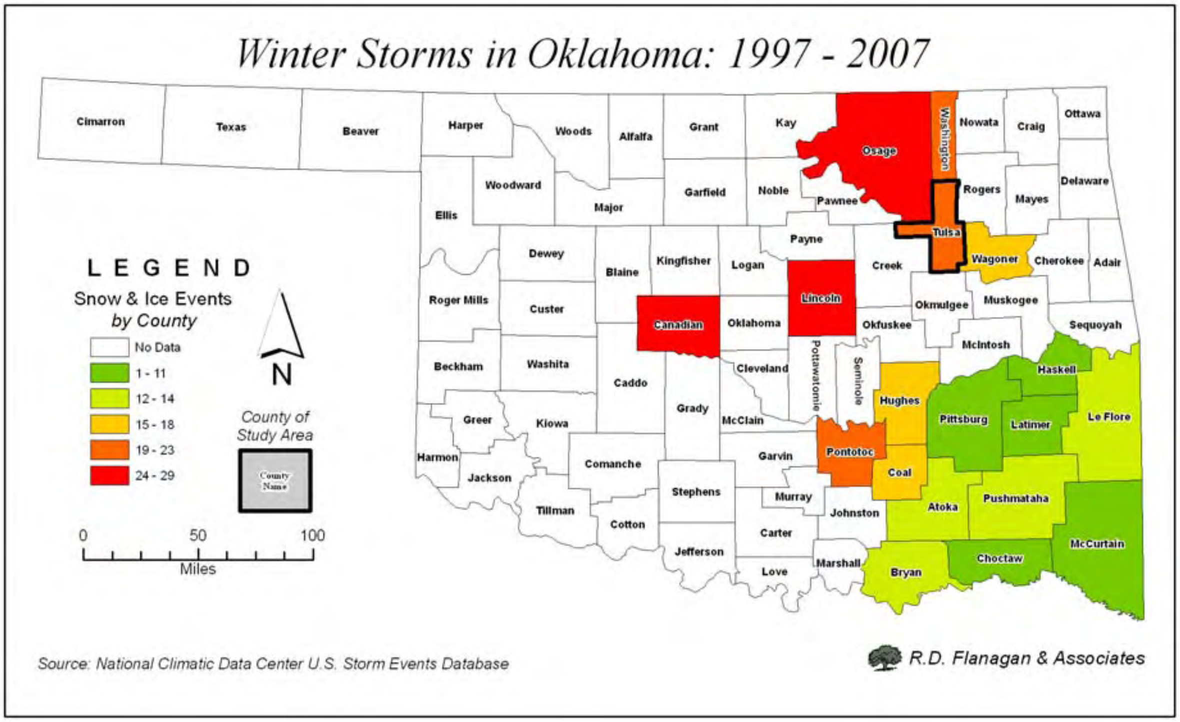
4.6.1.1 Location

The northeast corner of Oklahoma is situated in a prime location to experience the periodic collision of warm, moist Gulf air and arctic air from the Canadian Shield. Because of this climatic positioning, Tulsa has the ability to experience winter weather ranging from the extreme to the almost mild in nature. Therefore, the entire jurisdiction of the City of Tulsa is considered vulnerable to the effects of a severe winter ice/snow event.

4.6.1.2 Extent (Magnitude/Severity)

Winter storms cause great inconvenience, injuries and deaths. Everyone is affected by the loss of mobility. Streets and highways are slick and hazardous, and even walking from house to car can be dangerous. Public transportation is often blocked. Residents, commuters, travelers and livestock may become isolated or stranded without adequate food, water and fuel supplies. People are often inconvenienced or at risk of physical harm from loss of power to their homes. Above-ground electrical and telephone lines and tree limbs are often coated in a heavy build-up of accumulating ice, which break when under the stress of sufficient weight. Falling trees also often down power lines. When electrical lines are damaged, other utilities, such as natural gas, can become inoperable.

Physical damage to homes and facilities can occur from wind damage, accumulation of snow, ice, and hail from accompanying winds. Even small accumulations of snow can wreak havoc on transportation systems due to a lack of snow clearing equipment and experienced drivers. (OEM King County)



Winter storms are deceptive killers because most deaths are indirectly related to the storm. While approximately 70 percent of deaths from winter storms occur due to traffic accidents, other risks may include:

- Cold temperatures that accompany winter storms create the threat of hypothermia, primarily in the elderly;
- Slips and falls due to slippery walkways;
- Back injuries or heart attacks may occur during snow removal or debris cleanup;
- House fires occur more frequently in winter due to lack of proper safety precautions when using alternate heating sources, i.e. unattended fires, improperly placed space heaters, etc. Fires during winter storms present a great danger because frozen water supplies may impede firefighting efforts.
- Improper hookup of home generators may cause "back feed" into electrical transmission lines thought to be disconnected, threatening utility workers;
- Carbon monoxide from improperly located generators or other heating sources may threaten residents.

The *Wind Chill* temperature you have undoubtedly heard of is simply a measure of how cold the wind makes real air temperature feel to the human body. Since wind can dramatically accelerate heat loss from the body, a blustery 30° day would feel just as cold as a calm day with 0° temperatures. The index was created in 1870, and on November 1, 2001, the National Weather Service released a more scientifically accurate equation, which we use today. Here is a chart for calculating wind chill. (Please note that it is not applicable in calm winds or when the temperature is over 50°.)

Wind Chill Chart

Wind (mph) \ Temperature (ºF)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	29	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes · 10 minutes · 5 minutes

Wind Chill (ºF) = $35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$

Where, T= Air Temperature (ºF) V= Wind Speed (mph)

Effective 11/01/01

Source: National Weather Service and NOAA

The following table gives a range of physical intensities from winter storms along with the potential effect on the City of Tulsa

Level 1 – Nuisance Event No Major Impact	Little snow/ice accumulation. Roads not hazardous	Little to no effect on the Jurisdiction.
Level 2 – Minor Event Caution Advised	Dusting to 2 inches of snow. No measurable ice. Winter Weather Advisory	Untreated roadways may become hazardous and slick. Livestock may need additional supplemental feed.
Level 3 – Major Event **Isolated Emergency Conditions In the Jurisdiction**	Significant Snow Accumulations 2-8 inches. Ice Accumulations of ¼ to ½ inch. Reduced visibility. Wind causing drifting snow.	Widespread hazardous road conditions. Travel discouraged. Areas isolated because of drifting snow. Isolated power outages because of down power lines from ice accumulation.

	Winter Storm Warning	Tree damage. Livestock loss potential increases, supplemental feed necessary.
Level 4 – Extreme Event **The Jurisdiction is Under a Full State of Emergency**	Crippling Event. Snow accumulations over 8 inches. Winds over 35 mph. Drifting snow, little to no visibility. Ice Accumulations of more than ½ inch. Blizzard Warning	Road conditions hazardous to impassable. People and livestock isolated. Widespread power and utility outages. Infrastructure damage. High potential for loss of livestock. Structures threatened from accumulating snow and ice. Communications infrastructure lost from ice accumulation. May be a long lasting event.

Table 4–25: Casualties and Damages Caused by Winter Storms from 1998 thru 2007
Source: National Climatic Data Center

Location	*Events*	*Fatalities (Direct)*	*Injuries*	*Damages*
Tulsa Area	20	0	0	$50,154,000
Oklahoma	225	0	7	$726,358,000
United States	16,349	517	2,556	$4,265,142,000

The National Weather Service does not isolate damages with enough specificity to determine only the City of Tulsa damages.

4.6.1.3 Frequency

The National Climatic Data Center shows 302 Snow & Ice Events reported for the state of Oklahoma between 1994 and 2007. This calculates to an average of 21 winter storm events each year for the state. Occurrences of daily low temperatures below freezing range from an average of 140 days per year in the western panhandle to 60 days in the Red River plain in extreme southeastern Oklahoma. Occurrences of daily high temperatures below freezing range from an average of 15 days per year in portions of north central and northwest Oklahoma to 3 days per year in the southeast. Tulsa County reported 26 snow and ice events for this same period. Winter Weather events are, by nature, not isolated events – therefore it could be stated that Winter Weather events affecting the general Tulsa County area will also have an impact on the City of Tulsa of varying degrees.

4.6.1.4 History/Previous Occurrences

In Oklahoma, the National Climatic Data Center reported 225 winter storm events with snow, ice, sleet, freezing rain and drizzle during the 10-year period from January 1998 through December 2007.

The most significant of these storms bear out the frequency of occurrence and across the jurisdiction.

December 2000 (McIntosh, Latimer & Pittsburg counties): Power outages to 120,000+ homes, property damage of approximately $170 million.

January 2002 (large section of Northwest and Central Oklahoma): Power outages to 255,000+ homes, property damage exceeding $100 million, seven fatalities directly attributed to the storm.

January 30, 2002, winter storm caused widespread damage in Tulsa

December 2002 (West Central to North Central Oklahoma): Mostly rural areas affected, power outages to approximately 30,000 homes, damages primarily to electrical distribution systems of approximately $4.5 million.

January 2007 (Eastern one-third of Oklahoma): Power outages to 100,000+ homes, damages estimated at $50+ million, 32 deaths and 3,919 injuries linked to this storm. More than 100 cases of possible carbon monoxide poisoning cases were reported in the state, involving those seeking alternate methods of heat and/or power sources. Prolonged power outages combined with extreme temperatures created water supply crises in some of the more rural, isolated communities.

December 2007 (Central to Northeastern Oklahoma also referred to as the I-44 Corridor): Power outages to 260,000+ homes across the state ***– 226,500 homes in Tulsa***; 29 deaths statewide ***– 6 deaths in Tulsa*** (4 fire fatalities, 1 traffic fatality, 1 hypothermia fatality); ***Tulsa International Airport closed to incoming/departing flights for 24+ hours; 3 Tulsa hospitals forced to rely on emergency generators.***

4.6.1.5 Probability/Future Events

Based on the number of storms reported between 2000 and 2007, and factoring in the weather patterns experienced in, the entire jurisdiction can, and should, expect to experience a severe winter snow/ice event every 2 – 3 years. Of course, with the unpredictability of constantly weather patters, that frequency could be more or less often.

4.6.2 Existing Vulnerability

4.6.2.1 Population

A broad spectrum of any community's population is vulnerable to the effects of winter storms. People who travel in winter storms are at the most risk. 70% of winter storm-related deaths occur in cars, more than the number of people caught out in the storm. The elderly are also at risk due to poor health and frequent isolation. People over 60 years of age account for half of all exposure-related deaths. According to NOAA, 50% of hypothermia cases occurred in people over the age of 60. In addition, more than 75% of all hypothermia victims were found to be male. Exhaustion and heart attacks caused by overexertion are also likely causes of winter storm-related deaths.

The City of Tulsa has four shelters providing refuge for the homeless population. During the December 2007 ice storm, all shelters were reporting operation at or above capacity. The homeless population is also a high-risk population to the effects of a severe Winter Event.

As witnessed to by the 26 winter storm events between 1998 and 2007 and the four Presidential Disaster Declarations for Tulsa County, the Tulsa area has a high vulnerability to winter storms. The City of Tulsa is vulnerable to a winter storm event, as are all future development areas.

4.6.2.2 Structures/Buildings

A direct threat to structures/buildings from a severe winter event would be excessive snow/ice accumulation onto flat / low grade sloped roofing surfaces. This would be especially true of older structures that were not constructed to withstand that type of stress. More indirect threats to structures/buildings would be from power outages causing interruption to heating (loss of supplies, food, sensitive equipment) and frozen water pipes (excessive flooding causing damage to interior and sensitive electronic equipment if pipes break) and; fires caused by power lines being torn away from structure or power surges as lost power is restored. During the peak period of the December 2007 Ice Storm, Tulsa Fire Department responded to more than 200 structure fires in 5 days.

4.6.2.3 Critical Facilities

During a winter event, all critical facilities in the Tulsa jurisdiction would be susceptible to the same potential effects. Power outages causing interruption of vital services and inaccessibility due to road closures or blockages from ice/snow accumulation or debris from damaged trees.

During the December 2007 ice storm, 3 of Tulsa hospitals were dependent on generator power for an extended time and a nursing home facility in Collinsville was forced to evacuate its 90 residents due to power outages. Additionally, only one Tulsa Police Substation had an operational fuel station. Tulsa Fire Department reported that 13 of their stations were without power (some without heat) and they were running low on oxygen bottles.

4.6.2.4 Infrastructure

Water Treatment – Most significant effect during a winter event would be from loss of electrical power, delays to chemical deliveries (road inaccessibility), personnel and staffing issues. Both of the City of Tulsa's water treatment plants would be vulnerable to these risks.

During the 2007 ice storm, the Mohawk Water Treatment Plant was offline for a period of approximately 4 days. Due to the severity of the storm, electrical power from both feeds to the plant was interrupted. The A.B. Jewell plant was able to provide water during the event and meet the baseline needs of the City. Due to widespread power outages in the City, the overall water demand was significantly reduced.

Wastewater Treatment – The most significant threat to the operation of Tulsa's 4 wastewater treatment plants during a winter storm would be power outages. All four plants and lift stations have either double feeds or generators. In the December 2007 ice storm no outages were reported at any of the four stations.

Utilities: Damage to utilities infrastructure can result in damages of up to $2 billion per winter storm event. The primary utility providers for Tulsa's jurisdiction is AEP/PSO (electricity) and ONG (natural gas). The service stations and substations for both of these providers would be vulnerable to the risks from a severe winter event.

Electricity - During a winter event, providers of electrical service could experience any combination of the following challenges in meeting the needs of the Tulsa jurisdiction: Destruction of distribution and transmission poles, downed broken power lines, staffing issues due to the inclement weather (some workers may not be able to get out of their homes), danger to workers derived from downed power lines, hazardous road conditions and fallen debris from trees or insufficient field and/or office staff to effectively handle the workload.

As a result of the December 2007 Ice Storm, AEP/PSO reported 226,500 customers without power (78% of their Tulsa customer base), 750-800 distribution poles broken, approximately 150 transmission poles broken and countless miles of power lines repaired/replaced. Additionally, 4,600 restoration workers were utilized (as opposed to 600 in normal operations) working 73,600 man-hours per day (4,600 workers putting in 16-hour days) with support staff handling more than 512,600 calls pertaining to the event.

Gas – During a winter event, providers of gas service to a community could experience a variety of challenges in meeting the needs of the Tulsa jurisdiction, including: damage to gas meters from ice accumulation, falling power lines or tree debris, inaccessibility to underground gas meters from falling debris, danger to field employees related to road conditions, downed power lines, extreme temperatures, insufficient field and/or office staff to effectively handle workload generated by such an event.

During the December 2007 Ice Storm, ONG reported that there were approximately 50 above-ground gas meters damaged due to power lines and falling tree debris; several underground meters inaccessible due to debris, and several instances where field employees had to practice extra caution while working in areas affected by downed electric lines and tree limbs. Fortunately, ONG reported that during that event there were no customer outages related to the storm.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – All manners of transportation would be at risk during a winter event in the Tulsa jurisdiction. Road closures due to ice/snow accumulation can result in loss of retail trade, wages and tax revenue. Such closures exceed $10 million/day in the eastern part of the country. The inability of public transportation (taxis, buses) to function after a winter event can also contribute to increased risk to the population if it hampers access to necessary medical care or safe shelter. Fortunately, Tulsa's public bus system (MTTA) experienced only minor disruptions in their operations during the December 2007 ice storm, and was able to provide essential services to the local Emergency Operations staff during the event.

Flight delays cost an average of $3.2 billion annually for air carriers in the United States. Severe winter weather could result in the interruption of normal operations at Tulsa's International Airport and the private business airports. Major ice or snow accumulations can impact runway safety and result in cancellation or major delays in regular flight schedules. December 2007's storm resulted in flights being cancelled by all airlines servicing TIA for 24+ hours. In addition to delaying the transportation of goods and materials in a timely manner on courier flights, passengers were stranded with no real timeline for resumption of services. The impassability of roads in the area pretty much isolated many stranded fliers at the airport for this time period.

Emergency Services- Fire, Police and Medical Services would all be vulnerable to the same potential affects of a Winter Storm event. Staffing issues due to the inclement weather (some workers may not be able to get out of their homes), danger to workers derived from downed power lines, hazardous road conditions and fallen debris from trees or insufficient field and/or office staff to effectively handle the workload would be expected in all areas.

Additionally, the fallen debris or impassable roads could potentially hamper effective response times for emergency calls and hazardous road conditions add to the risk of accidents for responders, therefore potentially reducing both fleet resources and manpower (injuries). During the December 2007 ice storm, Tulsa Police Department reported 11 cars damaged during the event.

4.6.3 Winter Storm Scenario

4.6.3.1 Overview

The Eastern portion of Oklahoma experienced two major winter storm events in 2007. The first occurred in January, hitting Muskogee and surrounding counties the hardest. The second came in December of the same year wreaking havoc on holiday planning all across Oklahoma, but greatly impacting the Tulsa area. Both of these events resulted in an Emergency Declaration issued by the Governor of Oklahoma for all 77 counties in the state. The major effect of both storms was widespread and prolonged power outages. These outages had a profound impact on the residential and business communities alike.

The response phase of the January 2007 winter event was longer in duration than that in December – attributed greatly to the lower temperatures during and immediately following the precipitation. More roads were inaccessible longer, smaller surrounding communities experienced severe potable water issues due to power outages at pump stations, and persons affected sought shelter outside their homes longer.

Daytime temperatures during and after the January event struggled to stay at or near freezing, with nighttime temperatures dipping into the teens and twenties for several days. The December event experienced many different circumstances as daytime temperatures remained well above freezing with nighttime temperatures remaining somewhat steady in the upper twenties to lower thirties. The robust daytime temperatures in that event are credited for clearing roadways and power lines of ice allowing recovery to begin much more quickly.

The very fact that the first storm affected a largely rural/small community area of Oklahoma and the second storm affected a largely metropolitan area make it difficult to compare these two events. However, by applying key assumptions such as (a) Equivalent Temperature Conditions, (b) Equivalent Ice Accumulations, and (c) Equivalent Resource Response, some very basic correlations between the Muskogee/January event and the Tulsa/December event may be made. Many Tulsa officials have discussed the potential ramifications of an event as widespread and geographically located as the December storm occurring in the same temperature conditions as the January storm. All agree that the frigid nighttime and lower daytime temperatures in January hampered the ability of the communities affected to recover from the damage – a challenge that Tulsa was not faced with.

In an effort to examine the potential effect of conditions similar to those in the Muskogee area on the City of Tulsa, an analysis of key points of data was performed and applied to the base information from Tulsa's event. Data utilized for this analysis was gathered from Daily Situation Reports from the State of Oklahoma Department of Emergency Management, the NOAA National Climatic Data Center and the National Weather Service Forecast Office. The SitReps reviewed for the Muskogee event provided data for 11 days – so this time frame was applied to the scenario.

4.6.3.2 Summary of Muskogee Event – January 2007

SitReps including information for the Muskogee area began on January 13th with an initial reporting of 11,095 customers without power, and concluded with a final report on January 23rd showing 92 customers still without power. The rate of restoration throughout that reporting period (based on daily SitReps) as a percentage has been calculated and is demonstrated on the table below.

Table 4–26: Summary of Muskogee Event – January 2007
Source: National Climatic Data Center

Date	Daily High	Daily Low	Customers Without Power	% increase / decrease restoration
13-Jan	41	25	11,095	--
14-Jan	30	25	10,062	-9.31%
15-Jan	31	24	8,587	-14.66%
16-Jan	26	16	9,156	6.63%
17-Jan	21	16	9,277	1.32%
18-Jan	30	20	9,039	-2.57%
19-Jan	33	22	7,267	-19.60%
20-Jan	40	23	6,497	-10.60%
21-Jan	38	32	3,564	-45.14%
22-Jan	37	31	322	-90.97%
23-Jan	35	19	92	-71.43%

Oklahoma Highway Patrol reported nearly 700 motor vehicle accidents (injury/non-injury/fatal) over that period across the state. 19 fatalities were attributed to traffic accidents. Oklahoma Department of Transportation discouraged travel on many roadways due to the presence of "black ice". ODOT resumed normal operations on January 21st.

There were 8 fatalities related to hypothermia, 2 smoke inhalation and 3 related to falls, bringing the statewide total to 32. Oklahoma State Department of Health reported that nearly 4,000 people were treated at Oklahoma hospitals for various injuries related to winter storm conditions.

On January 21st, the American Red Cross reported 4,742 overnight stays in the various Shelters established throughout the state for this event. Assuming shelters began operating on the night of January 12th and ran through the night of January 20th, this would equate to an average of approximately 526 shelter residents per night. Many of those without power and heat chose to remain either at their own home or the home of a family member/friend, sighting their fear of looting as a primary reason. The Red Cross and the Salvation Army served approximately 70,000 meals through mobile and fixed feeding sites.

Prolonged freezing temperatures created a largely undocumented side effect – ruptured water lines. Many older, less insulated homes experienced frozen water lines that, left untended for several days, burst as they began thawing out. Depending on where the breaks occurred, this could cause anywhere from minimal to catastrophic damage to a residence. No official data providing insight to this damage has been made available to date.

4.6.3.3 Summary of Tulsa Area Event – December 2007

The first SitRep reporting customer power outages for Tulsa was issued on December 10th with a total of 75,000 customers without power, however as precipitation continued to fall, that number rose to 225,769 on the following day's report. For the purpose of this scenario, the December 11th report will serve as the starting point. On December 21st, the SitRep stated that power had been restored to all structures that could safely receive power. Table 4-27 below demonstrates that Rate of Restoration.

For the duration of this event, the daytime temperatures did not dip below freezing – and actually were reported in the upper 50's / lower 60's within one week. This aggressive warming trend contributed greatly to the elimination of ice accumulation on streets, power lines, and trees – thus allowing the recovery phase to begin very quickly. Crews were able to begin almost immediately on the clearing of toppled trees and broken/downed power poles/lines.

Twenty-nine fatalities were reported in the store for this event – 16 were related to motor vehicle accidents, 9 to house fires, 2 to carbon monoxide poisoning and 2 to hypothermia. One injury was reported in the SitReps, a lineman that was injured on duty and required hospitalization.

Table 4–27: Summary of Tulsa Area Event – December 2007
Source: National Climatic Data Center

Date	Daily High	Daily Low	Customers Without Power	% increase / decrease restoration
11-Dec	36	32	225,769	--
12-Dec	*35*	*32*	178,507	-20.93%
13-Dec	*34*	*31*	169,724	-4.92%
14-Dec	*41*	*30*	81,000	-52.28%
15-Dec	*38*	*25*	62,454	-22.90%
16-Dec	*44*	*20*	42,145	-32.52%
17-Dec	*55*	*25*	30,205	-28.33%
18-Dec	*56*	*35*	8,344	-72.38%
19-Dec	*62*	*27*	2,000	-76.03%
20-Dec	*61*	*36*	1,000	-50.00%
21-Dec	*65*	*31*	--	-100.00%

Shelter populations for this event were much greater. The American Red Cross reported shelter population for the state at over 2,000 the night of December 11th, 860 on the 17th, 30 the night of the 19th with all shelters closed the following day. The average for that time period is 1,836 shelter residents per night. But as noted above, the shelter populations fell off drastically in the last three days of operation.

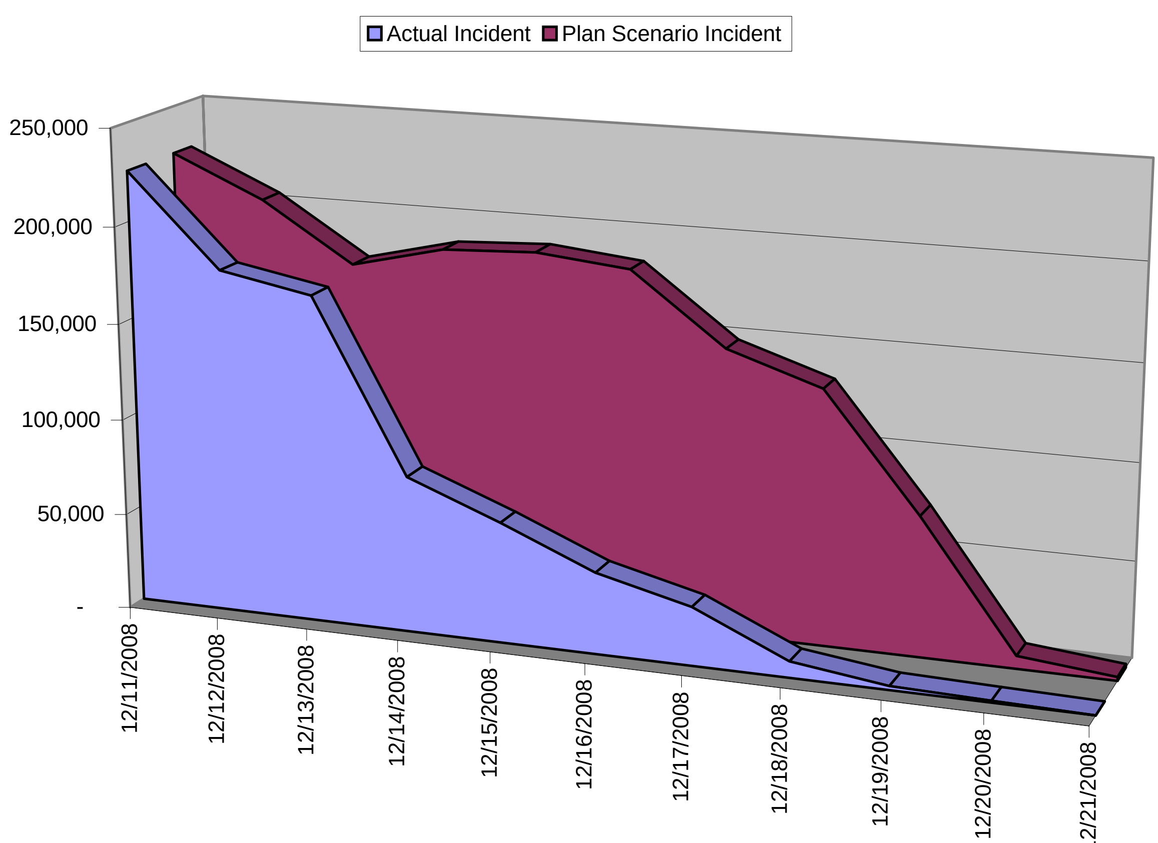
4.6.3.4 Introduction to Proposed Scenario

By applying the Rate of Restoration determined for the Muskogee/January event to the initial number of affected customers for the Tulsa/December event, a comparison of certain Economic Values can be determined. A chart demonstrating the differences between the Actual Tulsa Rate of Restoration to the Scenario Rate of Restoration is below.

What this demonstrates is that under the proposed conditions, the number of customers without power is higher, longer. For the 11 days used in this analysis, the Actual Tulsa reported outages averaged 72,832 customers/day without power. For the same time period under the Scenario Rate, the average increases to 138,664 customers/day without power.

This can be translated in to an Economic Value of Loss of Utilities by using the formula provided by "What is a Benefit", a valuation tool utilized by planners and analysts across the country. The National Average for the cost of utilities (at time of publication) is $6.74 per kilowatt hour (kwh). Each day without utility service represents 24kwh – so by multiplying the number of customers without power by 24, and that number by the rate of $6.74, you will arrive at the Value of the Loss of Utilities for any given day.

December 2007 Ice Storm Scenario



The same comparison can be made regarding the Economic Value of the Interruption of

Daily Activities. When people have been affected by any disaster, there are scores of tasks and chores to be dealt with. Evacuation; cleanup of damaged property; meeting with insurance representatives, emergency officials, social service agencies, etc; arranging alternate daycare schedules, transportation schedules for work/school, etc. The time utilized for dealing with these issues is classified as "time lost". This "time lost" is valued at $21.16 per person, per day. For the purposes of this comparison, the total number of *customers* vs the total number of individuals, and 12-hour days were used in the formula[3]. By multiplying the number of customers without power by 12, and that number by $21.16, you will arrive at the Value of Interruption of Daily Activities.

The following chart provides comparisons between the Actual and Scenario Economic Values for both of these categories.

Table 4–28: Actual vs. Projected Economic Losses for Tulsa Winter Storm Scenario

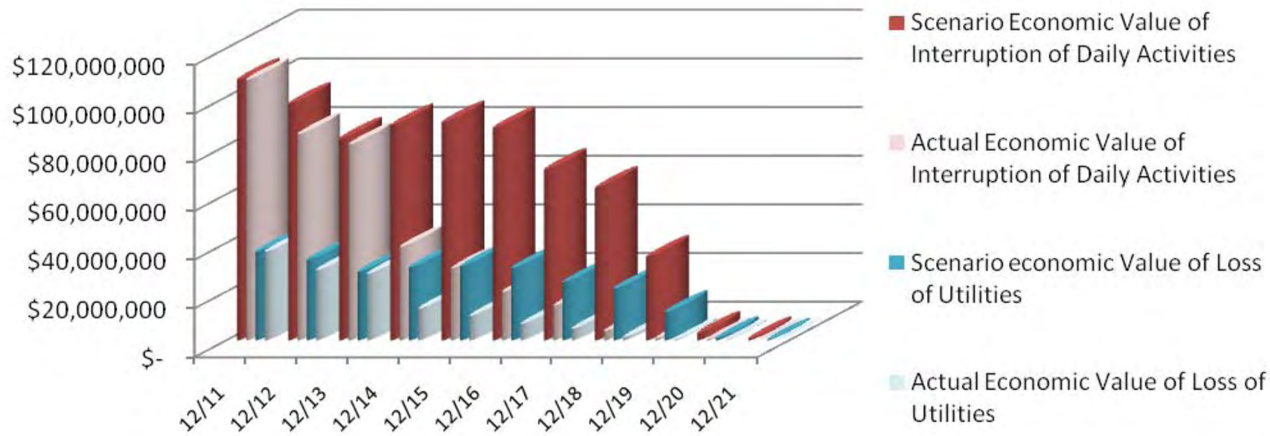
Scenario Event Economic Values				Tulsa Actual Event Economic Values		
Dates	Customers	Economic Value of Loss of Utilities ($6.74/kwh)	Economic Value of Interruption of Daily activities ($21.16/ customer/ hr - 12hrs)	Customers	Economic Value of Loss of Utilities ($6.74/kwh)	Economic Value of Interruption of Daily activities ($21.16/ customer/hr – 12 hrs)
11-Dec	225,769	$36,520,393.44	$107,156,696.04	225,769	$36,520,393.44	$107,156,696.04
12-Dec	204,750	$33,120,344.81	$ 97,180,407.64	178,507	$28,875,292.32	$ 84,724,742.28
13-Dec	174,734	$28,264,902.26	$ 82,933,759.88	169,724	$27,454,554.24	$ 80,556,068.72
14-Dec	186,318	$30,138,865.28	$ 88,432,268.16	81,000	$13,102,560.00	$ 38,445,014.06
15-Dec	188,778	$30,536,698.30	$ 89,599,574.10	62,454	$10,102,559.04	$ 29,642,529.73
16-Dec	183,926	$29,751,905.16	$ 87,296,865.04	42,145	$ 6,817,375.20	$ 20,003,273.06
17-Dec	147,877	$23,920,531.75	$ 70,186,679.49	30,205	$ 4,885,960.80	$ 14,336,193.21
18-Dec	132,202	$21,384,955.38	$ 62,746,891.47	8,344	$ 1,349,725.44	$ 3,960,311.08
19-Dec	72,526	$11,731,786.52	$ 34,422,944.66	2,000	$ 323,520.00	$ 949,259.61
20-Dec	6,549	$ 1,059,380.32	$ 3,108,391.90	1,000	$ 161,760.00	$ 474,629.80
21-Dec	1,871	$ 302,664.96	$ 888,067.57	-	$ -	$ -

4.6.3.5 Conclusions / Additional Considerations

These comparisons are just two of the many areas to consider in this type and scope of event. But looking at these numbers, there is an increase of 47% in Economic Value under the scenario utilizing a prolonged Rate of Recovery. Some other considerations would include:

- With lower temperatures prevailing for 4 days or more, clearing of fallen trees would have been delayed. This could trickle down to the delay of accessibility to

[3] *In the absence of a confirmed number of businesses vs households affected, accurate numbers of individuals affected are difficult to assess for both locations. Additionally, as most affected individuals returned to their homes at night for the larger portion of the analysis time, it was felt that interruptions to nighttime activities were at a minimum*



homes for wellness checks. Many homebound, elderly, socially isolated individuals were unable/unwilling to leave their homes. First responders were able to go door-to-door to check on these residents – thus ensuring their wellbeing and their awareness of possible resources for shelter and meals almost immediately after the December storm passed. Not being able to address this critical service in such an expeditious manner could potentially result in a higher fatality rate due to exposure.

- Without the warmer daytime temperatures melting the ice so quickly, more damage to trees and power lines/poles could occur. Again, this could create secondary effects of larger numbers structures damaged, power outages lasting even longer, greater numbers of injuries caused by falling debris, more house fires (more trees down translates to more power lines pulled from structures which leads to greater potential for power surges during the restoration process), etc.
- Under actual conditions, residents of Tulsa were able to travel to nearby convenience stores to obtain daily food and supplies, and to intermingle with others similarly affected…a true benefit to a community dealing with such a widespread crisis. With bitter temperatures prevailing at night, with near/below freezing temperatures during the day, streets and sidewalks would have become impassable for several days. This would have effectively isolated many residents in their homes. Aside from the impact of not being able to get out to care for basic needs, stress from that isolation would have settled in on an already stressed population.
- Additionally, those very same retail outlets would have experienced a further economic blow from a reduced customer flow. The Chamber of Commerce reported that 50% of the Tulsa businesses surveyed after the ice storm reported power outages. The median length of service interruption was 4.5 days, resulting in an average of $5,100 lost in income. Again, larger numbers affected for longer times would be experienced with lower temperatures. This of course would translate into more businesses reporting larger losses.

4.6.4 Future Trends

For a map of Tulsa's potential future development areas, see Figure 1-13

4.6.4.1 Population

Increasing energy costs combined with the increase in cost of basic necessities will continue to put a strain on those in the jurisdiction already struggling to take care of their most basic needs. A steadily increasing population relying on fixed incomes could very easily translate into an increasing population unable to provide heat for their homes in times of severe winter weather.

Additionally, more and more elderly are choosing to remain in their homes rather than move into assisted/progressive living situations – many of them with some type of special needs that may be exacerbated during such an event. Any populations with special needs will require additional planning considerations.

4.6.4.2 Structures/Buildings

All residential, commercial and industrial buildings added to the city's inventory should take certain planning precautions. For all new construction, attention to the placement of trees and large shrubs is necessary to reduce the risk of power line interference. Burying of electrical power lines when possible is most favorable. Commercial and industrial projects should include adequate backup power systems to protect critical equipment and data storage.

4.6.4.3 Critical Facilities

All considerations for Structures/Buildings above apply equally, if not more so, to critical facilities. Several mitigation measures included in this plan address the issue of power outages at City of Tulsa fueling stations and water/wastewater plants. In addition, due to the extremely widespread power outages in December of 2007, this plan includes a mitigation measure addressing the development of a Comprehensive Master Generator Plan which reviews the capabilities of all City facilities, their necessity in the response and recovery process, their current capabilities to keep up and running during an extended power outage, and the costs of retrofitting them to a workable level.

4.6.4.4 Infrastructure

Since many new residential subdivisions are including buried power lines as part of their planning, it is hopeful that this mitigation measure will produce a measurable effect on future winter storms in currently undeveloped areas.

4.6.5 Conclusions

Due to the rich, moist atmosphere present in Tulsa, the entire jurisdiction should expect to be repeatedly affected by winter events. The degree of severity is dependant greatly on the temperature fluctuation between daytime and nighttime, and the duration of any extreme temperature conditions. The vulnerability to Winter Storms in the Tulsa area is considered High.

4.6.5.1 Data Limitations

Data kept by the National Climatic Data Center cannot separate out geographically the effects of winter storms that may encompass an extremely wide area. With that in mind, casualties, damages, and the effects of historic events are frequently aggregate numbers for storms that extend outside the geographical boundaries of the designated area.

4.6.5.2 Update Changes

Identified significant changes made from the 2003 City of Tulsa Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the *Local Multi-Hazard Mitigation Planning Guidance* document of July 1, 2008.

4.6.5.3 Sources

Tulsa Tornado Tribune (Spring '08) at www.srh.noaa.gov/tsa/tribune/Spring08.pdf

Northeast States Consortium at www.nesec.org/hazards/winter_storms.cfm

National Weather Forecast Office at www.wrh.noaa.gov/otx/safety/winter.php

NOAA Economics (The Economics and Social Benefits of NOAA Data & Products – Research paper by Adams et al., 2004 on Economic Costs of Snowfall in U.S.

FEMA Fact Sheet: Winter Storms, p. 30. Federal Emergency Management Agency, March 1999.

Information on Federally Declared Disasters, "Ice Storm Disaster Aid Reaches $122 Million," at Web address: www.fema.gov./diz01/d1355n23.htm. Federal Emergency Management Agency.

Oklahoma Department of Emergency Management Update on Federally Declared Disasters at Web address: www.odcem.state.ok.us/.

King County Office of Emergency Management, "Severe Local Storms," at Web address: www.metrokc.gov/prepare/hiva/storm.htm. Office of Emergency Management, King County, Washington.

Marler, J.W. "About 250,000 in State Still Without Electricity," *Tulsa World*, February 1, 2002.

Multi-Hazard Identification and Risk Assessment, p. 76–81. Federal Emergency Management Agency, 1997.

Myers, Jim. "FEMA head adds counties to aid list," *Tulsa World*, February 8, 2002.

NCDC Storm Event Database, at Web address: www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms. National Climatic Data Center.

National Weather Service: Office of Climate, Water, and Weather Services, at Web address: http://www.nws.noaa.gov/om/hazstats.shtml.

Oklahoma Strategic All-Hazards Mitigation Plan, "Hazard Identification and Vulnerability Assessment," p 5. Oklahoma Department of Emergency Management, September 2001.

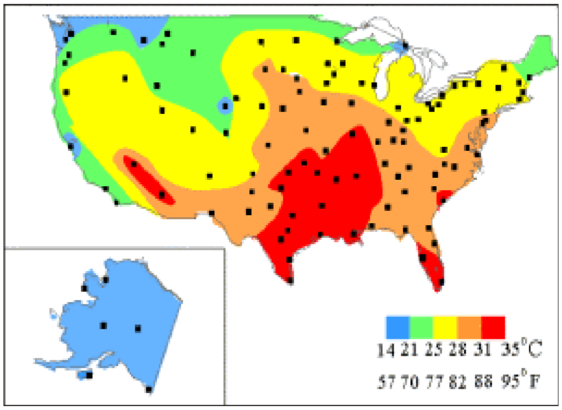
Wack, Kevin. "Prepare for Deep Powder," *Tulsa World*, February 3, 2002.

Winter Storms…The Deceptive Killers, National Oceanic and Atmospheric Administration, December 2001.

4.7 Extreme Heat

Extreme summer weather is characterized by a combination of very high temperatures and exceptionally humid conditions. A heat wave occurs when such conditions persist over long periods. A lack of nighttime cooling can exacerbate the conditions when community infrastructure fails to release ambient heat increases gained during the day.

The City of Tulsa has experienced major heat waves 3 times in the past 10 years: in 2001, 2006 and 2007. Extreme heat impacts the entire population of Tulsa and can be expected every summer. The population at most risk to extreme heat is the 12.9% of the Tulsa population aged 65 and above, the 20.2% of the population classified as low income, and that segment of the population that works outdoors. Property damage is also possible, but damage due to extreme heat is minimal.



Tulsa County's average high temperature in July is 94° Fahrenheit

4.7.1 Hazard Profile

Each year in the United States, the cause of death for approximately 200 people is listed as heat-related[4], although some estimates of heat-attributable mortality run as high as 1,000 per year. Despite the history of adverse effects, there is consensus that most of these deaths are preventable. Extreme summer temperatures are also hazardous to livestock and crops, can cause water shortages, increase fire hazards, and prompt excessive demands for energy. Even roads, bridges, and railroad tracks are susceptible to damage from extreme heat.

Human bodies dissipate heat by varying the rate and depth of blood circulation and by losing water through the skin and sweat glands. Perspiration is about 90% of the body's heat dissipating function. Sweating, by itself, does nothing to cool the body unless the water is removed by evaporation. High relative humidity retards evaporation, so under conditions of high temperature (above 90° Fahrenheit) and high relative humidity, the body is pressed to maintain an internal temperature of 98.6° Fahrenheit. When heat gain exceeds what the body can remove, or when the body cannot compensate for fluids and salt lost through perspiration, the temperature of the body's inner core begins to rise and heat-related illness may develop.

Heat also affects local workforce capabilities. Workers exposed to these elements must be monitored for heat exhaustion and heat stroke.

Heat-related illnesses can include the following:

[4] In most communities in the United States, the cause of death is listed as "heat-related" when the body core temperature is determined to have been above 105° Fahrenheit at the time of death. In recent years, some communities have adopted a broader criterion, declaring a heat-related death when a body is found "in an enclosed environment with a high ambient temperature without adequate cooling devices and the individual had been known to be alive at the onset of the heat wave." When the City of Philadelphia adopted the more general standard, reported heat-related deaths jumped from 20 in 1991 to 105 in 1993.

- **Heat Cramps**: muscular pains and spasms due to heavy exertion. They usually involve the abdominal muscles or legs. It is generally thought that the loss of water from heavy sweating causes the cramps.
- **Heat Exhaustion**: typically occurs when people exercise heavily or work in a warm humid place where body fluids are lost through heavy sweating. Blood flow to the skin increases, causing blood flow to decrease to the vital organs. This results in a form of mild shock. The skin will be cool and moist, and could appear to be either pale or flushed. The victim may have a headache and/or be suffering from nausea. There may also be some dizziness.
- **Heat stroke**: the most serious heat emergency. It is life threatening. The victim's temperature control system, which produces sweating to cool the body, stops working. The body temperature can rise so high that brain damage and death may result if the body is not cooled quickly.

Another extreme heat hazard is air pollution. During the summer months, consistent high temperatures and stagnant airflow patterns cause a build-up of hydrocarbons to form a dome-like ceiling over large cities. The abundance of factories, automobiles, lawn equipment, and other internal combustion machines emit high particulate matter that builds and worsens with the increase in temperature. The resulting stagnant, dirty, and toxic air does not move away until a weather front arrives to disperse it.

When the particulate matter reaches a pre-determined level, cities issue ozone alerts and implement measures to reduce the use of cars and the output of the offending chemicals. Ozone alerts usually include advisories for the elderly and those with breathing difficulties to stay indoors in air-conditioned environments.

Damage to property during extreme heat is more a factor of expanding and contracting soil and is covered in the section, "Expansive Soils."

Measurements

The Heat Index and Heat Disorders table relates index ranges with specific disorders, particularly for people in the higher risk groups. The heat index illustrates how the human body experiences the combined effects of high temperature and humidity. It more accurately reflects what the body experiences than simply measuring the air temperature. For example, when the air temperature is 98° Fahrenheit and the relative humidity is 50%, the human body experiences the discomfort and stress equivalent to 113° Fahrenheit with no humidity.

Relative Humidity (%)

Heat Index (Apparent Temperature)

Air Temperature (°F)	40	45	50	55	60	65	70	75	80	85	90	95	100
110	136												
108	130	137											
106	124	130	137										
104	119	124	131	137									
102	114	119	124	130	137								
100	109	114	118	124	129	136							
98	105	109	113	117	123	128	134						
96	101	104	108	112	116	121	126	132					
94	97	100	102	106	110	114	119	124	129	136			
92	94	96	99	101	105	108	112	116	121	126	131		
90	91	93	95	97	100	103	106	109	113	117	122	127	132
88	88	89	91	93	95	98	100	103	106	110	113	117	121
86	85	87	88	89	91	93	95	97	100	102	105	108	112
84	83	84	85	86	88	89	90	92	94	96	98	100	103
82	81	82	83	84	84	85	86	88	89	90	91	93	95
80	80	80	81	81	82	82	83	84	84	85	86	86	87

With Prolonged Exposure and/or Physical Activity

- **Extreme Danger** – Heat stroke or sunstroke highly likely
- **Danger** – Sunstroke, muscle cramps, and/or heat exhaustion likely
- **Extreme Caution** – Sunstroke, muscle cramps, and/or heat exhaustion possible
- **Caution** – Fatigue possible

Extent of Impact

The extent of the hazard is largely dependent on the weather conditions occurring across the jurisdiction. High heat events typically will not affect property as adversely as it will vulnerable populations, such as outdoor laborers, the elderly, and low-income populations of the jurisdiction. The extent of an extreme heat hazard can be mitigated by notifications and warnings to vulnerable populations, the establishment of cooling rooms, utility cost assistance programs, backup electric generation for critical facilities, Medical Reserve Corps training, and similar measures.

4.7.1.1 Location

Sustained high temperatures are a hazard that impacts the entire jurisdiction of the City of Tulsa, but particularly the aged, the poor, the obese, those with heart problems, and people who work out of doors. See Figures 1-5 and 1-6 for demographic data on locations of elderly and low income in the City of Tulsa.

4.7.1.2 Extent (Magnitude/Severity)

Over the past ten years, the average high temperature for July and August in the Tulsa area has been 94 degrees F with an average humidity of 56%, which puts the area in the "Extreme Caution" category on the National Weather Service (NWS) Heat Index scale, without factoring in relative humidity.

Sustained high temperatures are a hazard that impacts the entire community, but particularly the aged, the poor, the obese, those with heart problems, and people who work out of doors. The impact of the extreme heat hazard can be mitigated by notifications and warnings to vulnerable populations, the establishment of cooling rooms, utility cost assistance programs, backup electric generation for critical facilities, Medical Reserve Corps training, and similar measures.

4.7.1.3 Frequency

Tulsa has experienced major heat waves five times in the past 14 years: in 1994, 1996, 2001, 2006 and 2007. Based on this limited data, sustained periods of temperatures above 100 degrees Fahrenheit can be expected on the average of once every 3 years.

4.7.1.4 History/Previous Occurrences

In Oklahoma, July is generally the hottest month of the year, closely followed by August. The NWS compiled a 106-year record of monthly and annual average temperatures in Oklahoma, and the dust bowl years of 1921, 1931, and 1936 show the highest average temperatures across a 12-month period for the past 100 years.

In the 40-year period from 1936 through 1975, nearly 20,000 people were killed in the United States by the effects of heat. In the summer of 1936, temperatures across two-thirds of the United States rose well above 110 degrees Fahrenheit, and to as high as 121 degrees in some places. The heat wave lasted for 13 days, killing about 5,000 people in the U.S., and nearly 800 in Canada. In the disastrous heat wave of 1980, more than 1,250 people died.

A 1988 drought and heat wave affecting the central and eastern United States caused approximately $40 billion in livestock and crop damage. Another in 1993 in the southeastern United States caused approximately $1 billion in livestock and crop damage and an undetermined number of deaths.

In July 1998, a blistering heat wave struck the south-central part of the nation – including much of eastern Oklahoma – causing five heat-related deaths. A drought also accompanied the heat wave in southeast Oklahoma, combining with the heat to cause devastating crop damage.

The Central Plains and Corn Belt States experienced a heat wave July 11 through 19, 1995, when temperatures climbed above 120° Fahrenheit. A significant portion of the Eastern States was in the danger category during the same period, with temperatures ranging from 105° to 120° Fahrenheit. This heat wave caused 670 deaths, 465 of them in the City of Chicago alone.

In July 1998, a blistering heat wave struck the south-central part of the nation – including much of eastern Oklahoma – causing five heat-related deaths. A drought also accompanied the heat wave in southeast Oklahoma, combining with the heat to cause devastating crop damage.

During 2005-2006, Oklahoma experienced the worst drought in its history—a result of months of high temperatures and low precipitation. One result was a record number of wildfire outbreaks (see Section *4.8 Drought* and *4.10 Wildfire*, below).

The table below shows that 62 deaths resulted from extreme heat episodes from 1995 to 2005 in Oklahoma compared with 2,504 deaths in the United States. The table also illustrates the percentage of fatalities in the United States that were people over 60 years of age.

Table 4–29: Deaths from Extreme Heat
From NOAA National Climatic Data Center Annual Summaries

Year	Oklahoma	United States	Over 60, US
1995	0	1,021	73%
1996	10	36	84%
1997	0	81	65%
1998	24	173	68%
1999	10	502	67%
2000	5	158	68%
2001	9	166	62%
2002	0	167	52%
2003	3	36	61%
2004	0	6	50%
2005	1	158	56%
Totals	**62**	**2,504**	**68.2%**

Tulsa and Tulsa County Extreme Heat Events

Tulsa has experienced extreme heat on five occasions since 1993: in 1994, 1996, 2001, 2006 and 2007.

June 27, 1994 – Temperatures climbed to above 110 degrees in southwest Oklahoma with reading in excess of 100 in northwest and central Oklahoma during the afternoon hours on June 27. The high temperature of 120 degrees from the Oklahoma Mesonet four miles south of Tipton tied the record for the highest temperatures ever recorded in the state. In Tulsa, temperatures were in triple-digits for over 10 days.

July 1-7, 1996 – High temperatures topped 100 F in central Oklahoma through the first week of July. During this prolonged period of hot temperatures, seven deaths were attributed to the excessive heat. All of the victims were elderly and all but one were in their homes without air conditioning. One of the deaths was a 67-year-old man in Cushing in Tulsa County.

July 6, 2001 – An extended period of excessive heat affected all of western and central Oklahoma in July. Most areas regularly experienced high temperatures at or above 100 degrees, particularly western and north central Oklahoma. Eight fatalities resulted from the heat. A 78 year-old male died July 6th in Tulsa while loading equipment at a storage facility.

July-August, 2006 – Temperatures reached above 100 F starting in mid-July and continued through the middle of August. Many locations at times reached 105 degrees of greater with higher heat index values. The heat caused 10 fatalities across the area during this time period.

August, 2007 – Humidity as a result of the spring rains continued well into the summer and increased the danger from the temperatures. The combination of heat and high humidity resulted in daytime heat index values from 105 to 113 degrees across much of eastern Oklahoma. Two men died in Tulsa as a direct result of the heat. Two hundred other people were treated by EMS in Tulsa for heat related illnesses. Many of those victims were in attendance at the PGA Championship.

4.7.1.5 Probability/Future Events

It is a given that extreme heat will continue to be a vulnerability for the residents of Tulsa. Due to aggressive heat plans in the City/County of Tulsa Emergency Operations Plan, the impact of these heat waves has been greatly reduced. The impact of future event will be directly related to the continuation of this aggressive program, and other mitigation measures that may be incorporated into the community to reduce the effect of the urban heat island, particularly in central Tulsa.

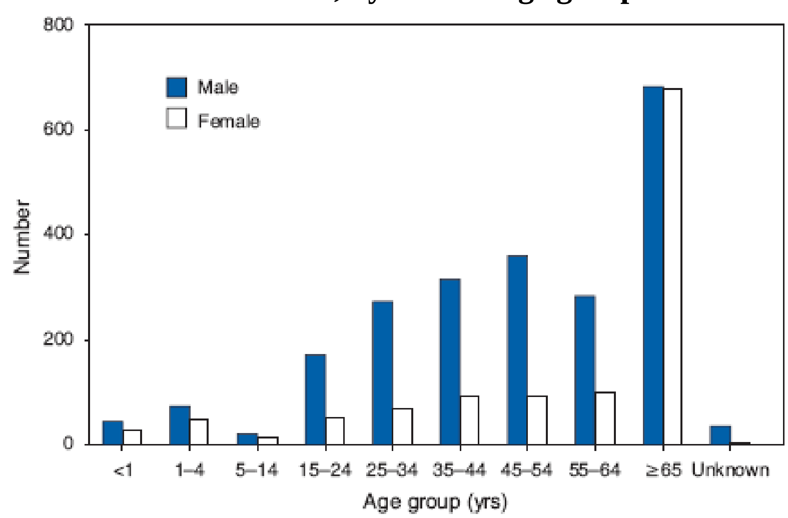
4.7.2 Existing Vulnerability

4.7.2.1 Population

Every person is subject to health problems during a heat wave. However, the following groups are more likely to suffer:

- Elderly (65 years of age or older)
- Infants (under 1 year of age)
- Homeless
- Low income
- People who are socially isolated
- People with mobility restrictions or mental impairments
- People taking certain medications (i.e., high blood pressure, insomnia, etc.)
- People engaged in vigorous physical exercise or outdoor labor
- People under the influence of drugs or alcohol

Figure 4-15: Number of heat-related deaths, by sex and age group – United States, 1999-2003



*** Exposure to extreme heat is reported as the underlying cause of or a contributing factor to death.**

In general, the poor and elderly populations of a community are less able to afford high utility bills and air conditioning units, leaving them with an increased vulnerability to extreme heat events. Another segment of the population at risk are those whose jobs consist of strenuous labor outside exposed to high temperatures and humidity.

Studies indicate that, all things being equal, the severity of heat disorders tend to increase with age. Sweating is the body's natural mechanism for reducing high body temperature, and the body temperature at which sweating begins increases with age. Therefore, heat cramps in a 17-year-old may become heat exhaustion in a person who is 40 and heat stroke in a person over 60. The following chart, from the Center for Disease Control's Morbidity & Mortality Report for July 2006, demonstrates vulnerability created by age.

More deaths from extreme summer weather occur in urban centers than in rural areas. The masses of stone, brick, concrete, and asphalt that are typical of urban architecture absorb radiant heat energy during the day and radiate that heat during what would be otherwise cooler nights. This phenomenon is referred to as the "heat island effect." Tall buildings may effectively decrease wind velocity, thereby decreasing the contribution of moving air to evaporative and convective cooling.

The average high temperature in Tulsa for July is 93.6° Fahrenheit, with an average afternoon humidity of 56%. This calculates to a heat index of 106° Fahrenheit, putting the area in the "Danger" category on the National Weather Service (NWS) Heat Index scale. This indicates that with prolonged exposure and/or physical exertion, heat related maladies are likely. Therefore, the City of Tulsa is vulnerable to extreme heat on a yearly basis. This is especially true of the 12.9% of the population of Tulsa aged 65 and above and the 20.2% of the population living in poverty. All future development areas are also at risk from extreme heat events.

4.7.2.2 Structures/Buildings

During an extreme heat event, it is likely to be hotter in cities than in surrounding rural areas, especially at night. Temperatures typically rise from the outer edges of the city and peak in the centre. This phenomenon is referred to as the 'Urban Heat Island' (UHI) and its impact can be significant. A range of factors varies between rural and urban areas and contributes to the UHI – for example:

- **Thermal properties** of building and road materials, the height and spacing of buildings and air pollution levels. These factors result in more of the sun's energy being captured, absorbed and stored in urban surfaces compared to rural surfaces during the day and a slower loss of this energy at night, thus resulting in comparatively higher air temperatures.
- **Less evaporation and shading**, with the consequent reduction in associated cooling, takes place in the typically drier urban areas as there is less vegetation.
- **Greater inputs of heat** as a result of the high density of energy use in cities. All this energy, for example from buildings and transport, ultimately ends up as heat.

Strategic planning is therefore required which takes account of the above factors, particularly in the context of climate change. At a local scale these include the modification of surface properties, for example, 'cool roofs', 'green roofs' and 'cool pavements'. Planting trees and vegetation and the creation of green spaces to enhance evaporation and shading are other options, as temperatures in and around green spaces can be several degrees lower than their surroundings.

4.7.2.3 Critical Facilities

Critical Facilities would face the same issues as other structures and buildings above. In addition, a great many city facilities, such as City of Tulsa recreation centers, may be designated as cooling centers for vulnerable neighborhoods. As such, these facilities need to include this ability in their plans.

Of especially high vulnerability would be the medical care and long-term care facilities. During an extreme heat event, power outages are not uncommon. While the larger medical treatment facilities in the City are supplied with dependable, redundant generator backup systems, an alarming number of long-term care / nursing home facilities are not. In July 2006, a Grove area nursing home was forced to evacuate 84 patients when power at the facility failed. Temperatures in parts of the state ranged from 101 – 109 at that time.

4.7.2.4 Infrastructure

Water Treatment – Water demand during extreme heat increases significantly. Demand could possibly exceed treatment capacity. City Ordinance is in place to restrict outdoor and non-essential water use during drought or in times of emergency.

Given that extreme heat conditions also increase the demand for electricity, power outages could be a potential secondary effect. However, the water treatment plants are a high priority customer and would not be impacted by planned rolling outages.

Wastewater Treatment – The most significant threat to the operation of Tulsa's 4 wastewater treatment plants during an extreme heat would be power outages. All four plants and lift stations have either double feeds or generators, so it is not anticipated that this would pose a threat to wastewater systems.

Utilities: The primary utility providers for Tulsa's jurisdiction are AEP/PSO (electricity) and ONG (natural gas).

Electricity - During extreme heat, providers of electrical service could experience any combination of the following challenges in meeting the needs of the Tulsa jurisdiction: Failure of vital delivery components due to exposure to high heat and/or excessive/ simultaneous demand of supply or insufficient field and/or office staff to effectively handle the workload.

During typical workweek schedules, it has been noted that demand for electrical power spikes in the hours of 4-7pm as workers are returning to their homes and adjusting thermostats accordingly. This results in an overwhelming demand placed on power station and transformer components sometimes resulting in power outages across the jurisdiction.

Gas – No significant vulnerabilities in the delivery of natural gas supply during extreme heat events have been reported.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Increase in passengers utilizing the City's public transportation system (MTTA) as a method of staying out of the heat during peak heat danger hours is expected as part of the City's heat alert process.

Emergency Services- Fire, Police and Medical Services would all be similarly at risk to the effects of an Extreme Heat Event. Fire and Medical Services typically receive a higher volume of heat-related call requests, therefore taxing the response capabilities of both services. Fire and Police services could be considered at risk to secondary effects of this type of event due to the added physical stressors of working in extreme heat events. While not an immediate threat to delivery of these services, the demand for additional personnel to affect an effective response could potentially increase the cost for these resources.

4.7.3 Heat Scenario

During the summer of 1980, the state of Oklahoma was one of several states heavily impacted by a major heat wave. Across the United States, reported heat-related fatalities exceeded 1,700. In Oklahoma, 37 such fatalities were reported, with 12 of those from the city of Tulsa. Eight of those fatalities were Tulsa residents, the other four were individuals overcome/injured by the extreme heat and transported to Tulsa where they passed away. The ages of the eight Tulsa residents ranged from fifty-four years of age to eighty-seven – 50% were over the age of sixty-five.

Between June 25th and September 19th that year, Tulsa International Airport reported 58 days with temperatures reaching 100 degrees Fahrenheit or higher. Twenty-eight of those days were in the month of July, which was particularly brutal. For seventeen consecutive days the temperatures did not dip below 80 at night, and the daytime temperatures soared as high as 108-109 degrees. The average daytime high for July was 103.6 degrees. These relentless conditions provided no relief to those most vulnerable to the cumulative effects of such extreme heat conditions, and prompted local social service agencies to examine possible measures to implement during such times.

Tulsa's Community Service Council stepped forward with the development of the Weather Coalition Air Conditioner Loan Program following that tragic year. This innovative program is designed to provide window air conditioners to the community's vulnerable population during an extreme heat event; the homebound elderly, those with medical conditions placing them at a higher risk and those on fixed incomes. Applications are accepted each year for inclusion in temporary placement of these life-saving appliances.

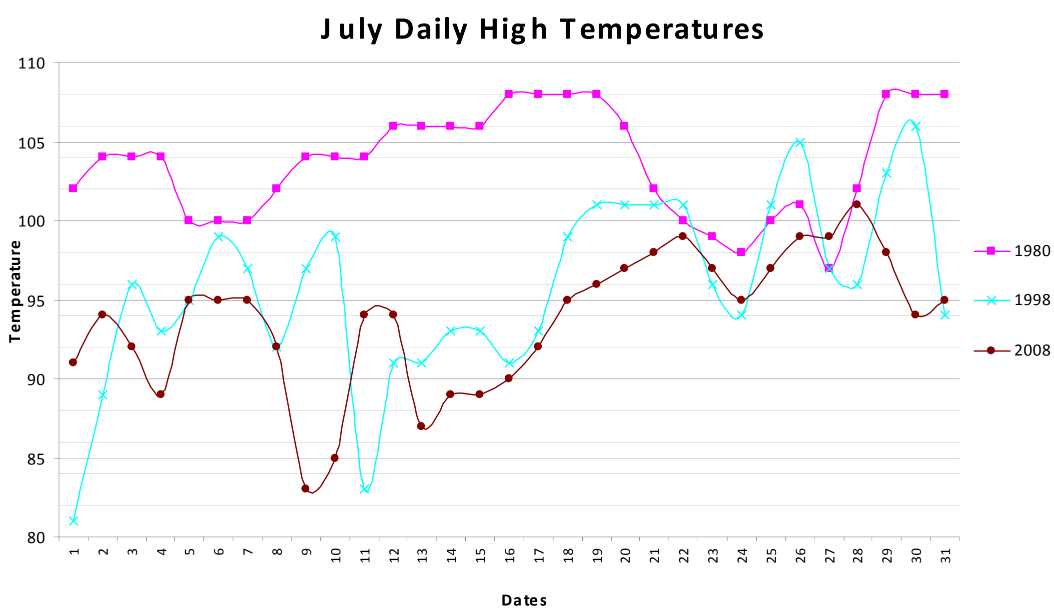
Tulsa's LIFE Senior Services is another resource with its founding roots in the early 1980's – 1983 to be exact. LSS currently provides adult day service for senior citizens at three area locations (one in Broken Arrow, two in Tulsa) as well as two separate senior centers also located in Tulsa. These locations provide a safe and cool place for Tulsa's senior population to turn to during extreme heat events – reducing their risk to the effects of high temperatures and humidity.

Tulsa has experienced several extreme heat periods since 1980, but none quite as severe or long lasting. Two periods examined are the summers of 1998 and 2008.

The summer of 1998 delivered a heat wave and accompanying drought that led to one hundred seventy-three heat-related deaths in the country with twenty reported for the state of Oklahoma. Three of those fatalities were recorded in the city of Tulsa, with all three being 40-year old males occurring in varying circumstances. The year 1998 has been ranked number eight in Tulsa's top ten 100-degree days (since 1938). The first 100-degree day was recorded on July 19th, and the last one for the year was recorded on September 22nd – a total of 22 days with temperatures at or above 100 degrees. The average daytime high for that July was 95.7degrees. Only eight days in the month were at or above 100 degrees.

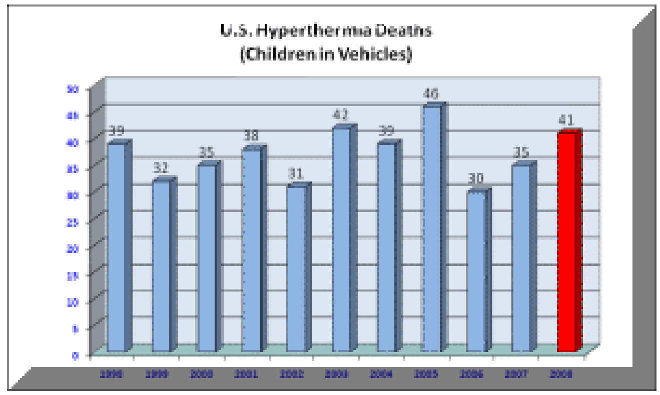
The summer of 2008 has presented its own level of heat-related concerns for Tulsa. Nationwide, USA Today reported that by August 1st, approximately 50 people had died due to heat-related illness. This was before many states had gone through their hottest portion of the year. Tulsa International Airport only reported one day with temperatures above 100 degrees for Tulsa, but there were several days with temperatures hovering between 95 and 99 degrees in the daytime, yet not dipping below 78 degrees overnight. This small fluctuation paired with the humidity created a ripe environment for heat related illnesses.

Tulsa's Emergency Medical Services Authority (EMSA) reported 64 heat-related calls from July 11th through July 31st. The average age of patients involved in these calls was 41.1 years of age, with a variance between male and female patients. Two heat-related fatalities were reported for Tulsa between mid-July and mid-August.



A worst-case scenario for this community would be a repeat of an extreme heat event with the severity and longevity of the one in 1980, without the progressive resources that have developed over time in response to the needs of the community.

Tulsa's Weather Coalition has consistently provided between 200 and 220 window air conditioning units to qualified members of the Tulsa community each year– a service that was not available during the summer of 1980.



Additionally, an increase in the number of heat-related deaths in children under the age of 13 years locked in cars has been reported across the country. Between 1990 and 1992, ten such deaths were reported. For 2004 through 2006, 110 heat related deaths were reported related to children left in vehicles. This represents an increase of approximately 14 more deaths in this population group every two years. Should this trend continue, that number could escalate to 138 nationwide by the end of 2008.

Comparatively, between 2004 and 2006, Oklahoma reported 8 heat-related fatalities for children under the age of 13 left in vehicles. One of these deaths was reported in Tulsa (2005). Examination of these figures in comparison to the national numbers suggests that Tulsa could possibly expect to have at least one fatality for this demographic group reported between 2006 and 2008.

Review of the heat-related fatalities reported for the City of Tulsa would support the conclusion that the Tulsa Weather Coalition Program has indeed had a positive impact in preventing deaths among the most vulnerable population. Without this program, or others that also facilitate that care, two hundred additional people would be placed at grave risk in the event of a heat wave like that in 1980.

The statistics from the previous years' extreme heat events would suggest that, should Tulsa experience a heat wave similar to that of 1980, without the existing programs and with current social trends in place, it could be reasonably assumed that the number of fatalities could reach four over the age of sixty-five, three between the ages of thirteen and sixty-five, and one below the age of thirteen.

4.7.4 Future Trends

For a map of Tulsa's potential future development areas, see Figure 1-13.

According to NOAA, future extreme heat events are likely to be even worse—more frequent, longer lasting, and more intense.

4.7.4.1 Population

With the rising cost of fuel and related travel expenses, more people are opting for vacations and/or recreational entertainment at local venues such as public parks etc. close to home. As the number of people enjoying the increasing number of local outdoor venues increases, vulnerability also increases.

Also at risk for an increase in vulnerability is the homeless population. With the recent home mortgage situation and additional economic stressors on those already struggling to meet financial obligations, the number those in the homeless population may also increase. Facilities designated as shelters (either daytime only or residential) will be further taxed to meet that need, suggesting that the number of those unable to utilize these facilities would be greater.

It would also follow that an increasing number of those in the more vulnerable population (elderly, fixed income, compromised health situations) would not be able to afford the cost of cooling their homes. This would be attributed to both economic situations and an increase in the population numbers of those in the elderly bracket.

With an increase in development in the downtown and surrounding areas, the number of outdoor workers would also be increasing. Care should be exercised to ensure that workforce is appropriate educated.

4.7.4.2 Structures/Buildings

While structures and buildings are only vulnerable in a limited way, such as in damage from expansive soils, the development of City of Tulsa areas needs to take into account the potential adverse health concerns of the urban heat island effect when large quantities of dense materials, such as stone, concrete, asphalt, and other construction materials, absorb the heat of the sun rather than reflect it. In addition, these materials act as "storage units" for the energy, and continue to radiate it at night, keeping the ambient temperature from reducing to a level which could provide relief from harmful effects.

4.7.4.3 Critical Facilities

Any future development or renovation of existing critical facilities should include plans for dependable backup systems for delivery of critical power.

4.7.4.4 Infrastructure

As certain developed areas of the city continue to age, the water line systems will also continue to deteriorate thus increasing the likelihood of line ruptures during peak usage periods during extreme heat events. Any development in areas facing this possibility should be closely monitored to ensure existing water lines are capable to handle the additional load – and replaced as necessary.

Sporadic power outages are commonplace during prolonged periods of high temperatures in any community. With an average of more than six hundred new residential building permits issued each year, the burden on power delivery systems will only continue to grow. Developers working in previously undeveloped areas should remain in constant contact with utility companies to prevent unnecessary overloading of current power stations.

4.7.5 Conclusions

Oklahoma can expect to be hit by the hazard of extreme heat every summer. The severity of the hazard is dependent on a combination of temperature, humidity, and access to air conditioning. With July average high temperature being 93.6° Fahrenheit, and average afternoon humidity 56% resulting in a heat index of 105° Fahrenheit, Tulsa is at moderate risk to extreme heat.

The most effective proven way to mitigate casualties from extreme heat is through public information and education, although other community programs, such as cooling stations and air conditioner loan programs, can also produce an impact.

While the documented deaths and medical transports appear to have been reduced based on the above-mentioned Extreme Heat Action Plan, heat will continue to be an ongoing threat in Tulsa County, although the risk factors are less for the less developed areas than for the major urban "concrete islands" due to less heat retention during the nighttime hours.

4.7.5.1 Data Limitations

The state Medical Examiner's office and the state Health Department have no standardized protocols for defining a "heat-related" death, relying on the judgment of the individual physician attending. This could lead to substantially lower mortality/morbidity figures. In addition, death by other causes such as cardiac, with heat as a "contributing factor" can further confound the final statistics for deaths and injuries.

4.7.5.2 Update Changes

Identified significant changes made from the 2003 City of Tulsa Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.7.5.3 Sources

Extreme Heat: A Prevention Guide to Promote Your Personal Health and Safety. http://www.bt.cdc.gov/disasters/estremeheat/heat_guide.asp. Accessed January 24, 2005.

Heat-related deaths - four states, July-August 2001, and United States, 1979-1999. Morbidity and Mortality Weekly Report 51(26): 569-570.

Heatwave Plan for England: Protecting Health and Reducing Harm From Extreme Heat and Heatwaves. Department of Health, UK. 2008

Multi-Hazard Identification and Risk Assessment, p. 84–88. Federal Emergency Management Agency, 1997.

National Weather Service, 1971-2000 Average Monthly Data at Web address: http://www.srh.noaa.gov/oun/climate/getnorm.php?id=chko2.

National Weather Service, Natural Hazard Statistics at Web address: http://www.nws.noaa.gov/om/hazstats.shtml.

Tulsa World Publications, "Heat blamed for deaths as outages hit areas of Tulsa" July 17, 2006 by Michael Smith at Web address: www.tulsaworld.com/news/article.aspx?articleID=060719_Ne_A1_Heatb29305

4.8 Drought

Drought is a normal, recurrent feature of climate, although many erroneously consider it a rare and random event. It occurs in virtually all climatic zones, but its characteristics vary significantly from one region to another. Seattle's Emergency Management Office defines drought as "climatic dryness severe enough to reduce soil moisture and water below the minimum necessary for sustaining plant, animal, and human life systems." Drought is caused by a deficiency of precipitation, which can be aggravated by high temperatures, high winds, and low relative humidity. Duration and severity are usually measured by deviation from norms of annual precipitation and stream flows.

The "Dust Bowl" of the 1930s, the greatest natural disaster in Oklahoma history, drove over 800,000 people off the land

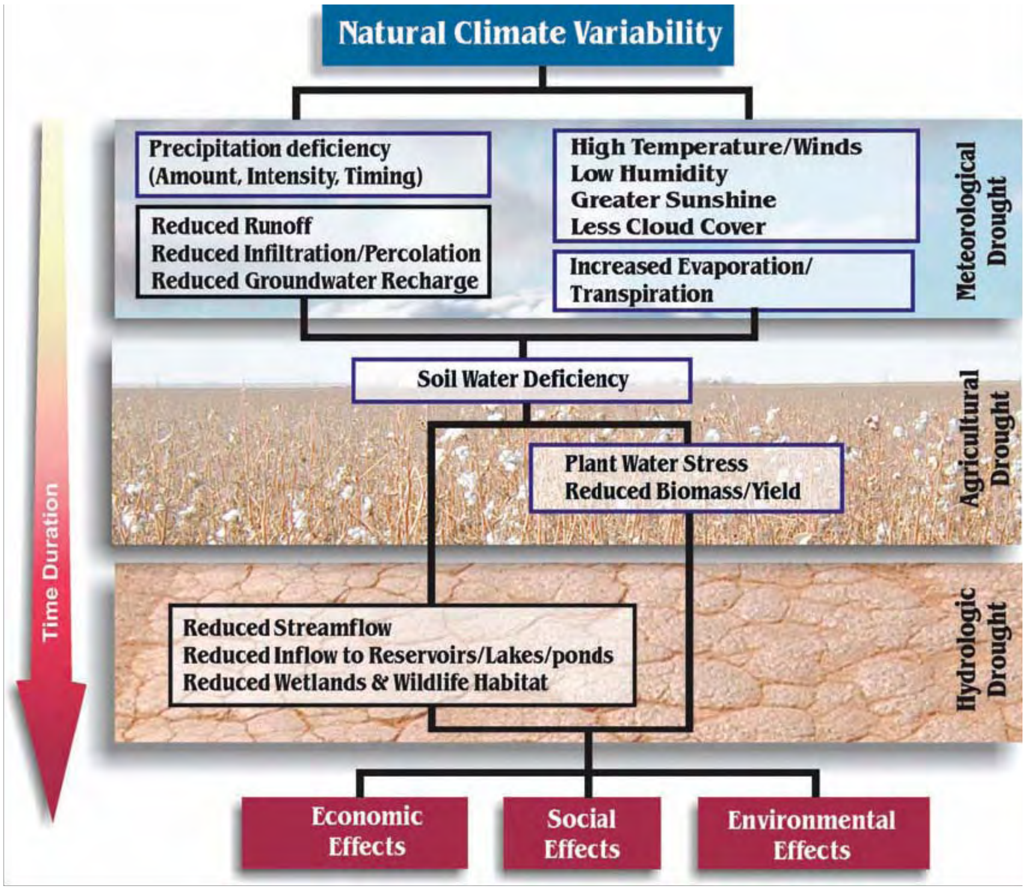
4.8.1 Hazard Profile

Drought is an insidious hazard of nature, characterized as a "creeping phenomenon." It is often difficult to recognize the occurrence of drought before being in the middle of one. Drought analysis is more subjective than that for floods, because droughts do not occur spontaneously. They evolve over time as certain conditions are met and are spread over a large geographical area. Drought severity depends on its duration, intensity, geographic extent, and the regional water supply demands made by human activities and vegetation. This multi-dimensional nature makes it difficult to define a drought and to perform comprehensive risk assessments. This leads to the lack of accurate, reliable, and timely estimates of drought severity and effects, and ultimately slows the development of drought contingency plans.

There are normally considered to be three kinds of drought, which occur at different stages, illustrated by the chart below. **Climatological drought** is based on precipitation, temperature, runoff, and other meteorological indices. As this continues, it will result in **Agricultural drought,** measured by soil water deficiency and plant water stress. **Hydrologic drought** is the end result of Climatological drought, when wetlands, reservoirs, and stream flow have substantially been reduced. This is the stage that can seriously affect urban/rural water supplies and the community infrastructure.

Measurements

Different measures are used to predict the severity and impact of droughts, but each one measures different aspects or types of drought. Any single index cannot describe everything about the original data, and the indices are only approximations of real-world phenomena.



The Palmer Index, the most familiar and widely used, measures the departure from normal precipitation. This index uses a range from 4 (extremely wet) to –4 (extremely dry). It incorporates temperature, precipitation, evaporation, runoff, and soil moisture when designating the degree of drought. Hydrologic Indices of drought (such as groundwater levels, reservoir volumes, or water levels) may be used to determine surface water supplies.

Palmer Drought Severity Index (PDSI)

In 1965, Palmer developed an index to "measure the departure of the moisture supply". Palmer based his index on the supply-and-demand concept of the water balance equation, taking into account more than only the precipitation deficit at specific locations. The objective of the Palmer Drought Severity Index (PDSI), as this index is now called, was to provide a measurement of moisture conditions that were "standardized" so that comparisons using the index could be made between locations and between months.

The Palmer Drought Index is based on precipitation and temperature. The Palmer index can therefore be applied to any site for which sufficient precipitation and temperature data is available.

The Palmer Index varies roughly between -4.0 and +4.0. Weekly Palmer Index values are calculated for the Climate Divisions during every growing season and are on the World Wide Web from the Climate Prediction Center.

Source: http://drought.unl.edu/whatis/indices.htm

PDSI Classifications for Dry and Wet Periods

4.00 or more	Extremely wet
3.00 to 3.99	Very wet
2.00 to 2.99	Moderately wet
1.00 to 1.99	Slightly wet
0.50 to 0.99	Incipient wet spell
0.49 to -0.49	Near normal
-0.50 to -0.99	Incipient dry spell
-1.00 to -1.99	Mild drought
-2.00 to -2.99	Moderate drought
-3.00 to -3.99	Severe drought
-4.00 or less	Extreme drought

Fire: Keetch-Byram Drought Index, fire danger rating system, acres burned, fuel load;

The Keetch-Byram Drought Index (KBDI) is basically a mathematical system for relating current and recent weather conditions to potential or expected fire behavior. This system was originally developed for the southeastern United States and is based primarily on recent rainfall patterns.

The KBDI is the most widely used drought index system by fire managers in the south. It is also one of the only drought index systems specifically developed to equate the effects of drought with potential fire activities.

The result of this system is a drought index number ranging from 0 to 800 that accurately describes the amount of moisture that is **missing**. A rating of zero defines the point where there is no moisture deficiency and 800 is the maximum drought possible.

These numbers correlate with potential fire behavior as follows:

0 - 200 Soil and fuel moisture are high. Most fuels will not readily ignite or burn. However, with sufficient sunlight and wind, cured grasses and some light surface fuels will burn in spots and patches.

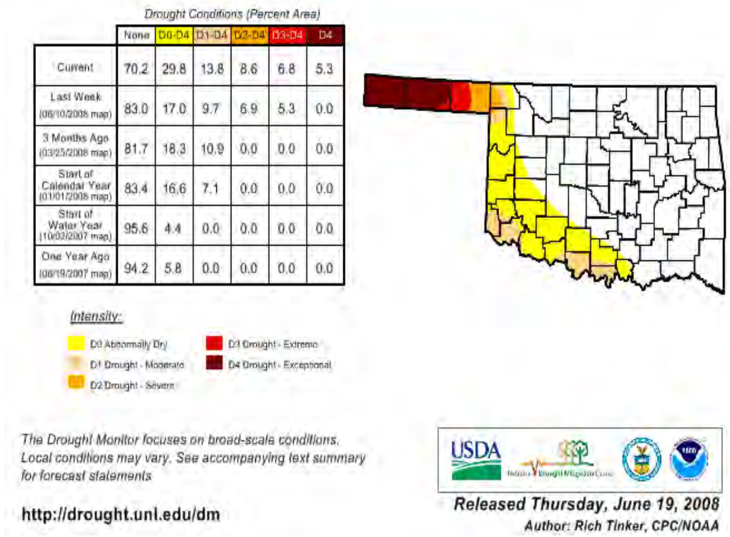
200 - 400 Fires more readily burn and will carry across an area with no gaps. Heavier fuels will still not readily ignite and burn. Also, expect smoldering and the resulting smoke to carry into and possibly through the night.

400 - 600 Fire intensity begins to significantly increase. Fires will readily burn in all directions exposing mineral soils in some locations. Larger fuels may burn or smolder for several days creating possible smoke and control problems.

600 - 800 Fires will burn to mineral soil. Stumps will burn to the end of underground roots and spotting will be a major problem. Fires will burn thorough the night and heavier fuels will actively burn and contribute to fire intensity.
Source: http://www.wfas.us/content/view/32/49/

4.8.1.1 Location

Drought is a widespread phenomenon that occurs over broad regions encompassing not only multiple communities, but frequently multiple states. Over the last few years, western Oklahoma has been harder hit by water shortages than eastern Oklahoma, but no location is immune. The City of Tulsa is at risk from Drought. See the illustration at right for current information.



Source: U.S. Drought Monitor, University of Nevada

4.8.1.2 Extent (Magnitude/Severity)

Because of the gradual nature of drought's onset, and its uneven impacts, it is often difficult to determine the beginning and end of a drought event. Tulsa has experienced drought three times in the past 7 years, characterized by primarily by crop damage and wildfire. Based on the Palmer Drought Index, Tulsa drought conditions can range from 4 to –4. This value is adjusted weekly through the Climate Prediction Center. Tulsa's municipal water supply is strong, with water from two separate watersheds, one originating in Kansas, which flows into the Mohawk Water Treatment Facility, and one originating in Arkansas, which flows into the A.B. Jewell Water Treatment Facility. The City's water supply and treatment capacity is three times its current maximum demand.

Economic damage due to crop loss and wildfire remains, however, a significant threat to the community. Property and crop damage due to drought in Oklahoma between 2000 and 2007 reached $594 million ($32.5 million to property and $561.6 million to crops). The impacts of drought can be lessened by early warning and notification systems, backup sources of water supply, cooperative agreements with neighboring jurisdictions, local ordinances for rationing water use, clearing brush and Eastern Red cedar from structures in the urban/rural interface, and participating in the national FireWise program.

Effects

Adverse consequences of drought occur because of deficiencies in the following:

- Public and rural water supplies for human and livestock consumption
- Natural soil water or irrigation water for agriculture
- Water for hydroelectric power, forests, recreation, and navigation
- Water quality

The most direct impact of drought is economic rather than loss of life or immediate destruction of property. Drought affects water levels for use by industry, agriculture, and individual consumers. Water levels can have both a direct and indirect effect on hunting, fishing, and other recreational activities that may have a significant place in a community's revenue.

Water shortages affect fire-fighting capabilities through reduced water flows and pressures. Drought also affects power production, since when water levels drop, electric companies cannot produce enough inexpensive hydropower to meet demand and are forced to buy electricity from other, usually more costly sources. Communities that rely on hydroelectric vs. coal/gas-fired generating plants may be more vulnerable.

Most droughts dramatically increase the danger of wildland fires. When wildlands are destroyed by fire, the resulting erosion can result in the heavy silting of streams, rivers, and reservoirs. Serious damage to aquatic life, irrigation, and power production then occurs. (See the section, "Wildfires")

4.8.1.3 Frequency

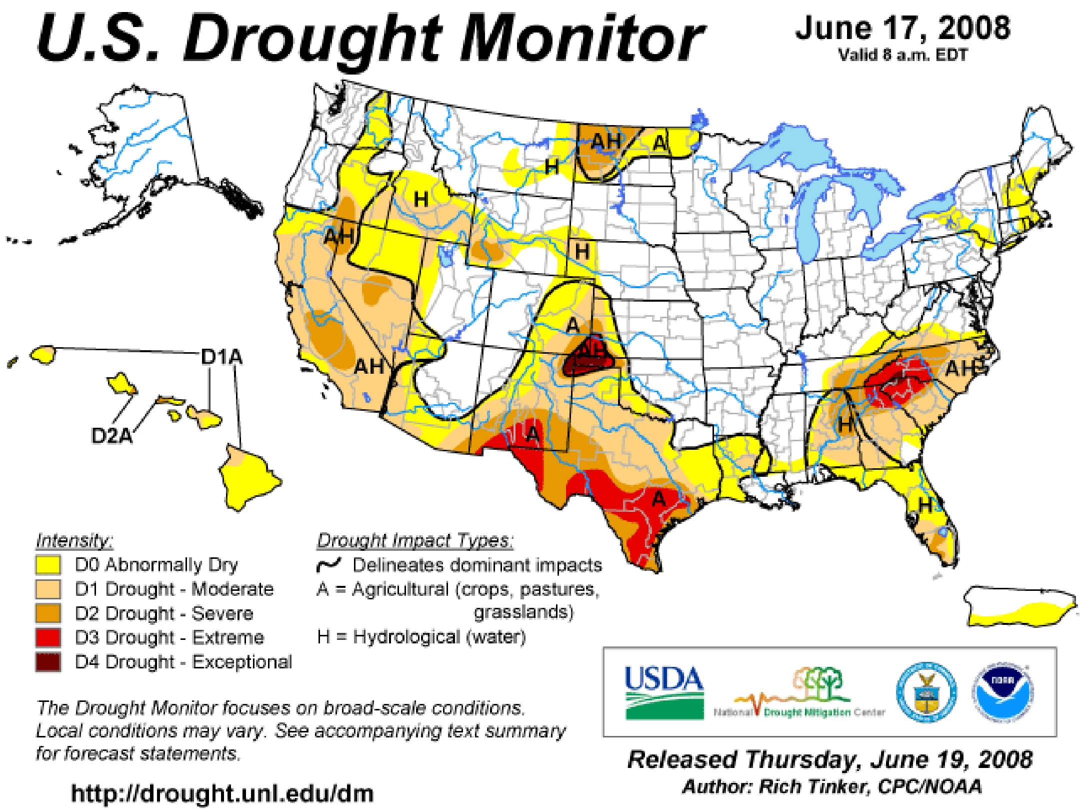
Drought is a normal part of virtually all climates. However, an ample water supply is critical to the economic well being of the United States and of Oklahoma. During droughts, crops do not mature, wildlife and livestock are undernourished, land values decrease, and unemployment increases.

Given that six major drought events have occurred in Oklahoma over the past 50 years and that nine notable droughts occurred nation-wide in the twentieth century, one may conclude that Oklahoma can expect a drought every decade and expect droughts to occur more frequently than in the country as a whole. However, long-term forecasts of droughts are difficult and inexact. There is no commonly accepted way of determining the probability that is analogous to the 100-year or 1-percent-annual flood chance.

The U.S. Army Corps of Engineers (USACE) is preparing the *National Drought Atlas* to provide information on the magnitude and frequency of minimum precipitation and stream flow for the contiguous United States. On average, the July-to-January period is the lowest six-month period of stream flow throughout the U.S. and is used to characterize drought. The mean monthly flow from July to January has a once-in-20-years chance of falling below a level that would classify it as a drought. In other words, the average occurrence of drought is once every twenty years. Oklahoma, with one per ten years over the past fifty years, is obviously at a greater than normal risk from drought.

4.8.1.4 History/Previous Occurrences

The National Weather Service's drought monitor map illustrates the pervasive nature and degrees of dryness and prolonged droughts in several areas of the country. Following is the Drought Monitor map for the U.S., which is updated weekly.



One of the greatest natural disasters in U.S. history and the most severe and devastating to Oklahoma was the decade-long drought in the 1930s that has become known as the Dust Bowl. Reaching its peak from 1935 through 1938, high temperatures and low rainfall combined to destroy crops and livestock. High winds literally blew the land away, causing massive soil erosion. Hundreds of small rural communities were ruined and about 800,000 people were displaced. The total expenditure by the American Red Cross for drought relief in Oklahoma in 1930-1931 was the third largest ever in the nation.

Nine notable droughts occurred during the twentieth century in the United States. Damage estimates are not available for most, however estimates indicate that the 1976-1977 drought in the Great Plains, Upper Midwest, and far Western States caused direct losses of $10-$15 billion. The 1987-1989 drought cost $39 billion including agricultural losses, river transportation disruption, economic impacts, water supply problems, and wildfires.

Approximately 20% of the contiguous United States is currently suffering from the effects of prolonged severe to extreme drought. Parts of the east coast have been particularly hard hit, and the drought in those areas is so severe that months of above-normal rainfall would be necessary to end it, according to the National Weather Service.

In Oklahoma, five major drought events were reported over the past 50 years resulting in damage to crops estimated at $900 million.

Major droughts in Oklahoma, as determined from stream flow records collected since the early 1920s, have predominately occurred during four periods: 1929-1941, 1951-1957, 1961-1972, and 1975-1982.

Oklahoma has begun the new century with drought conditions. Since June of 2001, Oklahoma has received only 71 percent of its normal rainfall, according to the Oklahoma Climatological Survey.

In March of 2002, lack of rainfall and an infestation of insects were taking a toll on western Oklahoma's wheat crop. State officials said 26 percent of the wheat crop was in very poor shape and conditions were so dry in the Panhandle that soil erosion was beginning to occur. The state's "wheat belt" region, the area around and west of U.S. 81, had received less than 50 percent of its normal rainfall since October of 2001, said Derek Arndt, climatologist with the Oklahoma Climatological Survey.

4.8.1.5 Probability/Future Events

As drought is a direct by-product of normal Climatological activity, it is accepted that the entire Tulsa jurisdiction will continue to be vulnerable to drought of varying severity.

As stated above, based on history and previous occurrences from the past 50 years, the Tulsa jurisdiction can expect to experience the effects of a drought cycle every 10-15 years. However, as in the past, it can be expected that drought effects will be more severe in western Oklahoma than in the eastern part of the state, and to have a more devastating effect on rural areas and the agricultural and ranching community than on urban residents.

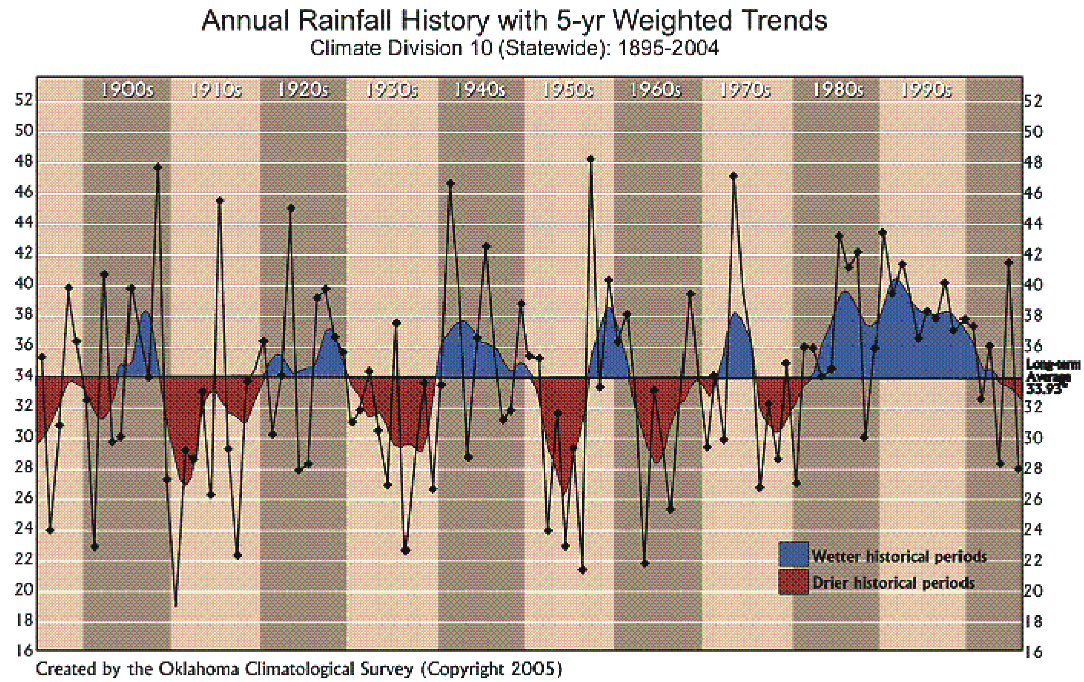
4.8.2 Existing Vulnerability

Drought and Water Conditions in Tulsa County and Tulsa

Tulsa draws its raw water from Spavinaw/Eucha and Oologah Lakes. Lake Hudson has provided water in the past and is available for future use. Spavinaw runs two major flowlines – a 54-60 inch and a 66-72 inch diameter line. Oologah also runs two flowlines – a 42-inch and a 54-72 inch line. Raw water is stored in Yahola Lake (2.0 billion gallon capacity) near the Mohawk Water Treatment Plant and the Lynn Lane Reservoir (1.1 billion gallon capacity) near the A.B. Jewell Water Treatment Plant. The two plans have the capacity to treat 220 Million Gallons per Day. Tulsa is currently operating at significantly below its water service capacity. Even in times of drought and extreme heat, as in the record-setting July of 1999, water usage can double, but has yet to exceed 190 MGD, well below the maximum capacity. Tulsa has not had to impose any kind of rationing since the summer of 1981.

The primary impacts of drought in Tulsa County have been to farming and ranching. A secondary impact for both Tulsa County and Tulsa, each of which has a good number of residential estates within their jurisdictions, is urban interface wildfire. Following upon a very wet spring in 2005, the drought conditions of 2005-2006, combined with unseasonably warm, windy weather from November to January, resulted in the worst wildfire season in state history. Over 1,500 acres in Tulsa County and Tulsa were burned by wildfire. This fire complex resulted in a Presidential Disaster Declaration. As illustrated in the graph, Oklahoma has gone through six drought cycles, state-wide, since the early 1900s, with the latest being an almost 20-year period of wet weather lasting from about 1983 to 2003.

Tulsa and Tulsa County have reported drought conditions for two of the last five years—in 2001 and 2006. During 2001, Tulsa County and Tulsa suffered moderate drought in July and August, a period of severe drought in September, and moderate drought again from October to December. During 2006, Tulsa and Tulsa County experienced moderate drought in February and March, a period of severe drought in April, and moderate to severe drought in May and June. By August 2006, over 50 communities in Oklahoma had been forced to impose either mandatory or voluntary water rationing. Tulsa, with its relatively abundant and stable water supply, was not forced into rationing. If these trends continue, and the recent wet phase of the cycle is followed by a number of dry years, then the State may well be facing a period of prolonged drought in the coming decades. At this point, the big lakes in this area such as Keystone, Eufaula, Tenkiller, Broken Bow, and Fort Gibson have been over full conservation storage levels, indicating sufficient water for urban needs.



Each of the 111 individual years in Oklahoma's precipitation history is represented with a black diamond, and the average of all years (33.93") is shown as a horizontal line. Five year weighted trends within the record are shown in color. Blue indicates period with greater-than-average, and brown indicates below-average precipitation.

Large reservoirs may have several target storage levels, each level planned to ensure a usable amount of water at a certain time of year. For instance, in addition to its normal or Full Supply level, a reservoir may have a Conservation Storage Level (i.e., the desirable level for a flood-control reservoir at the start of each flooding period), a Flood Storage Level (the maximum desirable level that is permitted for reservoir safety during floods), a Dead Storage Level (the level below which water may not be withdrawn for consumptive uses) and various other target levels established to meet such needs as summer recreational use, irrigation uses and hydropower discharges throughout the year.

A reservoir used for municipal purposes will be designed to have no shortages because the users (people in cities) cannot tolerate periods without water. When uses are such that shortages, although they may be inconvenient, will not cause severe economic hardship, reservoirs are often designed to allow for an acceptable percentage of shortages in critically dry years.

Birch, Skiatook and Grand lakes were at low levels in the winter of 2002. Skiatook Lake was between five and six feet below normal, about 17% down, according to a U.S. Army Corps of Engineers report. Birch was nearly 3 feet down, and Grand Lake was 8 feet down. However, none have dropped as dramatically as Copan Lake and Hulah Lake in recent years.

4.8.2.1 Population

Generally, in times of severe drought, states rely on the Federal Government to provide relief to drought victims when water shortages reach near-disaster proportions. Forty separate drought relief programs administered by 16 Federal agencies provided nearly $8 billion in relief because of the series of drought years during the mid-1970s. Federal assistance efforts totaled more than $5 billion in response to the 1987–1989 drought. However, since the mid-1970s, most states have taken a more active role and drought contingency plans are now in place in at least 27 states. According to the University of Nevada's Drought Monitor, the primary impact currently to the Tulsa area is the effect on wheat production, although other factors listed above may come into play for individual homeowners and businesses.

4.8.2.2 Structures/Buildings

The primary threat to structures within the City of Tulsa lies in the effect of drought on Expansive Soils. More information on that hazard is available in Section 4.9.

4.8.2.3 Critical Facilities

See Critical Facilities in Appendix G.

4.8.2.4 Infrastructure

The effect on infrastructure is, for the most part, similar to the effect on structures, in that the primary danger is drought's effect on expansive soils.

In many communities, drought can have impacts on the community's ability for firefighting, with both wildland and structure fires. The City of Tulsa's water supply is significantly robust enough that the Tulsa Fire Department does not consider this an issue.

Water Treatment – Drought increases the demand for water and at the same time may impact the availability of raw water. The City of Tulsa monitors and regulates our lake levels to mitigate the impacts of drought and conserve water. In addition, the City's primary water supply lakes (Eucha, Spavinaw and Oolagah) are located in different water sheds. Due to differences in local weather patterns, one area may be impacted to a lesser degree than another. The City of Tulsa also has an emergency contract in place to purchase water from Lake Hudson.

Wastewater Treatment – No vulnerabilities outside those experienced by other City services/facilities.

Utilities- No vulnerabilities outside those experienced by other City services/facilities.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Roadways could potentially face secondary effects if located in areas situated in an expansive soil base.

Emergency Services- Fire services could potentially be affected if a severe drought reduces availability of water for fire suppression. Police and medical services would not face any vulnerabilities outside those experienced by other City services/facilities.

4.8.3 Drought Scenario

Since the primary impact of drought is in the areas of agriculture, recreational outdoor activities, and the impact on a City water system, it is not considered necessary to include a specific Drought Scenario in the Hazard Mitigation Plan. Due to Tulsa's forward thinking water supply engineering in the 1970's and 1980's, drought impact on City water supply is minimal, and Tulsa's economic climate is not as heavily dependent on agricultural and outdoor recreational activities as it is with many communities in Oklahoma.

4.8.4 Future Trends

For a map of Tulsa's potential future development areas, see Figure 1-13.

4.8.4.1 Population

As drought is primarily an agricultural threat in nature, and Tulsa is a largely urban jurisdiction, the population vulnerable to this threat would remain basically unchanged. The only additional note might be that should the area surrounding Tulsa become affected by a drought severe enough to have an impact on local agricultural businesses, those Tulsa residents dependent on outdoor labor or recreational opportunities in surrounding for income could be affected by this event.

4.8.4.2 Structures/Buildings

The primary threat to structures within the City of Tulsa lies in the effect of drought on Expansive Soils, therefore any future development/renovations undertaken by the city involving structures/buildings should consider this possibility. More information on that hazard is available in Section 4.9

4.8.4.3 Critical Facilities

As with other structures/buildings within the City of Tulsa, the most severe threat to Critical Facilities lies in the secondary effects of Expansive Soils triggered by a severe drought in this area. Critical Facilities that have been identified as being located on grounds subject to potential shrink/swell activity should monitor the integrity of their facilities and plan for that potential. For a discussion of critical facilities in potential expansive soil problem areas, see Section 4.9.2.3.

Likewise, these facilities should plan for the possibility of water shortages during drought events – as this would have a severe impact on daycare, nursing home and other medical clinic/hospital facilities.

4.8.4.4 Infrastructure

The effect on infrastructure whether discussing current or future vulnerability is, for the most part, similar to the effect on structures, in that the primary danger is drought's effect on expansive soils.

As development within the city's jurisdiction continues (both new and existing projects), certain considerations present. The capacity, age and condition of the water delivery systems for the city should be reviewed on a regular basis to ensure the integrity is consistent with meeting the demand of increased and/or relocated populations; location and composition of roadways must be reviewed to ensure appropriate techniques and materials are utilized to allow for shrink/swell fluctuation in the event of a major drought; the city's main water supply sources should be monitored during severe heat events to ensure trigger points for water emergencies are accurate and sufficient. The recent drought events in western Oklahoma should serve as an indicator to this jurisdiction for review and development of appropriate emergency plans should this weather trend continue across the state in the future.

4.8.5 Conclusions

The severe droughts of the 1930s led to the construction of Oklahoma's numerous hydroelectric dams and reservoirs, as well as to the implementation of new farming and conservation policies. However, more recent drought response and recovery activities in Oklahoma, both at the state and local level, have not been as ambitious or successful. Planning for the state's critical and emergency water resources needs should not be carried on only during drought crises. There is a "need to focus more on long-term water management and planning issues; to integrate the activities of numerous agencies with drought-related missions into a coherent national approach; and to achieve better coordination of mitigation, response, and planning efforts between state and federal officials."

The City of Tulsa is at low to moderate risk of drought, and moderate to high risk from a secondary impact of drought in the urban interface, wildfire.

In all droughts, agriculture feels the impact, especially in non-irrigated areas such as dry land, farms, and rangelands. Other heavy water users such as landscapers are also negatively impacted. Water related activities of residential users might be restricted. Droughts may exacerbate the impact related to expansive soils (see Section 4.9). Droughts also cause power shortages in Oklahoma because much of the state's power comes from hydroelectric plants. Heavy power users can be negatively affected by the results of electricity shortages due to drought, such as brownouts, blackouts, and spiking prices.

4.8.5.1 Data Limitations

There are signs that drought is becoming an increasing problem in the United States, including Oklahoma. However, it is difficult to predict drought probabilities for the near future due to the nature and complexity of the hazard.

4.8.5.2 Update Changes

Identified significant changes made from the 2003 City of Tulsa Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.8.5.3 Sources

"Worst drought seen in parts of U.S.," at Web address: www.msnbc.com/news/ (article no longer available).

Drought Monitor: National Drought Mitigation Center, at Web address: http://drought.unl.edu/dm/index.html.

King County Office of Emergency Management, "Droughts," at Web address: www.metrokc.gov/prepare/hiva/drought.htm. Office of Emergency Management, King County, Washington.

Nascenzi, Nicole. "Drought, insects threaten state wheat crop," *Tulsa World*. March 14, 2002.

NOAA Event Record Details, Two Drought Events 08/01/00 and 07/04/01, at Web address: www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms.

Oklahoma Strategic All-Hazards Mitigation Plan, "Hazard Identification and Vulnerability Assessment," p 7. Oklahoma Department of Emergency Management, September 2001.

Oklahoma Water Resources Bulletin, p. 5, at Web address: www.state.ok.us/~owrb/features/drought.html. Oklahoma Water Resources Board, March 27, 2002.

Tortorelli, R.L. *Floods and Droughts: Oklahoma, National Water Summary 1988-89: US Geological Survey, Water Supply Paper 2375.USGS.* Water Resources of Oklahoma.

Wilhite, D.A. (Ed.). *Drought Assessment, Management, and Planning: Theory and Case Studies.* Natural Resource Management and Policy, Norwell, MA: Kluwer Academic Publishers, 1993.

4.9 Expansive Soils

Soils and soft rock that tend to swell or shrink due to changes in moisture content are commonly known as expansive soils. Expansive soils, also called shrink/swell soils, are sometimes referred to as swelling clays because clay materials attract and absorb water. Dry clays will increase in volume as water is absorbed and, conversely, decrease as they dry.

Measurements

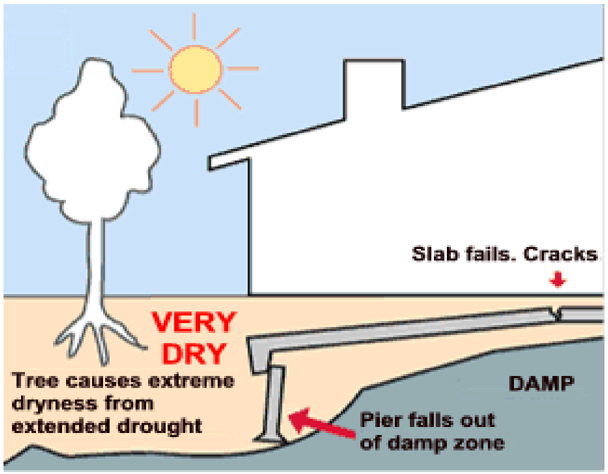
The risk associated with expansive soil is related to shrink/swell potential in a qualitative manner: very high, high, moderate and low.

The National Resource Conservation Service (NRCS), in its Soil Survey Geographic Database (SSURGO), identified expansive soils for the City of Tulsa as shown in Figure 4–16. SSURGO map units were classified from “low” to “very high” based on the weighted average of the Coefficient of Linear Extensibility (COLE) percent for the soils within the identified map units to depths between 0 inches and 60 inches, the depths at which damage to improvements from expansive soils is most likely to occur. Soil samples are dehydrated either through air-drying or oven drying for a predetermined length of time under a constant temperature. Bulk density, particle density, overall volume, and porosity are then plugged into a formula to obtain the above-mentioned COLE. In addition, the Oklahoma Department of Transportation has a program to evaluate the expansive tendencies of soils and shale formations in the state.

4.9.1 Hazard Profile

Changes in soil volume present a hazard primarily to buildings or infrastructure built on top of expansive soils. Most often, these volume changes involve swelling clays beneath areas covered by buildings and slabs or layers of concrete and asphalt.

Property damage can vary greatly across a jurisdiction, based on soils types, long-term weather conditions, the type and quality of construction, and materials used in construction. Other cases of damage involve increases of moisture volume from broken or leaking water



Tulsa is underlain by soils with shrink-swell potentials ranging from low to very high.

and sewer lines, over-watering of lawns and landscape, and modifications of the surface that produce ponding.

The effects of expansive soils are most prevalent in regions of moderate to high precipitation, where prolonged periods of drought are followed by long periods of rainfall. The most problematic soil type for expansive soils is found in the semiarid west-central United States.

The extent of damage from expansive soils can be reduced by mapping the soils in the jurisdiction and by notifying property owners and prospective buyers and builders of potential soil hazards and the techniques that can be used to limit their impacts.

4.9.1.1 Location

Based on surveys of underlying soils, Figure 4–16 shows a generalized map of the areas of Tulsa where soils have low to very high expansive qualities.

Generally, many Tulsa lowlands along the river and waterways have low shrink-swell soils. Many higher elevations have moderate to high potential, including large areas of central and east Tulsa. Localized sites with very highly expansive soils have been identified in North Tulsa and in smaller areas south and west. High shrink/swell soils predominate in future growth areas to the east and west of the city. Low and medium soils are most common in much of the far south and north, along with localized areas of very high expansive qualities.

4.9.1.2 Extent

More than half the soils in Tulsa rank in the moderate to very high classification for expansive potential. Specifically, soils classified with “low” shrink/swell properties cover 41.5% of the Tulsa land area. Soils classified as “high” and “moderate” rank second and third, covering 27.12% and 24.45% respectively. Soils with a “very high” classification are the least common in Tulsa, as they cover 3.66% of the total land area. Overall, the City of Tulsa has a “moderate-high” vulnerability to the damaging effects of expansive soils.

Table 4–30: City of Tulsa Expansive Soils

Expansion Potential	Area (mi²)	% of Total City Limits
Very High	7.34	3.66
High	54.37	27.12
Moderate	49.1	24.45
Low	83.2	41.5
Water	4.9	2.44

4.9.1.3 Frequency

Local frequency analyses have not been prepared because of the nature of this hazard, which is consistent with other geologic hazards that occur rarely or slowly over time.

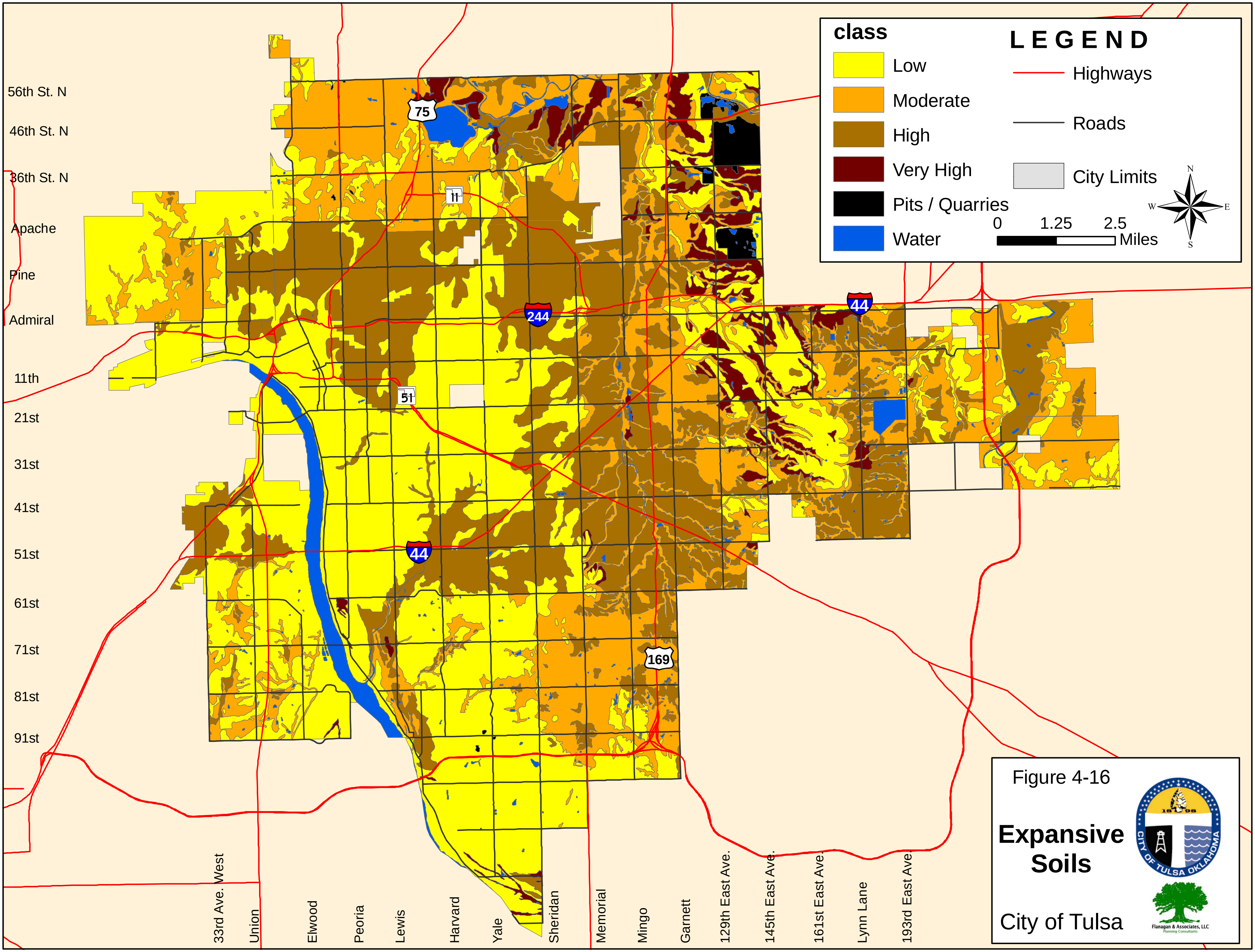


Figure 4-16

Expansive Soils

City of Tulsa

4.9.1.4 Historical Events

In Oklahoma, numerous foundation failures and pipeline breaks have resulted from soil shrinkage during the unusually hot and dry summers of 1998 and 2005-2006. During the drought of 2005-2006, soil shrinkage led to water main and sewer pipe breaks and leaks in many Oklahoma cities, including Holdenville, Okmulgee, Muskogee, and Ada.

For example, expansive soils are having a serious impact on Ada's aging water infrastructure, particularly during the drought and high temperature conditions of 2006. In July 2006, Ada lost about 2.5 MGD (million gallons a day) from its water distribution system due to breaks, leaks, and unmonitored (but authorized) use. Similar problems have plagued Okmulgee's water distribution system. Both cities have instituted aggressive pipeline maintenance programs to counter the effects of soil shrinkage during periods of prolonged drought.

Cracks in exterior walls caused by soil expansion

The only City of Tulsa structure with recorded damage from expansive soils is the motorcycle3 shop at 1720 W. Newblock. Damage was significant enough that retrofitting piering under the building was required. Since the City does not routinely list damage as having been caused by expansive soils, it is likely there has been other damage, but not to the extent that piering was required.

4.9.1.5 Probability/Future Events

There are shrink-swell soils in Tulsa that have a high probability of continuing to cause localized problems in areas of high to moderate expansive soils, similar to those experienced in the past.

4.9.2 Existing Vulnerability

Many researchers show that expansive soil is one of the most costly hazards in the United States, in terms of property damage caused by shifting soils.

For example, national studies have shown that expansive soils cause pervasive problems. Out of the 250,000 homes built each year on expansive soils, 10% sustain significant damage during their useful lives, some damaged beyond repair, and 60% sustain minor damage. For all types of building construction, annual losses of $740 million are estimated.

Despite its costly effects, expansive soil presents, in many ways, a silent hazard. Because the hazard develops gradually and seldom presents a threat to life, expansive soils have received limited attention. Many problems are not recognized as being related to expansive soils or may be considered only nuisances and therefore never repaired.

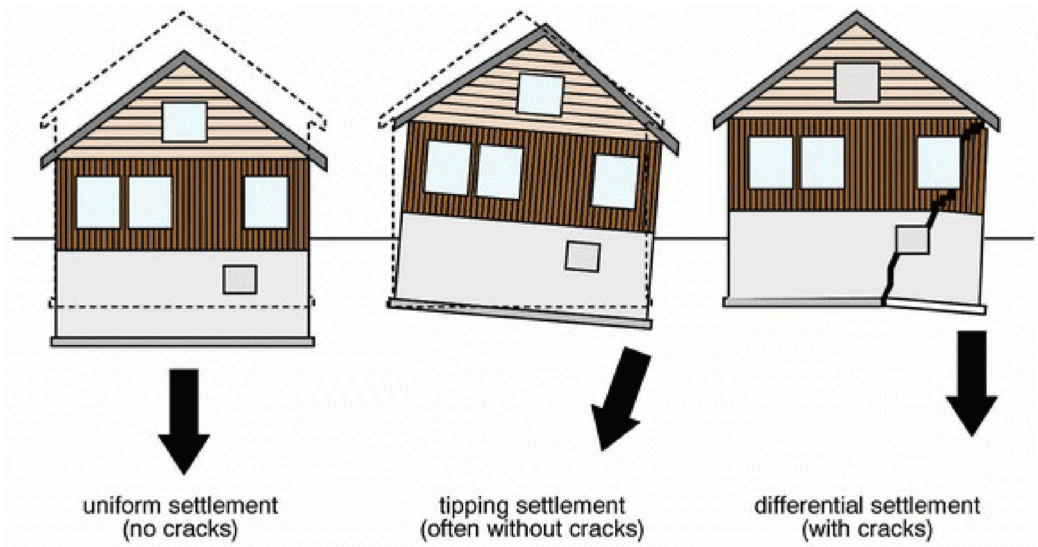
The total annual cost of expansive soil-related damage and preventive design of moderate- to high-risk structures throughout the United States has been conservatively estimated at between $2.5 billion and $10 billion (in1995 dollars).

4.9.2.1 Population

Direct threats to life or personal injury have not generally been documented for expansive soils, due to the nature of the hazard.

4.9.2.2 Structures, Buildings

The increase in soil volume can cause damage to foundations. The most obvious manifestations of damage to buildings are sticking doors, uneven floors, and cracked foundations, floors, walls, ceilings, and windows. If damage is severe, the cost of repair may exceed the value of the building.



Types of Expansive soil damage

It does not take much movement to damage buildings. As little as a differential movement of 0.25 inches between adjacent columns can cause cracking in load-bearing walls of a 2-foot wide bay.

Houses and one-story commercial buildings are more apt to be damaged by the expansion of swelling clays than are multi-story buildings, which usually are heavy enough to counter swelling pressures. However, if constructed on wet clay, multi-story buildings may be damaged by shrinkage of the clay if moisture levels are substantially reduced, such as by evapotranspiration or by evaporation from beneath heated buildings.

The greatest damage occurs when small buildings are constructed when clays are dry, such as during a drought, and then subsequent soaking rains swell the clay. Other cases of damage involve increases of moisture volume from broken or leaking water and sewer lines, over-watering of lawns and landscape, and modifications of the surface that produce ponding.

4.9.2.3 Critical Facilities

Sixty-nine of Tulsa’s critical facilities, identified in Table 4–31 are built upon soils classified as having “high” or “very high” shrink/swell potential.

Table 4–31: Critical Facilities Vulnerable to Expansive Soils

ID	Name
FD5	Tulsa Fire Station #10
FD7	Tulsa Fire Station #12
FD11	Tulsa Fire Station #16
FD12	Tulsa Fire Station #17
FD17	Tulsa Fire Station #22
FD18	Tulsa Fire Station #23
FD22	Tulsa Fire Station #27
FD25	Tulsa Fire Station #3
FD33	Tulsa Fire Station #7
FG2	USPS – Whittier Post Office
FG3	USPS – Northside Post Office
FG6	USPS – Northeast Post Office
FG8	USPS – Westside Post Office
FG11	USPS – Robert Jenkins Post Office
FG12	USPS – Sheridan Post Office
FG13	USPS – Southeast Post Office
FG16	NOAA – NWS
FG17	USACE
FG18	IRS
FG19	USPS – Postage Handling Facility
LF2	American TrustCor
PD7	Tulsa Police Station (East Division)
PW2	Equipment Maintenance
PW7	Satellite Fuel Station
PW9	Street Dept. Garage / Offices
PW16	Water District Office / Warehouse
UV1	Oklahoma State University – Tulsa
VT7	Tulsa Technology Center – Lemlely Campus

4.9.2.4 Infrastructure

Damage to the built environment results from differential vertical movement that occurs as clay moisture content adjusts to the changed environment. In a highway pavement, differential movement of 0.4 inches within a horizontal distance of 20 feet is enough to pose an engineering problem if high standards for fast travel are to be maintained.

4.9.3 Expansive Soils Scenario

Since specific cost data is not available for the average damages per property incurred from Expansive Soils, it is not possible to include a realistic Expansive Soils Scenario. (Reference Sections 4.9.5 and 4.9.5.1 below). In future versions of this plan, it is possible that research data will have been developed and made available that allows such a scenario to be constructed.

4.9.4 Future Trends

Soils in Tulsa's identified future-development areas are primarily classed as "Low" and "Moderate", but soils with a "High" shrink-swell potential are also present, along with a few areas that are "Very High." Of particular concern, more than 23% of the land in areas zoned for future industrial development in the north and northeast quadrants of the city are classed as "Very High." With 55% of the soils within the city limits being categorized as having "moderate" to "very high" shrink/swell potential, the City of Tulsa will continue to have moderate to high vulnerability to the damaging effects of expansive soils. It is important to note that Tulsa's future industrial development areas are also on soils with a "high" shrink-swell potential. Expansive Soils in the Future Growth Areas are shown in Figure 4-17.

Table 4–32: City of Tulsa Expansive Soils – SE Osage Co. FGA

Expansion Potential	Area (mi^2)	% of Total FGA
Very High	0.0	0.0
High	.02	2.83
Moderate	.21	28.86
Low	.50	68.22
Water	.0004	.07

Table 4–33: City of Tulsa Expansive Soils – Tulsa Industrial Area FGA

Expansion Potential	Area (mi^2)	% of Total FGA
Very High	1.48	23.12
High	1.52	23.62
Moderate	1.95	30.45
Low	1.42	22.16
Water	0.04	0.65

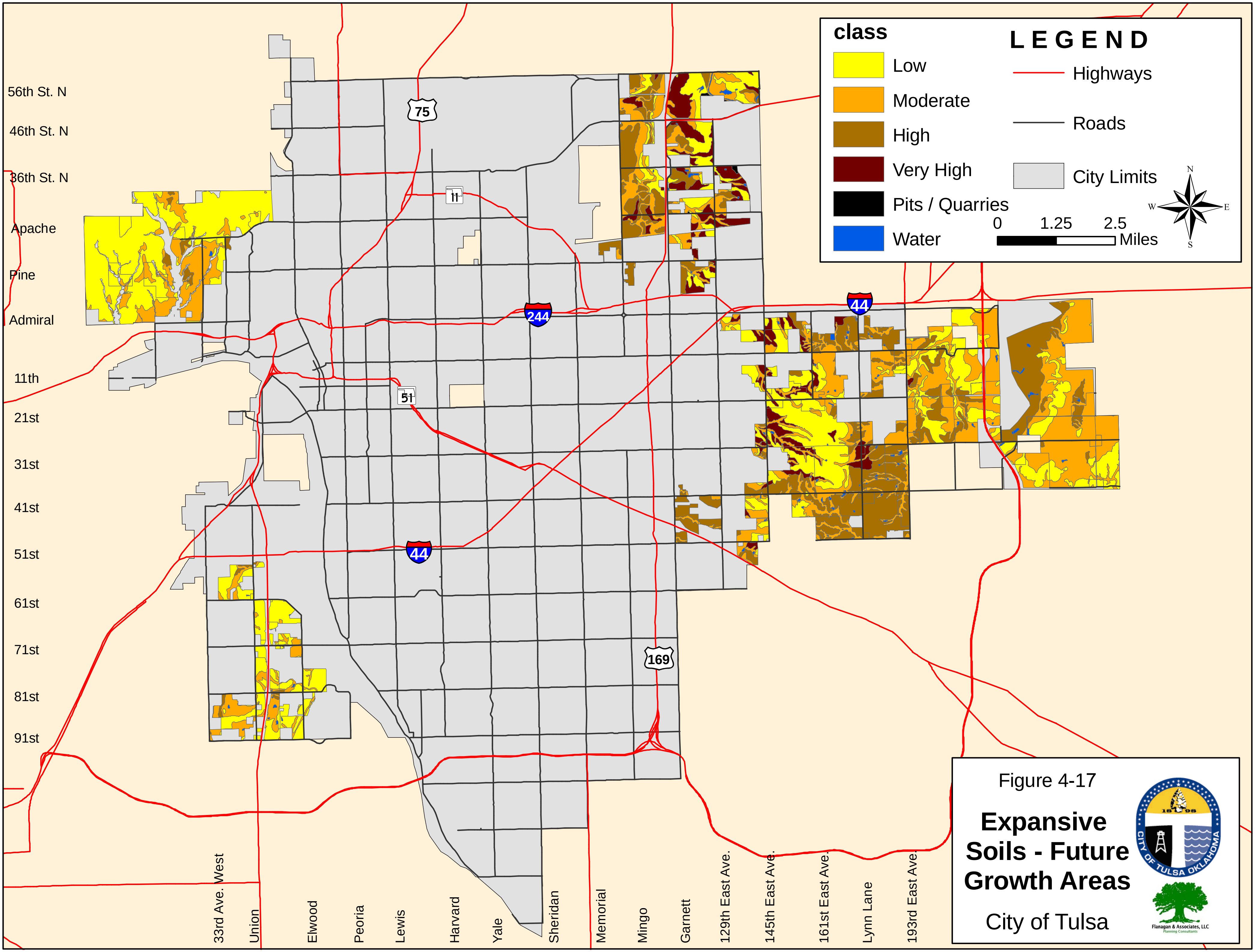


Figure 4-17

Expansive Soils - Future Growth Areas

City of Tulsa

Table 4–34: City of Tulsa Expansive Soils – SW Tulsa FGA

Expansion Potential	Area (mi²)	% of Total FGA
Very High	0.0	0.0
High	0.12	2.96
Moderate	1	25.79
Low	2.77	70.74
Water	.02	0.51

Table 4–35: City of Tulsa Expansive Soils – Wagoner County FGA

Expansion Potential	Area (mi²)	% of Total FGA
Very High	.02	0.11
High	2.94	21.88
Moderate	6.84	50.85
Low	3.53	26.24
Water	0.12	0.91

Table 4–36: City of Tulsa Expansive Soils – East Tulsa FGA

Expansion Potential	Area (mi²)	% of Total FGA
Very High	1.13	9.41
High	4.05	33.70
Moderate	3.58	29.81
Low	3.16	26.29
Water	.09	0.79

4.9.4.1 Population

Direct threats to life or personal injury have not generally been documented or projected for expansive soils because of the nature of the hazard. The primary threat is economic.

4.9.4.2 Structures / Buildings

Damage to structures in Tulsa can be expected during and following any period of extended drought. This is especially true of structures built during a period of a drought followed by soaking rains that cause swelling of clays.

4.9.4.3 Critical Facilities

As Tulsa is developed, expansive soils could cause considerable damage to new critical facilities if built without structural mitigation strategies in mind. While this will not be an immediate impact to the ability of the City of Tulsa to respond, it could shorten the effective lifespan of such facilities, thereby requiring expenditures in the future to replace these structures. In addition, long-term structural damage to buildings housing vulnerable populations – schools, long-term care facilities, childcare centers – could place the residents at risk when the building is exposed to a natural hazard event in a sub-standard condition.

4.9.4.4 Infrastructure

Long referred to as the "unknown hazard," expansive soils may be a hazard with more of a future than a past. As Tulsa's infrastructure continues to age – particularly water and sewer lines built at the beginning of the last century with materials and techniques that would not meet today's codes – a prolonged period of drought could significantly speed and intensify infrastructure deterioration. For example, aging gas and water pipelines, especially when originally constructed in wet soil, can rupture during periods of extended drought. The rehabilitation of roads and aging central business districts will likely include the replacement of much of the city's infrastructure that lies underground, especially if located in expansive soils. The use of the more flexible PVC or HDPE piping could reduce the impact of expansive soils.

4.9.5 Conclusions

The history of Tulsa's expansive soil hazard is difficult to track. Neither the City nor Insurance Companies monitor damage to structures from expansive soils as the impact of a specific natural hazard. The City treats all such damage as a maintenance issue. According to City Engineers, the expansive soil hazard is routinely taken into account in engineering studies and construction practices for infrastructure projects, but not specifically documented.

Expansive soils develop gradually and are seldom a threat to the population, but can cause severe damage to improvements built upon them. With 51.5% of the soils within the city limits classified as having moderate to high shrink/swell potential and less than 4% in the "very high" category, the City of Tulsa has a moderate to high vulnerability to the damaging effects of expansive soils. Increased damage to structures could be expected during and following a period of extended drought, particularly for structures built during a drought.

4.9.5.1 Data Limitations

Data are limited for Tulsa-specific hazard risk, vulnerability, impacts, preventive measures, costs, and benefits for damage to buildings, critical facilities, and infrastructure due to a lack of specific record keeping, as referenced in Section 4.9.5.

4.9.5.2 Update Changes

Identified significant changes made from the 2003 City of Tulsa Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.9.5.3 Sources

Extreme Weather and Climate Events at National Climatic Data Center website: http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms.

FEMA Flood Insurance Statistics at Website: www.fema.gov/cis/OK.pdf.

Landslides and Expansive Soils in Oklahoma, at Web address: www.ou.edu/special/ogs-pttc/earthsci/landsl.htm. Oklahoma Geological Survey, Earth Sciences, October, 1998.

Multi-Hazard Identification and Risk Assessment, p. 122–125. Federal Emergency Management Agency, 1997.

Soil Surveys of Tulsa County, Oklahoma, U.S. Department of Agriculture, Soil Conservation Service, 1977.

Tulsa's Physical Environment, Bennison, A.P., et al. Tulsa Geological Society, 1973.

4.10 Wildfires

As more people make their homes in woodland settings in or near forests, rural areas, or remote mountain sites, they face the real danger of wildfire. Wildfires often begin unnoticed and spread quickly, igniting brush, trees, and homes.

Wildfires can move on three different levels. A *surface fire* is the most common type and burns along the surface of grasslands or forests, usually moving quickly through an area. A *ground fire* is usually started by lightning and burns on or below the forest floor in the humus layer down to the mineral soil, mostly by smoldering combustion. A *crown fire* has ascended from the ground into the forest canopy, spreads rapidly by wind and moves by jumping along the tops of trees.

While many people associate wildfires with forest fires, fast-moving grass and wildland fires are the biggest threat in Oklahoma

4.10.1 Hazard Profile

Wildfire is a serious and growing hazard over much of the United States, posing a great threat to life and property, particularly when it moves from forest or rangeland into developed areas. However, forest and grassland fires are a natural process, and help to maintain healthy ecosystems. Naturally occurring or non-native species of trees, brush, and grasses fuel wildfires.

Fire suppression is now recognized to have created a larger fire hazard, because live and dead vegetation accumulates in areas where fire has been excluded. In addition, the absence of fire has altered or disrupted the cycle of natural plant succession and wildlife habitat in many areas. Consequently, United States land management agencies are committed to finding ways of reintroducing fire into natural ecosystems (such as prescribed burning) while recognizing that fire fighting and some types of fire suppression are still important.

According to FEMA, as stated in the report *Multihazard, Identification and Risk Assessment*, there are four categories of wildfires experienced throughout the United States:

- **Interface or intermix** fires are fires that are fueled by both wildland vegetation and the built-environment.

- **Firestorms** are events of such extreme intensity that effective suppression is virtually impossible. They occur during extremely dry weather and generally burn until conditions change or available fuel is exhausted.
- **Prescribed fires** are those that are intentionally set or selected natural fires that are allowed to burn for beneficial purposes.
- **Wildland fires** are fueled by natural vegetation and typically occur in national forests and parks.

4.10.1.1 Location

Wildfires occur in virtually all of the United States. The western states, with their more arid climate and prevalent conifer and brush fuel types, are subject to more frequent wildfires.

A worker tries to help Tulsa firefighters put out a grass fire at 56th St. North and U.S. 169 northeast of Tulsa International Airport.

(Source: Tulsa World, 10/25/06)

Within the Tulsa City/County jurisdiction development in more remote and wooded areas, also referred to as the Wildland Urban Interface (WUI) continues to take place. Residential and business structures developed in close proximity to grassy and woody fuels will be natural risks for this event. In addition, wildland/grassland fires are a strong threat to agricultural areas such as farms and/or ranches, especially during the high risk fire season.

The U.S. Forest Service (USFS) figures for 1990 indicate that 25.7% of wildfires reported were caused by arson, debris burns caused 24%, and 13.3% were caused by lightning. Lightning can cause particularly difficult fires when dry thunderstorms move across an area that is suffering from seasonal drought. Multiple fires can be started simultaneously. In dry fuels, these fires can cause massive damage before containment.

Hazard events other than lightning have the potential to cause wildfires, such as earthquakes and high winds. For example, in 1991, winds gusting to 62 mph downed power lines, resulting in 92 separate wildfires in Washington State.

4.10.1.2 Extent (Magnitude/Severity)

Between 2002 and 2006, the Tulsa Fire Department made a total of 2,571 runs related to wildfires that burned 3,388 acres and did $186,161 in damage. Based on this limited data, Tulsa can expect about 514 wildfires each year that burn 678 acres per year (1.31 acres per fire) and do approximately $37,230 in damage. However, wildfires have been increasing in number and economic impact nation-wide, largely due to the rapid spread of both mobile homes and rural estates on the peripheries of most American cities. In the winter of 2005-2006, drought and high winds combined to spread several wildfire outbreaks into wind-whipped firestorms. Between mid-November 2005 and mid-January

2006, Tulsa County lost 1,667 acres to wildfires that also did $200 damage to a building in Tulsa. While the 2006-2006 wildfires cannot be considered "normal", they do illustrate the growing frequency and impact of this hazard.

The extent of a wildfire threat can be estimated by analysis of a number of variables, including plant and soil moisture content, humidity, temperature, the presence of drought conditions, and wind speed. Current Conditions are less than 200 on the following index but Conditions vary and can be found at http://www.wfas.us/content/view/32/49/

Fire: Keetch-Byram Drought Index, fire danger rating system, acres burned, fuel load;

The Keetch-Byram Drought Index (KBDI) is basically a mathematical system for relating current and recent weather conditions to potential or expected fire behavior. This system was originally developed for the southeastern United States and is based primarily on recent rainfall patterns.

The KBDI is the most widely used drought index system by fire managers in the south. It is also one of the only drought index systems specifically developed to equate the effects of drought with potential fire activities.

The result of this system is a drought index number ranging from 0 to 800 that accurately describes the amount of moisture that is **missing**. A rating of zero defines the point where there is no moisture deficiency and 800 is the maximum drought possible.

These numbers correlate with potential fire behavior as follows:

0 - 200 Soil and fuel moisture are high. Most fuels will not readily ignite or burn. However, with sufficient sunlight and wind, cured grasses and some light surface fuels will burn in spots and patches.

200 - 400 Fires more readily burn and will carry across an area with no gaps. Heavier fuels will still not readily ignite and burn. Also, expect smoldering and the resulting smoke to carry into and possibly through the night.

400 - 600 Fire intensity begins to significantly increase. Fires will readily burn in all directions exposing mineral soils in some locations. Larger fuels may burn or smolder for several days creating possible smoke and control problems.

600 - 800 Fires will burn to mineral soil. Stumps will burn to the end of underground roots and spotting will be a major problem. Fires will burn thorough the night and heavier fuels will actively burn and contribute to fire intensity.

Source: http://www.wfas.us/content/view/32/49/

A factor to include in the extent is the reality that wildfires leave problems behind them, even when the last ember is extinguished. Post-fire effects can trigger additional consequences that cascade into other serious hazard events. The loss of ground-surface cover from a fire and the chemical transformation of burned soils make watersheds more susceptible to erosion from rainstorms. Subsequent unchecked debris flows can then carry mud, rock, chemicals, and other debris into water supplies, reducing water quality.

It is impossible to fully assess the economic impact of wildfires due to incomplete reporting. However, the U.S. Forest Service compiles statistics for wildfires on federal lands and is the primary federal source of information. The City of Tulsa currently has class 1 on the FIRE Danger Rating System.

Fire Danger Rating System		
Rating	**Basic Description**	**Detailed Description**
CLASS 1: Low Danger (L) COLOR CODE: **Green**	Fires not easily started	Fuels do not ignite readily from small firebrands. Fires in open or cured grassland may burn freely a few hours after rain, but wood fires spread slowly by creeping or smoldering and burn in irregular fingers. There is little danger of spotting.
CLASS 2: Moderate Danger (M) COLOR CODE: **Blue**	Fires start easily and spread at a moderate rate	Fires can start from most accidental causes. Fires in open cured grassland will burn briskly and spread rapidly on windy days. Woods fires spread slowly to moderately fast. The average fire is of moderate intensity, although heavy concentrations of fuel – especially draped fuel -- may burn hot. Short-distance spotting may occur, but is not persistent. Fires are not likely to become serious and control is relatively easy.
CLASS 3: High Danger (H) COLOR CODE: **Yellow**	Fires start easily and spread at a rapid rate	All fine dead fuels ignite readily and fires start easily from most causes. Unattended brush and campfires are likely to escape. Fires spread rapidly and short-distance spotting is common. High intensity burning may develop on slopes or in concentrations of fine fuel. Fires may become serious and their control difficult, unless they are hit hard and fast while small.
CLASS 4: Very High Danger (VH) COLOR CODE: **Orange**	Fires start very easily and spread at a vary fast rate	Fires start easily from all causes and immediately after ignition, spread rapidly and increase quickly in intensity. Spot fires are a constant danger. Fires burning in light fuels may quickly develop high-intensity characteristics - such as long-distance spotting - and fire whirlwinds, when they burn into heavier fuels. Direct attack at the head of such fires is rarely possible after they have been burning more than a few minutes.
CLASS 5: Extreme (E) COLOR CODE: **Red**	Fire situation is explosive and can result in extensive property damage	Fires under extreme conditions start quickly, spread furiously and burn intensely. All fires are potentially serious. Development into high-intensity burning will usually be faster and occur from smaller fires than in the Very High Danger class (4). Direct attack is rarely possible and may be dangerous, except immediately after ignition. Fires that develop headway in heavy slash or in conifer stands may be unmanageable while the extreme burning condition lasts. Under these conditions, the only effective and safe control action is on the flanks, until the weather changes or the fuel supply lessens.
source: http://www.wfas.net/content/view/34/51/		

4.10.1.3 Frequency

According to the National Interagency Fire Center statistics for fires on federal lands from 1985 to 1994 (the latest year with full figures available), an average of nearly 73,000 fires occur each year, resulting in over 3 million acres burned, 900 homes lost, and more than $411.5 million expended in suppression costs.

The Tulsa area has three primary wild land fire seasons. The most volatile is February through April, when grass fuels are dead, the humidity low, temperatures elevated and winds as high as 50-70 mph. A moderate wildfire season occurs in July or August, when some grasses are dormant or dead from the mid-summer heat. The third wildfire season, also moderate, is in the fall, after frost has killed the annual grasses.

The State of Oklahoma had an average of 14,740 wildfires per year between 1999 and 2003, burning over one million acres and doing over $43.5 million in damage. Tulsa County experienced an average of 148 fires a year over the same period, with nearly 4,700 acres burned and $153,000 in damages. Tulsa County ranked 62nd in the state with an average of 934 acres burned per year, but ranked 47th out of 77 with an average of $32.71 damage per acre. Tables 4-37 and 4-38 detail wildfire activity and damages for the State of Oklahoma and Tulsa County.

4.10.1.4 History/Previous Occurrences

The single worst wildfire event in terms of deaths in United States history occurred in Wisconsin in 1871, killing 1,182 people. (FEMA 1990). (ibid., Multi Hazard, p. 239)

North Tulsa Fire, January, 2006

In 1994, one of the worst years since the early 1900s, 79,107 fires burned over four million acres and cost $934 million for suppression. Tragically, 34 firefighters lost their lives. On July 6, 1994, 14 firefighters died in one terrible incident during the South Canyon Fire just west of Glenwood Springs, Colorado.

According to the National Interagency Fire Center, Oklahoma reported 3,519 wildland fires destroying 69,907 acres for 2007. For the same year, local statistics show that Tulsa County fire agencies responded to 1,335 wildland fires destroying 7,829 acres – with Tulsa Fire Department responding to 750 wildland fires responsible for the destruction of 2,109 acres.

On June 5, 2008, the entire community of Gotebo, OK (population approximately 270, located in Kiowa County) was evacuated in response to an out-of-control grass fire fanned by 35-40mph winds accompanying a storm system. Oklahoma authorities reported power lines from a pole knocked down by strong winds ignited the fire. In all, 2 homes and one barn were destroyed with approximately 50 additional homes receiving smoke or water damage, and one fire fighter was injured while battling the blaze. The fire consumed approximate 350 acres before fire crews were able to contain it later that evening.

Table 4–37: Oklahoma Grass and Crop Fires, 2002-2006
Source: Oklahoma State Fire Marshal

Year	*Runs*	*Acres Burned*	*Damages*
2002	13,088	149,806	$4,283,271
2003	16,200	286,991	$8,551,634
2004	12,880	248,325	$6,062,907
2005	18,584	918,128	$20,818,700
2006	18,566	659,622	$21,447,445
Total	**79,318**	**2,262,872**	**$61,163,957**
Average	**15,864**	**452,574**	**$12,232,791**

Table 4–38: City of Tulsa Grass and Crop Fires, 2002-2006
Source: Oklahoma State Fire Marshal

Year	Runs	Acres Burned	Damages
2002	412	86	$27,163
2003	437	264	$16,961
2004	387	178	$10,377
2005	585	751	$37,716
2006	750	2,109	$93,944
Total	**2,571**	**3,388**	**$186,161**
Average	**514.2**	**677.6**	**$37,232**

4.10.1.5 Probability/Future Events

The continuing alarming spread of Eastern Red cedar in open grassland, and the abundant fuel load in place from heavy rains and other naturally occurring events (2 ice storms within 12 months) – combined with the historical data available demonstrates that the threat of wildland/grass fires will continue to be a regularly occurring event in and around this jurisdiction. In addition, suburban growth in the wildland interface will be a significant factor in the potential increase in number of wildfires occurring. (See below)

4.10.2 Existing Vulnerability

Because more people are choosing to build expensive homes on acreage in rural settings, surrounded by grasslands and forest, the danger of wildland urban interface fire has increased enormously. This is particularly true of Tulsa, with its growing population and upscale economy. While most grasslands of the U.S. have a fuel load of 1,000 to 2,000 lb. per are, around Tulsa it is between 6,000 and 10,000 lbs. per acre.

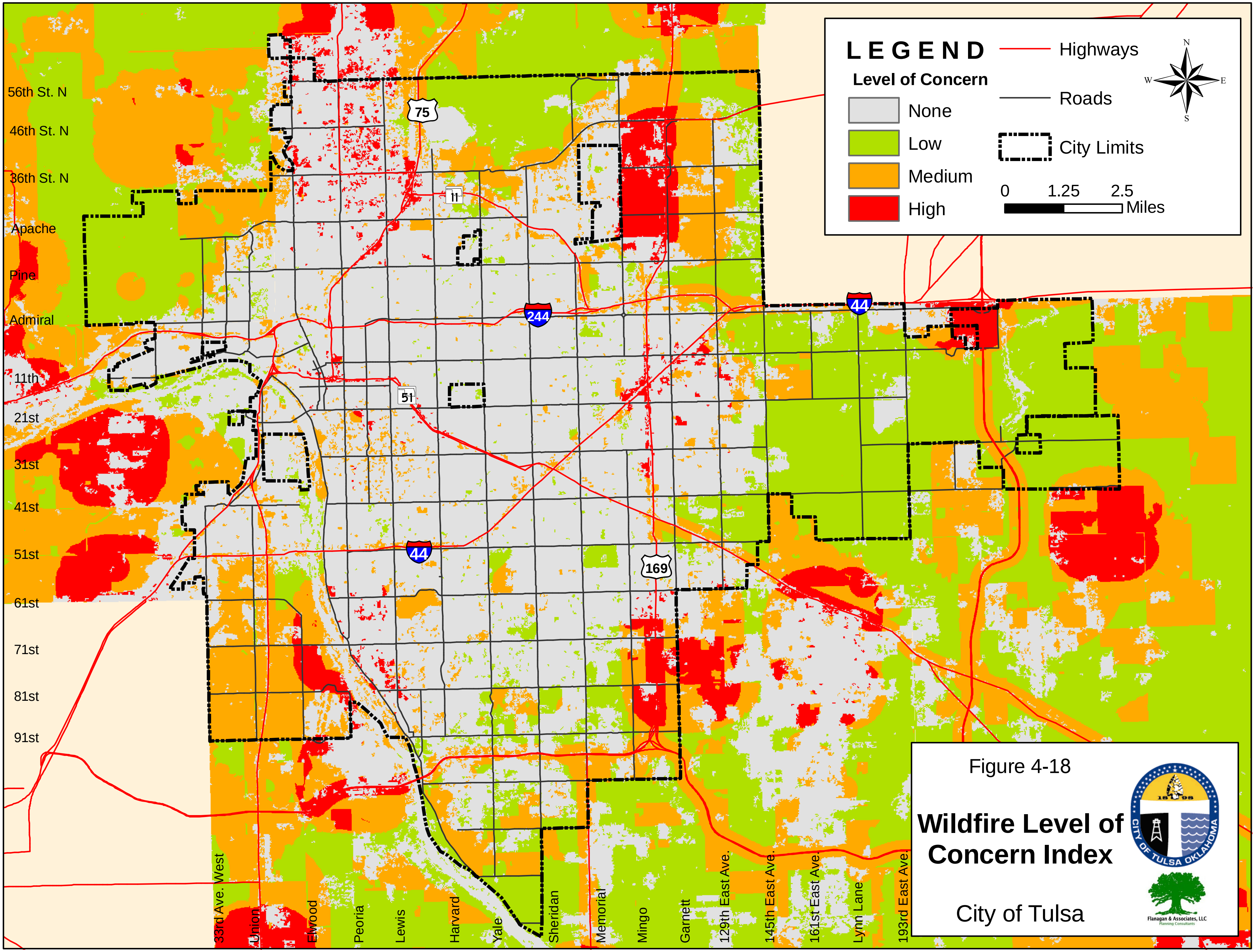
The wildland fire danger in the Tulsa urban fringe is made even higher by the spread of Eastern Red Cedar, which grows close to the ground, has fine foliage, thin bark and contains volatile oils. When it catches fire, the Eastern Red Cedar explodes into flame, showering sparks to the wind. Vulnerable Urban-Wildland Interface areas are shown on the map in Figure 4-18.

4.10.2.1 Population

As evidenced by the 2005-2006 wildfire outbreaks, the rural and urban/wildland interface areas of Tulsa are vulnerable to wildfires. Deaths and injuries with wildfires have been very low in the state, and largely confined to firefighters.

4.10.2.2 Structures/Buildings

Any structures/buildings constructed within the Wildland Urban Interface area or on ranches/farms situated in grassy/wooded areas should be considered at risk to the effects of a wildfire event.



LEGEND
Level of Concern
None
Low
Medium
High
Highways
Roads
City Limits
0 1.25 2.5 Miles
N
S
E
W
56th St. N
46th St. N
36th St. N
Apache
Pine
Admiral
11th
21st
31st
41st
51st
61st
71st
81st
91st
33rd Ave. West
Union
Elwood
Peoria
Lewis
Harvard
Yale
Sheridan
Memorial
Mingo
Garnett
129th East Ave.
145th East Ave.
161st East Ave.
Lynn Lane
193rd East Ave.
75
11
244
44
51
169
Figure 4-18
Wildfire Level of Concern Index
City of Tulsa
CITY OF TULSA OKLAHOMA
Flanagan & Associates, LLC

4.10.2.3 Critical Facilities

Critical facilities such as medical care facilities, resident care homes, daycare facilities, and utility out-stations located in these high-risk areas should be considered vulnerable to the effects of wildfires. Critical facilities at risk are shown on Figure 4-18.

Table 4–39: Critical Facilities with some Vulnerability to Wildfire
(SFRAS – Level of Concern Calculations)

ID	Name	Threat
AL12	Sterling House of Tulsa – South	High
CC2	ABC Preschool – Fellowship Bible Church	Low
CC20	Hope Worship Center	Medium
CC28	KinderCare Learning Center	Low
CC29	KinderCare Learning Center	Medium
CC39	Riverfield Country Day School	Medium
CG2	Tulsa City – County Health Dept. Main Office	Medium
FD26	Tulsa Fire Station #30	Low
FD32	Tulsa Fire Station #6	Medium
FG10	USPS – American Heritage Bank	Medium
HO8	Tulsa Spine & Specialty Hospital	Medium
HO10	SouthCrest Hospital	High
HO11	Saint Francis Heart Hospital	High
HO12	Southwestern Regional Medical Center	Medium
IL92	Town Village	Low
JC9	Tulsa Community College – Southeastern Campus	High
JMS1	Jenks – Middle School	Low
ML	Montereau in Warren Woods	Low
PS7	Lincoln Christian School	Low
PS16	Riverfield Country Day School	Medium
UES3	Union – Cedar Ridge Elementary School	Medium
UES8	Union – Rosa Parks Elementary School	Low
UES9	Union – Thomas Jefferson Elementary School	Medium
WD21	Tower Site	Medium
WW4	Lift Station	Medium

4.10.2.4 Infrastructure

Water Treatment – Most significant effect during most major events would be from loss of electrical power. Additional threat from wildfire is not currently documented for facilities of this nature.

Wastewater Treatment – Most significant effect during most major events would be from loss of electrical power. Additional threat from wildfire is not currently documented for facilities of this nature.

Utilities- The primary utility providers for Tulsa's jurisdiction are AEP/PSO (electricity) and ONG (natural gas). **Electricity**: The largest threat to the delivery of electrical service would be the destruction/damage of power poles/lines.

Transportation Systems (Highways, Public Transportation, Railway, Airports) – Roadway inaccessibility would be the largest vulnerability posed to the transportation system during a Wildfire event. During a wildfire located near a major highway, it may become necessary to close a section of highway or divert traffic along that route. Roads and bridges in the more rural portions of the City's jurisdiction would be at greater risk during a widespread event as they are located in closer proximity to fields/grasslands that could become involved in a wildfire.

Emergency Services- Fire, Police and Medical Services would all be similarly at risk to effects of a Wildfire event. During a severe outbreak of wildfire, roads may become impassable, therefore potentially isolating portions of the community to vital services and/or supplies. While an event of that scope affecting the entire community of Tulsa would be improbable, the possibility of a more remote portion of the city located on the outlying boundaries would not be out of the question. These small pockets of residential developments in the more rural settings of the city, along with any businesses/utilities supporting them in the immediate area, are especially at risk in the event of a large wildfire event.

4.10.3 Wildfire Scenario

The Tulsa Fire Department has determined that their emergency response would be sufficient in any identified high vulnerability areas that structural loss or loss of life would be minimal compared to a wildfire striking a rural area, or a community with a greater percentage of exposure. The Public Information Officer for the Fire Department states "Worst case scenario…would be injury to one civilian, firefighter, or loss of a piece of property." No more than 4-5 structures should be affected, with no more than 1-2 suffering major damage before the incident would be brought under control. Most of Tulsa's "grass rigs" are in the interface areas on the fringes of the City. During the height of wildfire season, they add or relocate resources to augment protection of vulnerable areas based on identifiable risk.

4.10.4 Future Trends

4.10.4.1 Population

With many locations of planned development lying within the urban/rural interface to the west and south of the city, future development areas will be at higher risk to wildfires. It is not anticipated that deaths and injuries would be a greater percentage than it already is.

4.10.4.2 Structures/Buildings

As development in areas identified as "at risk" within the Wildland Urban Interface progresses, any structures and/or buildings constructed as a part of that development would be at risk during a wildfire event.

4.10.4.3 Critical Facilities

Special care should be exercised to ensure the appropriate location of any new critical facilities such as medical care facilities, day care centers, utility outstations etc., and that such facilities are constructed / retrofitted utilizing proper fire resistant building and landscaping practices.

4.10.4.4 Infrastructure

As these areas continue to develop, roadways, utility access, emergency services and other support businesses will also be at risk for a wildfire event and should be planned for appropriately.

4.10.5 Conclusions

Wildfires are a serious and growing hazard because people continue to move their homes into woodland areas. The value of the property exposed to wildfires is increasing more rapidly, especially in the western states.

There were fire suppression measures taken in the past that caused an even greater fire hazard because ground cover that had been burning at natural intervals was able to build up. Western ecosystems have adapted to and have become dependent on wildfires, which play an essential role by thinning forests and creating stands of different plant species. Land management agencies are now changing their policies concerning the control of naturally occurring wildfires.

As shown during the rash of wildfire in the winter of 2005-2006, the areas of the City of Tulsa that are in the wildland/urban interface are at moderate to high risk to wildfires, and at severe risk during times of high wind and drought. However, that vulnerable area is a relatively low percentage of the total area of the community. So, the City of Tulsa's overall risk would be considered low to moderate.

4.10.5.1 Data Limitations

Data to the State Fire Marshall's office is frequently turned in well from localities over a year after the year in which events occurred, and takes time following that to enter into the state database. Consequently, complete data is frequently 1-2, or more, years behind. In addition, the Fire Marshall's office does not list actual number of wildfire events, but number of "fire department runs." The Tulsa Fire Department may send a unit for a small grassfire in a center median, which does not show up as a grassfire in the NCDC database. Also, for a larger wildfire complex, many runs may be made for the event to separate locations for a period of time. Hence, we have 6 Wildfire "events" listed by the National Climatic Data Center for the 1998-2007 period, but 2,571 "runs" during the most recent 5 year period for which the state's office has complete data.

4.10.5.2 Update Changes

Identified significant changes made from the 2003 City of Tulsa Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.10.5.3 Sources

Insurance Information Institute at Web address: www.iii.org

FireWise Communities USA at Web address: www.firewise.org

National Interagency Fire Center at Web address: www.nifc.gov/fire_info

Multihazard, Identification and Risk Assessment, p. 234, 236, 239. Federal Emergency Management Agency, 1997.

Oklahoma State Fire Marshal, "Fire Statistics 1997-2004," at web address: www.state.ok.us/~firemar/index.htm. Office of the Oklahoma State Fire Marshal

Talking About Disaster: Guide for Standard Messages, "Wildfire," p. 135. National Disaster Coalition, Washington, D.C., 1999.

USGS Wildland Fire Research, at Web address: www.usgs.gov/themes/Wildfire/fire.html. U.S. Geological Survey, August 23, 2000.

4.11 Earthquakes

An earthquake is a sudden, rapid shaking of the ground caused by the fracture and movement of rock beneath the Earth's surface. Most severe earthquakes take place where the huge tectonic plates that form the Earth's surface collide and slide slowly over, under, and past each other. They can also occur along any of the multitude of fault and fracture lines within the plates themselves.

The faults most likely to affect Oklahoma are the New Madrid Fault, centered in the Missouri Bootheel region, the Meers Fault, located in southwestern Oklahoma near Lawton, and the Nemaha Fault, running north from Oklahoma up through Topeka KS.

4.11.1 Hazard Profile

Although located in the relatively quiet Central Plains Province, nearness to the New Madrid, Missouri, fault exposes some Oklahoma communities to VI intensity tremors

As the Earth's crust moves and bends, stresses are built up, sometimes for hundreds of years, before suddenly breaking or slipping. This abrupt release of accumulated tension can be devastating to human communities on the surface.

The destructiveness of an earthquake depends upon a number of factors, including the magnitude of the tremor, direction of the fault, distance from the epicenter, regional geology, local soils, and the design characteristics of buildings and infrastructure, such as roads, bridges, and pipelines.

Earthquake intensity can be significantly affected by the stability of underlying soils. For example, during the Northridge, California earthquake, three times as much damage was done to single-family homes and buried utilities in ground failure zones than in nearby areas where the footing was more solid. In addition, the intensity of West Coast tremors is dissipated by the relative "warmth" of the region's geology. By contrast, the thick Pennsylvanian sandstone and limestone strata of the central United States are much more efficient conductors of tremors. Consequently, a 6.8-magnitude earthquake in the New Madrid Fault would have a much wider impact than a comparable event on the California coast.

Urbanization is probably the most important factor in translating earthquake magnitude into human impacts. In the continental United States, Alaska has the greatest number of large earthquakes—over a dozen above 7.3 magnitude between 1899 and 1999. However, these severe quakes resulted in relatively little loss of life or damage, since all but one occurred in uninhabited areas.

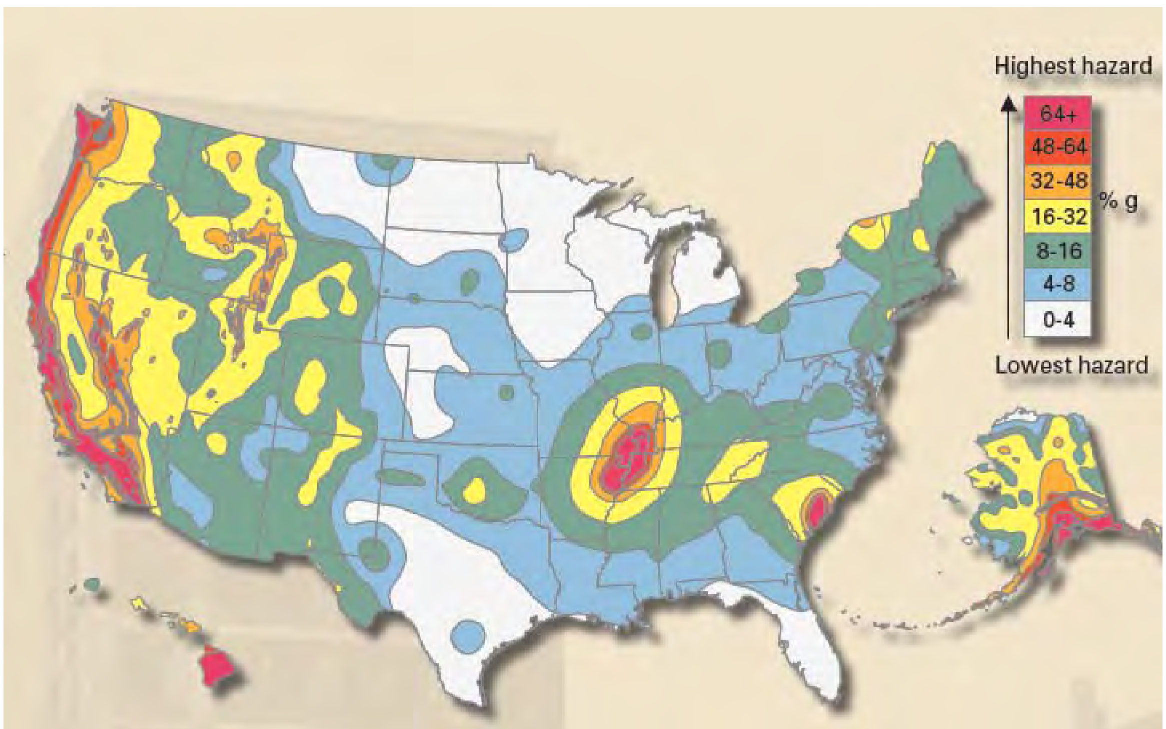
Effects

Earthquakes can cause poorly compacted, clay-free soils to temporarily lose strength and behave like viscous fluids rather than solids. This “liquefaction” can result in ground failure and damage to structures and buried utilities.

4.11.1.1 Location

In the United States, California experiences the most frequent damaging earthquakes, and Alaska has the greatest number of large earthquakes.

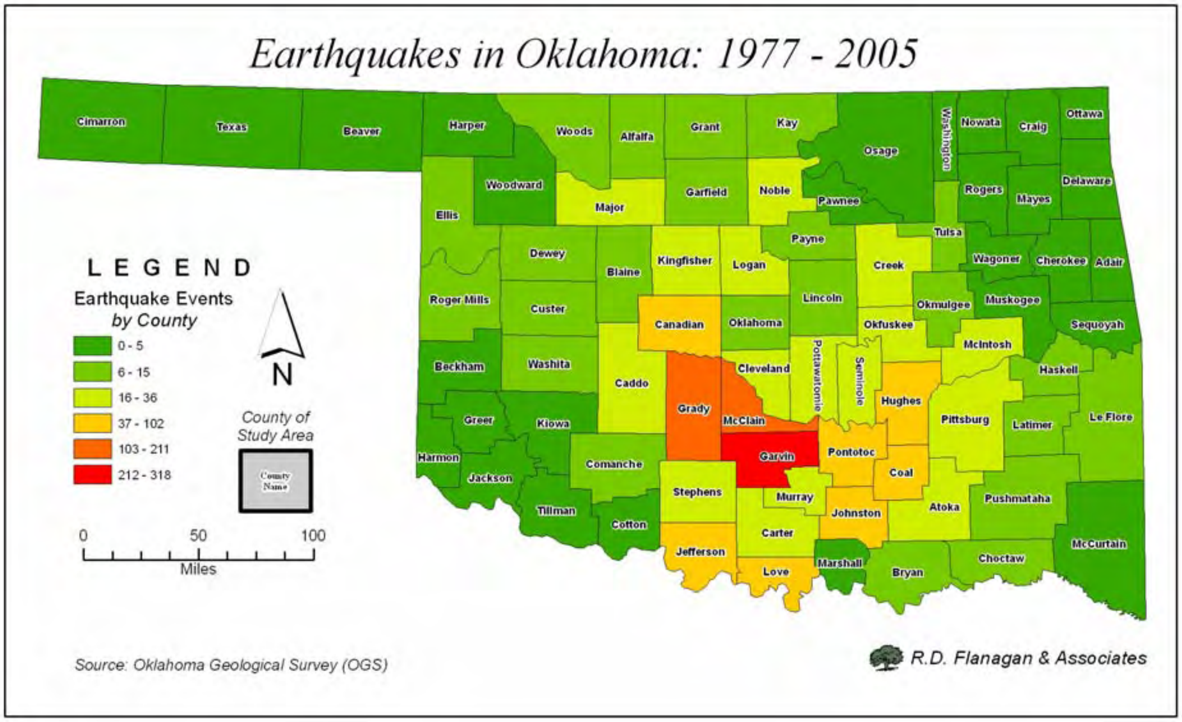
Oklahoma has experienced an average of 50 earthquakes each year since records have been kept by the Oklahoma Geological Survey. Most of these earthquakes were so small that they could not be felt by people. Only about two or three per year have been large enough to be felt and most were so small they caused no damage. As shown in the figure below, the majority of Oklahoma earthquakes are concentrated in Garvin, Grady, and McClain counties in south central Oklahoma where the Ouachita, Arbuckle and Wichita mountains converge. The City of Tulsa is at low-risk from earthquakes.



Colors on this map show the levels of horizontal shaking that have a 2-in-100 chance of being exceeded in a 50-year period. Shaking is expressed as a percentage of g (g is the acceleration of a falling object due to gravity.) – (Source: USGS, 2008 US Nat’l Seismic Hazard Maps)

4.11.1.2 Extent

Tulsa County has experienced 10 reported earthquakes since 1900, but only one of these was a “felt” event, and that one was in December, 1900, centered in Cushing.



FEMA's HAZUS software application provides a methodology to estimate earthquake losses at a regional scale. Building and population statistics from the U.S. Census are combined with estimated replacement values for local infrastructure to calculate potential losses from a specified earthquake event. The historic 5.5 magnitude El Reno earthquake event of April 9, 1952, was used as a "worst case" input event in the HAZUS model and run for the City of Tulsa.

A 5.7 magnitude event centered on the Nemaha fault in the El Reno area would not adversely affect any structures in the City of Tulsa, City of Tulsa critical facilities or populations living within the City of Tulsa city limits.

The historic 7.7 magnitude earthquake event of 1811 in Arkansas at Historical Epicenter ID # 266 was used to verify the impact from the New Madrid fault. A 7.7 magnitude event on the New Madrid fault would not adversely affect any structures in the City of Tulsa, City of Tulsa critical facilities or populations living within the City of Tulsa city limits.

Based on the results of the scenarios run using the HAZUS-MH model, the extent of damages from an earthquake are very low and would fall in the 0-4.3 range on the Richter scale.

4.11.1.3 Frequency

Tulsa County experienced six earthquakes between 1977 and 2005 (when formal seismic records were initially recorded), or 0.21 per year, none of which were "felt" earthquakes. None of the earthquakes was centered in the City of Tulsa, so a "low" probability score was awarded in the hazard analysis.

The Meers Fault has had two major ruptures in the last 3,000 years, the last one about 1,600 years ago. If the fault has a 1,500-year periodicity, it could be due for a major event in the next one or two hundred years.

The most likely major earthquake event that could impact the area would probably originate in the New Madrid Fault Zone, which has been relatively quiet for 150 years.

Seismologists estimate the probability of a 6 to 7 magnitude earthquake in the New Madrid area in the next 50 years to be higher than 90 percent.

According to Randy Keller, interim State Geologist for the Oklahoma Geological Survey, “The New Madrid seismic zone, centered in New Madrid, Mo., produced major earthquakes in the past, and the area affected was quite large. Oklahomans would feel an earthquake from that area if another large one happens.”

“It would shake Tulsa quite a bit. I’m not saying it would be a huge amount of damage, but we would know it had occurred,” he said. “It would cause some minor damage in the eastern part of the state. And whether or not damage happened here, Oklahoma would be a key player in providing relief.”

“The biggest impact in Oklahoma will be dealing with victims and dealing with other states,” said Gary Patterson, geologist with the Center for Earthquake Research and Information at the University of Memphis in Tennessee.

Oklahoma officials have agreed to aid other states in case of an earthquake. The Sooner State is one of nine associate members of the Central United States Earthquake Consortium.

Measurements

Modern seismological technology has greatly enhanced the capability of scientists to sense earthquakes. Before the development of today’s delicate sensors, only “felt” earthquakes were captured in the historical record.

Scientists use two standard measures to classify an earthquake’s extent: *magnitude* and *intensity*. These measures are sometimes referred to as the Richter Scale (magnitude) and the Modified Mercalli (intensity).

Magnitude is an Arabic number representing the total amount of energy released by the earthquake source. It is based on the amplitude of the earthquake waves recorded on seismographs that have a common calibration. The magnitude of an earthquake is thus represented by a single, instrumentally determined value.

Intensity, expressed as a Roman numeral, is based on the earthquake’s observed effects on people, buildings and natural features. It varies depending on the location of the observer with respect to the earthquake’s epicenter. In general, the intensity decreases with distance from the fault, but other factors such as rupture direction and soil type also influence the amount of shaking and damage. The Modified Mercalli and Richter Scales are compared in Table 4-40.

Table 4–40: Comparison of Mercalli and Richter Scales

Mercalli	***Richter***	***Description***
I	0-4.3	Vibrations are recorded by instruments. People do not feel any Earth movement.
II		A few people might notice movement if they are at rest and/or on upper floors of tall buildings.
III		Shaking felt indoors; hanging objects swing. People outdoors might not realize that an earthquake is occurring.

Mercalli	Richter	Description
IV	4.3-4.8	Dishes rattle; standing cars rock; trees might shake. Most people indoors feel movement. Hanging objects swing. Dishes, windows, and doors rattle. A few people outdoors may feel movement.
V		Doors swing; liquid spills from glasses; sleepers awake. Almost everyone feels movement. Dishes are broken. Pictures on the wall move. Small objects move or are turned over. Trees shake.
VI	4.8-6.2	People walk unsteadily; windows break; pictures fall off walls. Everyone feels movement. Objects fall off shelves. Furniture moves. Plaster in walls may crack. Trees and bushes shake. Damage is slight in poorly built buildings. No structural damage.
VII		Difficult to stand; plaster, bricks, and tiles fall; large bells ring. Drivers feel their cars shaking. Some furniture breaks. Loose bricks fall from buildings. Damage is slight to moderate in well-built buildings; considerable in poorly built buildings.
VIII	6.2-7.3	Chimneys fall; branches break; cracks in wet ground. Drivers have trouble steering. Houses that are not bolted down might shift on their foundations. Tall structures such as towers and chimneys might twist and fall. Well-built buildings suffer slight damage. Poorly built structures suffer severe damage. Water levels in wells might change.
IX		General panic; damage to foundations; sand and mud bubble from ground. Well-built buildings suffer considerable damage. Houses that are not bolted down move off their foundations. Some underground pipes are broken. The ground cracks. Reservoirs suffer serious damage.
X		Most buildings destroyed; large landslides; water thrown out of rivers and lakes. Some bridges are destroyed. Dams are seriously damaged. The ground cracks in large areas. Railroad tracks are bent slightly.
XI	7.3-8.9	Roads break up; large cracks appear in ground; rocks fall. Most buildings collapse. Some bridges destroyed. Underground pipelines destroyed. Railroad tracks badly bent.
XII		Total destruction; "waves" seen on ground surface; river courses altered; vision distorted. Almost everything is destroyed. Objects are thrown into the air. Large amounts of rock may move.

4.11.1.4 History/Previous Occurrences

World history is punctuated with hundreds of earthquake catastrophes. In 1556 the Shansi, China, earthquake killed 800,000 people. An earthquake in Lisbon in 1775 took 70,000 lives. More recently, a moderate 6.7-magnitude earthquake struck Northridge, California, on January 17, 1994, killing 57 people, injuring 9,000, and causing over $25 billion in damage. A year later, in Kobe, Japan, a 6.9 magnitude tremor killed 5,100 people, injured 27,000, destroyed 100,000 buildings, and did $120 billion in damage.

In the United States, California and Alaska have earthquakes the most frequently, but the largest earthquake felt in the United States in historical times occurred in Missouri, along the New Madrid Fault. There, in 1811 and 1812, three earthquakes larger than a magnitude 8 totally destroyed the town of New Madrid, caused the land to roll in visible waves, raised and sank land as much as 20 feet, and formed and emptied lakes. The tremors rang bells in church steeples as far away as Boston, Massachusetts. These earthquakes were probably the first ones felt by residents in Oklahoma in historical times. Intensity VII earthquakes hit the New Madrid area again in January 1852 and June 1862.

Oklahoma Earthquakes

The earliest documented quake in what is now Oklahoma occurred on October 22, 1882, near Ft. Gibson, Indian Territory. The *Cherokee Advocate* reported that "the trembling and vibrating were so severe as to cause doors and window shutters to open and shut, hogs to squeal, poultry to run and hide, and cattle to low." Other significant Oklahoma earthquakes include the following:

April 9, 1952 – The largest earthquake on record in the state – a VII-intensity event that registered 5.7 on the Richter Scale – happened near El Reno. It was apparently caused by slippage along the Nemaha Fault. The tremor toppled chimneys and smokestacks, cracked bricks on buildings, broke windows and dishes, and was felt as far away as Austin, Texas, and Des Moines, Iowa.

May 2, 1969 – A 4.6 magnitude, V intensity quake occurred at Wewoka, in Seminole County, causing cracks in plaster walls.

September 6, 1997 – A 4.4 earthquake shook Ada, in Pontotoc County, and rattled dishes as far away as Holdenville. The epicenter was 10 miles southeast of Ada, near Stonewall, at a depth of 15 km.

April 28, 1998 – One of the largest earthquakes recorded in Oklahoma, measuring 4.2 on the Richter Scale, occurred near Lawton, at Richard's Spur, in Comanche County. The quake rattled dishes and caused a 14-foot crack to appear in the second floor of the Comanche County courthouse building.

February 8, 2002 – A 3.8 magnitude earthquake was detected 5.6 miles north of Lawton. The quake passed from northeast to southwest with a rolling motion that lasted about 1.5 seconds. The tremor was described as moderate, which shook houses with a kind of rolling sensation rather than hard shaking. Pictures were knocked over on dressers.

4.11.1.5 Probability/Future Events

The City of Tulsa and its future development areas are at low risk from earthquakes. Any earthquake risk would most likely come from proximity to the New Madrid and Meers faults. The potential area that an earthquake would affect, due to the nature of earthquakes, is the entire City of Tulsa. According to Dr. James Lawson, chief geophysicist of the Oklahoma Geological Survey's Seismic Observatory at Leonard, the risk of an earthquake in the New Madrid Fault Zone should not be over emphasized. He believes a major seismic event there would have no greater impact on Tulsa than a locally generated earthquake. An 8-magnitude event in New Madrid would likely produce only VI-intensity tremors in Oklahoma, and would not be as severe as the Ft. Gibson quake of 1882.

4.11.2 Existing Vulnerability

Most earthquake injuries and fatalities occur within buildings from collapsing walls and roofs, flying glass, and falling objects. As a result, the extent of a community's risk depends not just upon its location relative to a known fault, and its underlying geology and soils, but also on the design of its structures. Buildings constructed to earlier seismic standards (or to no standard) can pose major threats to life and the continued functioning of key public services during an earthquake disaster. Un-reinforced masonry structures are the most vulnerable, while wood frame structures typically perform well. Of special concern are the design and construction of critical facilities such as hospitals and transportation facilities, oil and gas pipelines, electrical power and communication facilities, and water supply and sewage treatment facilities.

4.11.3 Earthquake Scenario

HAZUS, a software application developed by the Federal Emergency Management Agency and the National Institute of Building Sciences, provides a methodology to estimate earthquake losses at a regional scale. Building and population statistics from the U.S. Census are combined with estimated replacement values for local infrastructure to conclude an estimate on potential damages and losses to be expected within the region from a specified earthquake event.

The historic, 5.7 magnitude, El Reno earthquake event of April 9, 1952 was used as the input event in the HAZUS model run for the City of Tulsa. Affecting most of the State and parts of Arkansas, Iowa, Kansas, Missouri, Nebraska, and Texas, historically, this is Oklahoma's largest earthquake event.

For Tulsa, HAZUS estimated 144,139 buildings in the region with a total building replacement value of $35,361,000,000. Approximately 96% of the buildings and 72% of the building values are for residential housing.

HAZUS estimates that zero structures would have extensive damage, zero buildings would have moderate damage, and zero would have slight damage.

All essential facilities, including schools, the EOC, and Police and Fire Stations would receive zero damages. Functional losses to these facilities are considered non-existent.

Transportation system damages and economic losses associated with these systems are estimated at 0%. All utility system facilities, pipeline activity, electric power and potable water should be at 100% following the event. It is estimated that none of the 144,139 buildings in Tulsa would be affected with a power failure or loss of potable water. HAZUS estimates that no debris will be generated by the earthquake.

The scenario estimates casualties for three peak occupancy loads throughout the day, 2:00 AM (residential occupancy peak), 2:00 PM (non-residential occupancy peak) and 5:00 PM (commute peak). Zero minor injuries requiring medical attention is expected from the event at 2:00 AM, 2:00 PM, or 5:00 PM.

The total economic loss for the earthquake is estimated at $0. This includes building and lifeline related losses.

4.11.4 Future Trends

Based on a HAZUS analysis that worst-case scenario creates zero damage to life, health, and structural integrity for the City of Tulsa, there is no reason to believe that any future development will be impacted in any way.

4.11.5 Conclusion

Tulsa County experienced six earthquakes between 1977 and 2005 or 0.21 per year, none of which were “felt” earthquakes. None of the earthquakes was centered in the City of Tulsa, so a “low” probability score was awarded in the hazard analysis. As calculated using HAZUS software, an El Reno earthquake similar to the 1952 quake would cause an estimated $0 in damages. However, almost all Oklahoma earthquakes are too small to be felt and cause no visible damage.

4.11.5.1 Data Limitations

While the HAZUS software is very comprehensive, structural integrity and Code requirements for a jurisdiction can greatly affect the actual damage taken by structures. Earthquake resistant construction is not something routinely considered in Oklahoma, so damages are not as accurate as they might be in a jurisdiction such as a California community, where earthquake resistant construction and analysis are routinely more studied.

4.11.5.2 Update Changes

Identified significant changes made from the 2003 City of Tulsa Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.11.5.3 Sources

Oklahoma Geophysical Observatory Examines Earthquakes in Oklahoma, at Web address: http://www.ogs.ou.edu/earthquakes.htm. University of Oklahoma, 1996.

Oklahoma Strategic All-Hazards Mitigation Plan, “Hazard Identification and Vulnerability Assessment,” p 7. Oklahoma Department of Emergency Management, September 2001.

Program Statement, at Web address: www.cusec.org. Central United States Earthquake Consortium.

Talking About Disaster: Guide for Standard Messages, “Earthquake,” p. 41–49. National Disaster Coalition, Washington, D.C., 1999.

Von Hake, Carl A. *Earthquake History of Oklahoma*, Abridged from Earthquake Information Bulletin, Vol.8, Number 2. USGS National Earthquake Information Center, March–April 1976.

4.12 Dam and Levee Failures

Dams. The Federal Emergency Management Agency (FEMA) defines a dam as "a barrier constructed across a watercourse for the purpose of storage, control, or diversion of water." Dams typically are constructed of earth, rock, concrete, or mine tailings. A dam failure is the collapse, breach, overtopping or other failure resulting in downstream flooding.

Levees. A levee is an embankment or barrier of compacted soil designed to keep floodwaters away from buildings or other investments. Levees are considered "structural" flood control projects, and are generally constructed to protect floodplain development. Until the late 1960s, structural measures such as levees were the dominant approach to riverine floodplain management. Currently, however, under the National Flood Insurance Program (NFIP) regulations, levees are not recognized as acceptable measures for protecting new, substantially improved, or substantially damaged structures.

Measurement

The amount of water impounded in the reservoir behind a dam is measured in acre-feet. An acre-foot is the volume of water that covers an acre of land to a depth of one foot, or approximately 325,000 gallons. Even a very small dam may contain many acre-feet or millions of gallons of water.

A release of 40,000 cubic feet per second (cfs) from Keystone Dam, upstream of the City of Tulsa

Water discharge is measured in cubic feet per second (cfs). A cubic foot contains about 7.5 gallons of water. One cubic feet per second equals about 450 gallons per minute.

An artificial water barrier that has a height of 25 feet or more from the natural streambed and 50 acre-feet or more of storage capacity qualifies as a dam and is under the jurisdiction of the Oklahoma Water Resources Board (OWRB). The OWRB classifies dams as high-hazard, significant-hazard, and low-hazard, depending on the amount of water stored and downstream populations.

A **high-hazard dam** is one that has occupied dwellings immediately downstream – it does not mean that the dam is at risk of failing. A **significant hazard dam** is one that poses no threat to life, but whose failure may interrupt some road or pubic utility services. If a high-hazard dam fails, there probably will be loss of life. This designation does not mean that a dam is in need of repair—it could be in excellent condition or in poor condition. "High-hazard" simply reflects a dam's potential for doing damage downstream if it were to fail.

4.12.1 Hazard Profile

A break in a dam or levee produces an extremely dangerous flood situation because of the high velocities and large volumes of water. In the event of a dam or levee failure, the potential energy of the water stored behind even a small dam or levee can cause great property damage, as well as loss of life if there are people downstream from the dam or behind the levee.

The extent of this inundation may be minimal to uninhabited farmland or catastrophic in nature in an urban environment.

Dams. Dam failures are primarily caused by hydrologic or structural deficiencies. A hydrologic deficiency is inadequate spillway capacity caused by excessive runoff from heavy precipitation. Structural deficiencies include seepage, erosion, cracking, sliding, and overturning, mainly caused by the age of a dam and lack of maintenance. The operation of a reservoir can also influence the safety of the structure.

There can be varying levels of dam failure. Partial dam failures include inadequate spillway capacity that causes excess flow to overtop the dam; and internal erosion through the dam or foundation.

Complete failure occurs if internal erosion or overtopping results in a total structural breach, releasing a high-velocity wall of debris-laden water rushing downstream, damaging or destroying everything in its path.

Flooding can occur downstream from a dam without the structure being breached. Sometimes, to prevent overtopping and catastrophic failure, dams are forced to make emergency releases of large amounts of water, which can cause downstream flooding.

Levees. Levee failures or damages behind levees can be caused by several occurrences:

- Overtopping due to flood heights exceeding the levee design-protection elevation
- Flooding from upstream sources internal to the levee
- Erosion caused by embankment leaking or “piping” or excessive saturation of a sand levee. “Piping” is internal erosion caused by seepage, and can occur around pipes, through animal burrows, around roots of trees, and other weaknesses.
- Improper operation and maintenance, including failure to inspect and repair seepage problems or manage vegetation.

The failures of levees along the Mississippi River in 1993 and in New Orleans after Hurricane Katrina in 2005 have focused new attention on the inherent hazards of levees.

Levee failures can cause catastrophic floods, releasing sudden walls of water that can sweep across lands thought to be protected by the structure. Thus, levees and dams may create a false sense of security, increasing the amount of property at risk of flooding as people and businesses locate behind levees and floodwalls, believing they are totally safe. In addition, levees, dams, and other structural measures are extremely costly and can disrupt or destroy the natural environment.

4.12.1.1 Location

Inventory

Oklahoma dams. Oklahoma has 4,500 dams (including private structures), with approximately half operated by the Natural Resources Conservation Service (NRCS). The Oklahoma Water Resources Board coordinates the Oklahoma Dam Safety Program that requires annual inspections and emergency action plans for the state’s 165 high-hazard dams.

***Tulsa dams*.** There are 14 dams either within the City of Tulsa or of concern to Tulsans. These structures are described in Table 4-41 below and shown on Figure 4-19.

Keystone and three other high hazard dams would have a direct impact on the City of Tulsa if a failure were to occur. These four high hazard dams are included in the following table.

Table 4–41: Tulsa dams and levees

Keystone Dam	
Location	On Arkansas River, 10 miles west of Tulsa
Source	Arkansas River
Owner/operator	U.S. Army Corps of Engineers
Year built	1964 (with an estimated useful life of 50 years)
Length/ Height	4,600 feet/ 121 feet
Construction material	Masonry and earth-fill
Use of Dam	Water storage, flood control, hydroelectric, and recreation
Capacity	250,700 acre-feet of water
Land Area	23,610 surface acres of water
Flood damage history	Keystone has not failed, but high releases in 1986 caused significant downstream damages
Results of failure	Inundation of Sand Springs, Tulsa, Jenks, and Bixby
Emer. Action Plan (EAP)	Yes
Yahola Dam	
Location	North of Tulsa on Lake Yahola
Source	Tributary of Bird Creek
Owner/operator	City of Tulsa
Year built	1948
Length/ Height	17,500 feet/ 35 feet
Construction material	Earth-fill
Use of Dam	Water supply for Tulsa
Capacity	6,445 acre-feet of water
Flood damage history	None to date
Results of failure	Inundation of areas of North Tulsa
EAP	Yes

Warrenton Lake Dam	
Location	Near 61st and South Yale Avenue
Source	Tributary to Joe Creek
Owner/operator	Warren Medical Center
Year built	1936
Length/ Height	400 feet/ 37 feet
Construction material	Earth-fill
Use of Dam	Recreation
Capacity	41 acre-feet of water
Flood damage history	Downstream property inundation
Results of failure	None
EAP	Yes
A.B. Jewell Dam	
Location	East 21st Street and 193rd E. Avenue
Source	Local drainage
Owner/operator	City of Tulsa
Year built	1950
Length/ Height	13,300 feet/ 15 feet
Construction material	Earth-fill
Use of Dam	Raw water storage
Capacity	325 acre-feet of water
Land Area	None to date
Flood damage history	Inundation of areas of East Tulsa
Results of failure	None
EAP	Yes
Other high-hazard dams of interest to Tulsans:	
Spavinaw Lake Dam	
Location	50 miles east and north of Tulsa
Source	Spavinaw Creek
Owner/operator	City of Tulsa
Year built	1924
Length/ Height	3,500 feet/
Construction material	
Use of Dam	Water Supply for Tulsa, Recreation, Flood control
Capacity	31,686 acre-feet of water
Flood damage history	
Results of failure	
EAP	

Lake Eucha Dam	
Location	60 miles east and north of Tulsa
Source	Spavinaw Creek
Owner/operator	City of Tulsa
Year built	1952
Length/ Height	2,100 feet/
Construction material	
Use of Dam	Water Supply for Tulsa and Jay OK, Recreation
Capacity	80,000 acre-feet of water
Flood damage history	
Results of failure	
EAP	
Lake Hudson Dam	
Location	50 miles north and west of Tulsa
Source	Butler Creek
Owner/operator	City of Bartlesville
Year built	1949
Length/ Height	6200 ft./45 ft.
Construction material	Earth-fill, rock foundation
Use of Dam	Water Supply for Tulsa, Recreation
Capacity	
Flood damage history	
Results of failure	
EAP	

Tulsa dams classified as low or significant hazard include the following.

Page Belcher Golf Course	
Source	Tributary Nickel Creek
Year Completed	1950
Length/ Height	410 ft./ 30 ft
Hazard	Significant
Surface Area	3 acres
Recreation Lake Dam	
Source	Tributary Bird Creek
Year Completed	1950
Length/ Height	4000 ft./ 15 ft
Hazard	Significant
Surface Area	80 acres
Mill Creek Pond	
Source	Tributary Ark. River
Year Completed	1970
Length/ Height	1450 ft./ 28 ft
Hazard	Low
Surface Area	10 acres

Minshall Park 2nd	
Source......................................	Tributary Haikey Creek
Year Completed......................	1960
Length/ Height	400 ft./ 28 ft
Hazard	Low
Surface Area...........................	4 acres
OKNONAME 143013	
Source......................................	Tributary Ark. River
Year Completed......................	1960
Length/ Height	300 ft./ 30 ft
Hazard	Low
Surface Area...........................	2 acres
OKNONAME 143014	
Source......................................	Tributary Arkansas River
Year Completed......................	1950
Length/ Height	280 ft./ 25 ft
Hazard	Low
Surface Area...........................	4 acres
Southern HIlls C.C.	
Source......................................	Tributary Joe Creek
Year Completed......................	1970
Length/ Height	350. ft/ 35 ft
Hazard	Low
Surface Area...........................	1 acre

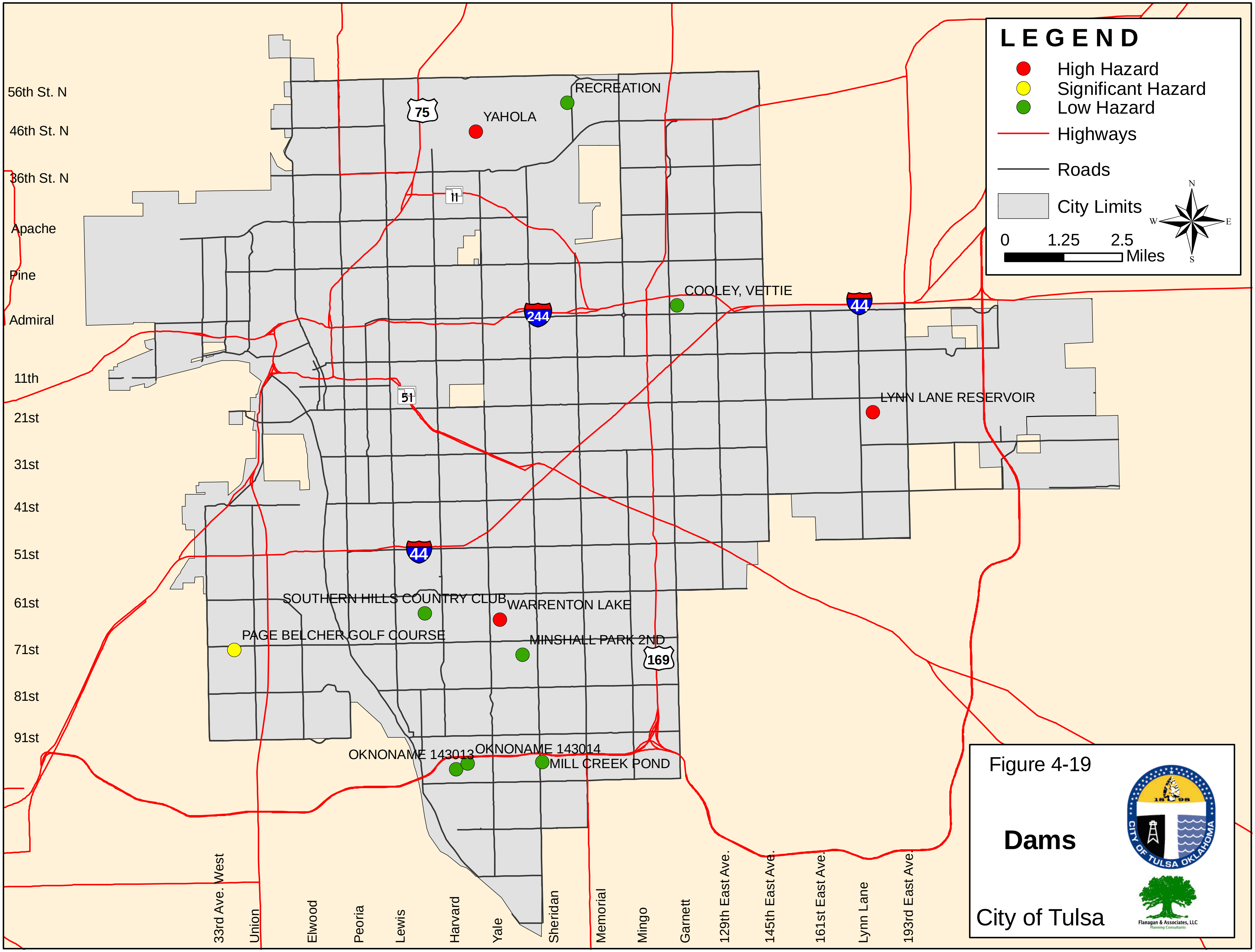


Figure 4-19

Dams

City of Tulsa

Arkansas River corridor

Of particular concern for Tulsa are Keystone Dam and three levees, all built by the Corps of Engineers on the Arkansas River upstream from and west of downtown Tulsa. These structures have prevented millions of dollars in flood damages since they were built, but they present inherent hazards for catastrophic disaster. Because of the unique hazard presented by these structures, this plan focuses on those structures and the Arkansas River valley corridor through Tulsa.

The Arkansas River is one of the longest tributaries of the Mississippi River. The Arkansas River drains 160,500 square miles west of the Mississippi. The Arkansas River rises at elevation 11,500 feet in the Rocky Mountains near Leadville, Colorado. It flows 1,450 miles through the Royal Gorge, on through Kansas, Oklahoma, and Arkansas to its Mississippi confluence, at elevation 106 feet above sea level. At Keystone Dam just above Tulsa, the Arkansas joins with a major tributary, the Cimarron River, which drains portions of New Mexico, Texas, and Oklahoma. Over the years, the Corps of Engineers has estimated bank-full channel capacity at between 90,000 and 110,000 cubic feet per second.

Keystone Dam. The Corps of Engineers completed Keystone Dam in 1964 about 10 miles west of Tulsa. Authorized purposes include flood control, hydropower, water supply, water quality, navigation, irrigation, recreation, and fish and wildlife management. Keystone Dam is 4,600 feet long, 121 feet wide, and composed of masonry and earth fill.

It is also relevant for Tulsa that, in 1976, the Corps completed Kaw Dam 115 river miles upstream (north) of Keystone. The Kaw flood pool contains 919,400 acre-feet of water, according to the Corps. The Corps estimates that, together, Keystone and Kaw dams provide an estimated 15-year level of flood control storage.

Arkansas River Levees at Tulsa. The levees of most concern for Tulsa are west of downtown on the north, south, and west sides of the Arkansas River, protecting the refineries and some adjacent neighborhoods.

In Tulsa, after disastrous floods in 1941 and 1943, residents appealed to the County Commission and the U.S. Department of War (now Corps of Engineers) to build levees to protect floodplain development and vital war industries, such as the refineries in West Tulsa. The levees were finished in 1945.

Garden City, an area of low-income homes, was left unprotected downstream from the Corps' refinery levee. Garden City residents subsequently built their own non-engineered private dirt levee on the west side of the Arkansas River between 21st and 51st streets to protect their homes.

Together, the three Corps earthen, grass-covered levees are about 20 miles long. The average height is 8 feet tall, with an average crest width of 8 feet.

The Corps designates these levees as:

- Levee A, the upstream left bank levee (the western levee, located north of the river in Sand Springs and Tulsa County)

- Levee B, the downstream left bank levee (the eastern levee, located north of the river, primarily within the jurisdiction of the City of Tulsa)
- Levee C, the right bank levee (the West Tulsa levee, within the Tulsa city limits, but also containing large unincorporated areas. These unincorporated areas, located in Tulsa County, contain oil refineries, oil tank storage farms, and railroad switching yards.)

Three levees are not connected, although the left bank levees tie into a floodway structure and operate as a system. The levee project also includes 7 pumping stations, 4 stop-log structures, wing levees, diversion channels, and a floodway structure to pass flows from three tributaries north of the river.

The Corps of Engineers designed the levees to contain and withstand a Keystone dam release of 350,000 cfs, with a minimum of 3 feet of freeboard.

By agreement between the Corps and Tulsa County, they are maintained by Tulsa County Drainage District 12, a legal entity that is funded by assessments on properties behind the levees. A 2008 Corps of Engineers inspection report was critical of current maintenance.

Arkansas River Regulation**.** It is important to note that the City of Tulsa regulates land use within the Arkansas River corridor only to the standard of the National Flood Insurance Program – a 100-year floodplain based on existing watershed development. It is arguable that this standard is justified because of the size of the Arkansas watershed but is less stringent than the City regulation over floodplains in the balance of Tulsa. On the other hand, the Arkansas offers far greater potential for catastrophic flooding than other Tulsa floodplains. City staff has proposed adjusting the regulatory standard so the Arkansas River regulations in Tulsa would be based on the 1986 flood, the current flood of record since Keystone Dam was built.

4.12.1.2 Extent

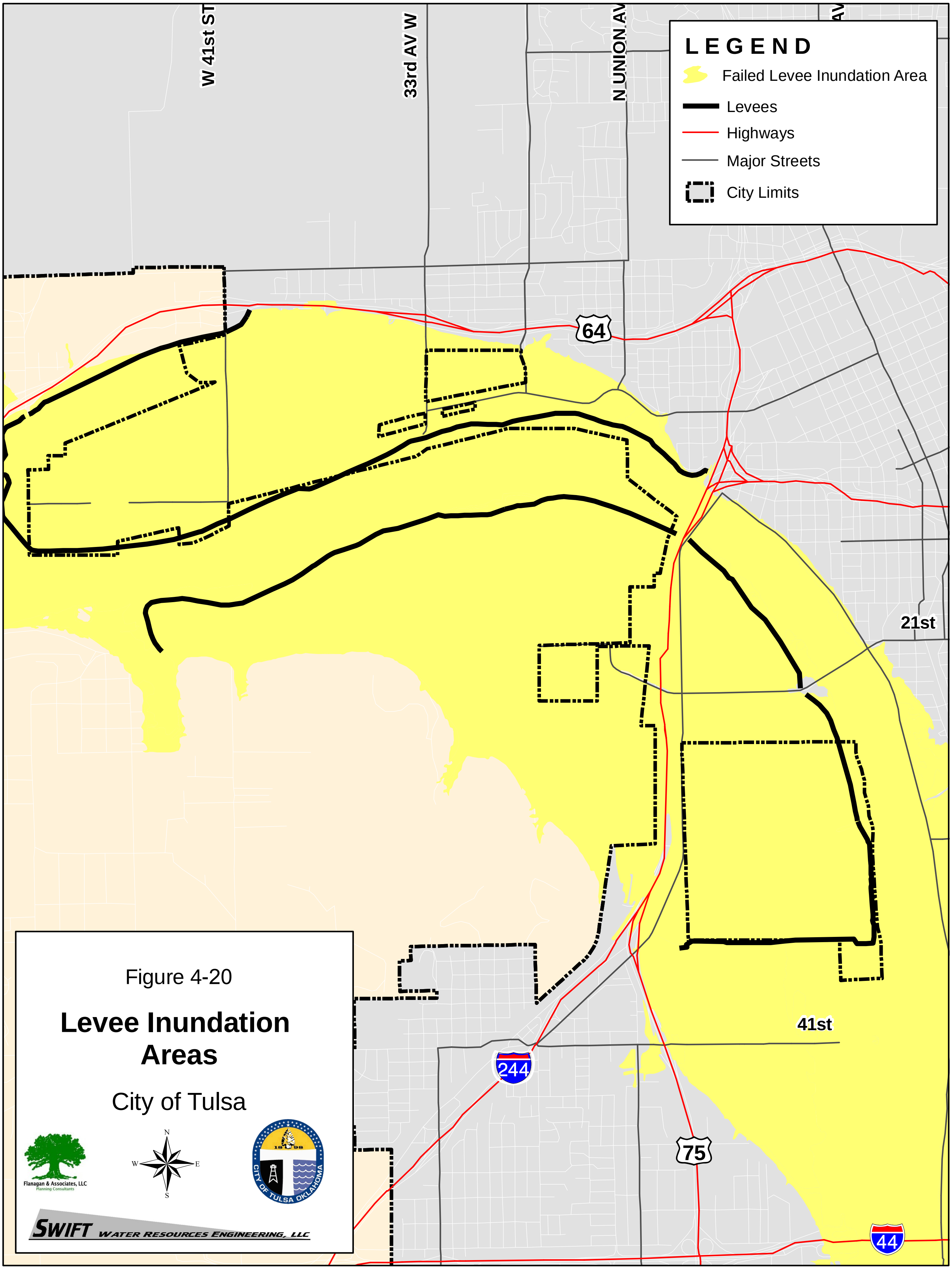
The failure of a major Tulsa dam or levee could cause catastrophic damage. In the words of the Corps of Engineers, failure of Keystone Dam or the Arkansas River Tulsa levees "would be catastrophic in terms of property damage, potential for loss of life, and environmental destruction."

The Corps predicts Tulsa's Arkansas River levees would overtop if Keystone Dam release rates reach 450,000 cfs. Some experts believe that a sustained flow of 300,000 cfs or greater could cause the levees to fail. Figure 4–20 shows the anticipated inundation area if the Tulsa levees fail.

Figure 4–21 shows the area of anticipated Tulsa inundation if Keystone Dam should fail or require forced flooding releases.

4.12.1.3 Frequency

In the area of chief concern for Tulsa, the Arkansas River corridor, the frequency of flooding has been dramatically reduced by Keystone and Kaw dams and the Arkansas River levees. Only one significant flood event (1986) has occurred along the Arkansas at Tulsa since the dams at Keystone and Kaw Lakes were completed.



W 41st ST
33rd AV W
N UNION AV
LEGEND
Failed Levee Inundation Area
Levees
Highways
Major Streets
City Limits
64
21st
41st
244
75
44
Figure 4-20
Levee Inundation Areas
City of Tulsa
Flanagan & Associates, LLC
Planning Consultants
N
E
S
W
CITY OF TULSA OKLAHOMA
SWIFT WATER RESOURCES ENGINEERING, LLC

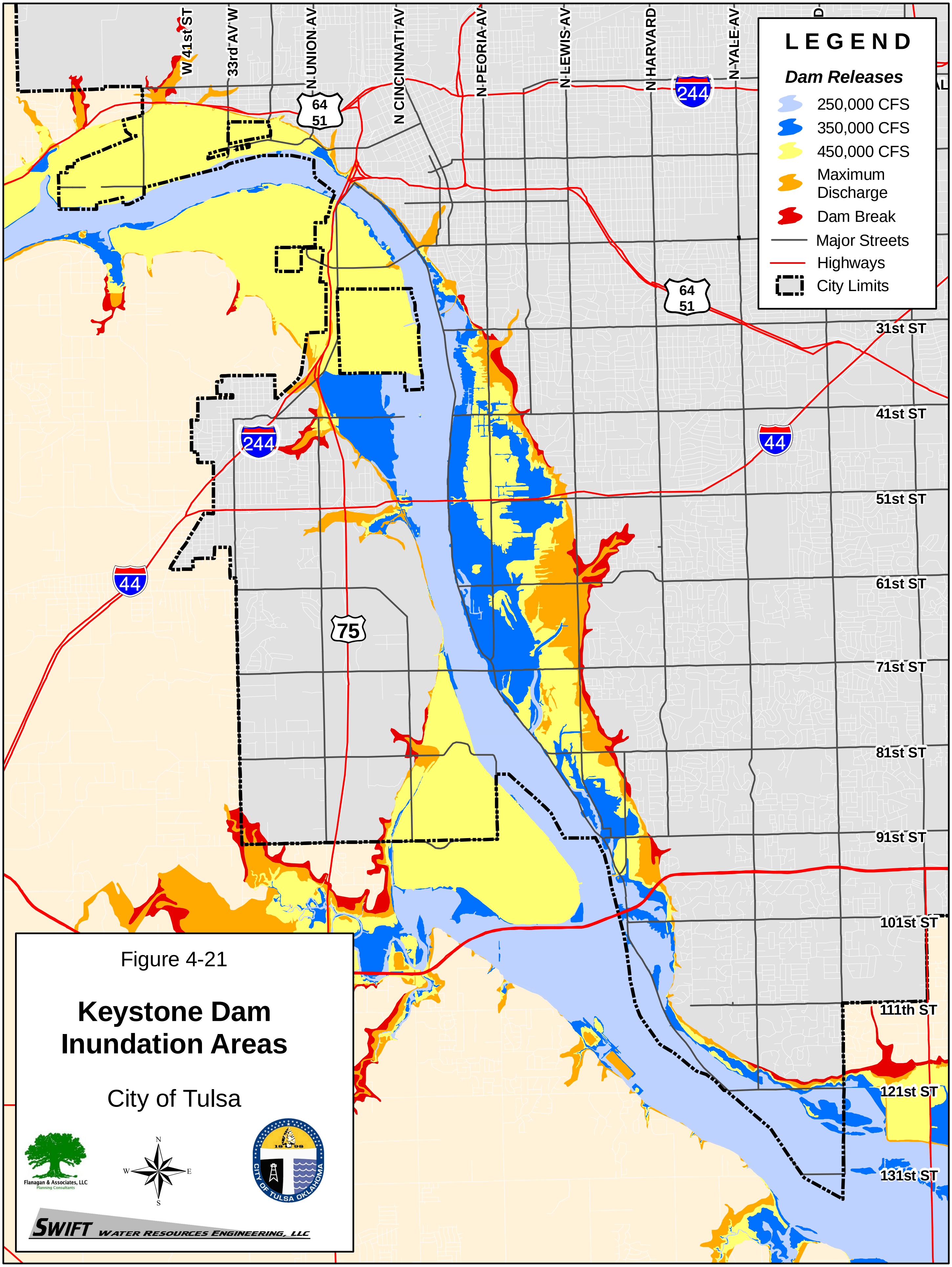


Figure 4-21

Keystone Dam Inundation Areas

City of Tulsa

As noted above, the Corps projects that Keystone and Kaw together provide an estimated 15-year level of flood control storage. The Corps estimates that the Tulsa levees could be overtopped at 450,000 cfs. Events that may exceed these projects' levels of protection are still probable and will be discussed in later paragraphs.

4.12.1.4 Historical Events

In Oklahoma, there have been three significant documented dam failures, each after sudden and heavy rainfall events:

A Sand Springs levee gives way during 1986 flood on Arkansas River

- On October 3, 1923, heavy rain caused a dam failure at Lake Overholser, which displaced 15,000 residents.
- Cleveland, in Pawnee County, suffered losses in the half-million dollar range when the town was inundated by the Cleveland Dam break on September 4, 1940.
- After 14.6 inches of rain fell in the Wewoka area the night of April 13-14, 1945, heavy flows on Coon Creek overtopped and breached the Wewoka Dam, sending a wall of water into Wewoka Creek. Eight people in the path of the deluge were killed and the town of Wewoka was under 4 feet of water. Eighty people were forced from their homes. (Kuhnert)

Although the Corps Tulsa levees have not suffered major failure, properties protected by the levees have suffered flood damages from internal flooding in 1984, and Corps levees were threatened with failure and overtopping in 1986 and 1993.

In 1986, the remnants of Hurricane Paine dumped nearly 2 feet of rain northwest of Tulsa, causing the Arkansas, Caney, and Neosho Rivers to flood. To prevent the Arkansas River from overtopping Keystone Dam, the Corps of Engineers opened floodgates and released 310,000 cfs of water through Sand Springs, Tulsa, Jenks and Bixby. No one knew if the sand levees would hold, and a catastrophic failure of the levee system was widely feared. In fact, the Sand Springs levee was breached, but volunteers quickly plugged it with sandbags.

On the west bank, the private levees failed during the 1986 Arkansas River flood, and the river swamped a number of Garden City houses up to the rooftops, causing $1.3 million in damages to 64 buildings. The disaster was complicated by pollution from old, underground refining and chemical storage and dumps. In all, more than 1,800 homes and businesses were flooded in Tulsa County, and1986 damages were estimated at $63.5 million (in '86 dollars).

With the exception of Keystone dams failure in 1986, there are no known failures of any of the dams listed in this plan.

4.12.1.5 Probability/Future Events

The Corps believes there is a low probability that Keystone Dam would fail, because it is operated by the Corps and inspected at least once each year. Nonetheless, the Corps of Engineers has projected the effects if there should be a failure of Keystone Dam. A dam break would send a 20-foot-high wall of water rushing down the Arkansas River valley, destroying or damaging almost everything in its path in the Arkansas River floodplain. The flood would reach Tulsa in a very short time. The average building would have from 10 to 20 feet of water in the building.

The age of Tulsa Arkansas River levees and Keystone Dam is another issue of concern for Tulsa. When Keystone was built in 1964, the Corps estimated it would have a 50-year useful life. In addition, a great deal of silt has collected upstream from the dam, including in the flood pool. The Keystone flood pool filled completely in 1974 and 1986.

Even though a dam break is unlikely, there is a very high probability that the Corps will be forced to make flooding releases from the dam. Even without a breach of the dam, forced releases of flooding waters from Keystone Dam, such as occurred in 1986, could cause extensive property damage and disruption, as well as safety risks. The Corps has studied and mapped the areas that would be inundated from 250,000 cubic feet per second, 350,000 cfs, and 450,000 cfs releases from the Keystone reservoir. (Keystone Dam's maximum discharge could be as much as 940,000 cfs. A "100-year" discharge is estimated at 200,000 cfs.)

The City of Tulsa has a low probability of a catastrophic dam failure, due to maintenance of the dams by the USACE and the City of Tulsa. However, the City of Tulsa has a moderate probability of being subjected to a non-catastrophic dam failure, due to excessive rainfall.

4.12.2 Existing Vulnerability

This section summarizes information about vulnerabilities to existing populations, buildings, critical facilities, and infrastructure in the event of a dam or levee break in Tulsa.

4.12.2.1 Vulnerable Population

People, property, critical facilities, and infrastructure downstream of dams and behind levees could be subject to devastating danger and damage in the event of failure. The number of fatalities or injuries resulting from dam or levee failures is highly influenced by the number of people occupying the inundation area, the amount of warning they are provided, and the amount of pre-event public education and planning. People who might be at risk include those who are living, working, at school or play, or traveling through vulnerable areas.

Dams

The estimated number of inhabitants below the four high-hazard dams are:

Keystone Dam: A Keystone Dam break or major release could impact an estimated 48,000 people and 14,285 parcels with improvement values. Of those citizens impacted by a dam break or release, current Tulsa census figures would indicate that this figure would include approximately 5,300 people over age 65 (12%) and approximately 2,556 (18.78%) classified as below the poverty level. (Source: OWRB, Nathan Kuhnert)

Yahola Dam: A breach or break of the Yahola dam could potentially impact an extremely limited number of citizens of Tulsa. Most of the area downstream of Lake Yahola is occupied by Mohawk Park, Mohawk Park Golf Course and the wide floodplains associated with Bird Creek. Therefore, the risk associated with this dam breach or break is highly dependent on the time of which it occurs. Naturally during the day of a weekend in the spring, summer or fall, there will be more citizens in the golf course and park. If the breach were to occur in the middle of the night or in the winter, the potential damage would be less, since fewer citizens would be using the park and associated facilities. There are no permanently habitable structures downstream of the Yahola Dam. However, there are approximately 12 structures associated with the golf course and Mohawk Park, which could potentially be destroyed or inundated with water due to a break or breach of Lake Yahola Dam.

Warrenton Dam: A breach or break of the Warrenton dam could potentially impact an extremely limited number of citizens of Tulsa. Most of the area downstream of Warrenton Dam is occupied by high-rise office buildings. Therefore, the risk associated with this dam breach or break is highly dependent on the time of which it occurs. Naturally, during a weekday, there will be more traffic on Yale Ave. and more residents working in the high-rise office buildings. If the breach were to occur in the middle of the night or on a weekend the risk would be less. There are six commercial structures that could potentially be affected by a breach or break of the Warrenton Dam.

A.B. Jewell Dam: A breach or break of the A.B. Jewell dam could potentially impact an estimated 46 households in Tulsa. Most of the area downstream of A.B. Jewell Dam is occupied single-family houses on large lots and there are two large baseball / softball complexes sit adjacent to the reservoir. The A.B. Jewell water treatment plant also sits directly below the reservoir. Therefore, the risk associated with this dam breach or break is highly dependent on the time of which it occurs. If the breach were to occur on a weeknight or on a weekend, the extent to which life could be lost would be higher, due to the nature of the land use and activities near the dam. However, any breach or break of the dam would adversely affect the water supply and distribution of the City of Tulsa due to lost treatment capacity.

Levees

There are an estimated 32,000 people living behind the Tulsa Arkansas River levees. Of those residents, 11.37% are older than 65, and 28.79% are classified as below the poverty level. In addition, the adult and juvenile detention centers and the Tulsa County Emergency Shelter are in the levee failure area. These facilities would require unusually extraordinary measures to evacuate effectively.

4.12.2.2 Buildings

Tables 4-42c and 4-42c illustrate properties and critical facilities affected by a 450,000 cfs discharge. A Maximum Discharge event is illustrated by Tables 4-42d and 4-43d.

As shown in Table 4-42 a-e, there are 14,285 buildings below Keystone Dam that could be affected by a failure or major release, including 13,044 residential dwellings and 1,174 commercial and industrial buildings.

In addition, there are a number of hazardous materials Tier II sites in the area. Major damage to some of the industrial buildings could trigger cascading disasters, such as chemical releases and explosions.

If the levee system were to fail to protect properties due to (1) planned releases from Keystone Dam in excess of the levee design protection, (2) from Keystone Dam failure, or (3) from flooding from internal sources, such as Harlow, Parkview, or Oak creeks, the damage to the City and County would be catastrophic. As Tables 4-42 and 4-43 show, damages would be high for large Keystone releases, and up to 14,285 buildings and their contents valued at over $2.75 Billion could be damaged or destroyed in the vulnerable area of a complete Keystone failure.

Table 4–42a: Keystone Dam Release of 250,000 cfs

Type	Number of Parcels	Improvement Value	Contents Value	Total Value
Residential	652	$132,156,350	$66,078,175	$198,234,525
Commercial	15	$8,472,900	$4,236,450	$12,709,350
Industrial	15	$10,082,500	$5,041,250	$15,123,750
Critical Facilities	3	-	-	-
Total	685	$150,711,750	$75,355,875	$226,067,625

Table 4–43a: City of Tulsa Keystone Dam 250,000 cfs Release Critical Facilities

ID	*Name*	*Address*
WW5	Sewer Lift Station	21st and Riverside
WW8	Southside Lift Station (Raw Sewage Pump House)	5300 S. Elwood

Table 4–42b: Keystone Dam Release of 350,000 cfs

Type	Number of Parcels	Improvement Value	Contents Value	Total Value
Residential	4,703	$525,685,650	$262,842,825	$788,528,475
Commercial	123	$68,432,100	$34,216,050	$102,648,150
Industrial	81	$54,976,800	$27,488,400	$82,465,200
Critical Facilities	12	-	-	-
Total	4,919	$649,094,550	$324,547,275	$973,641,825

Table 4–43b: City of Tulsa Keystone Dam 350,000 cfs Release Critical Facilities

ID	*Name*
PD2	Fuel Island – UDSW
PD8	Tulsa Police Dept. (Southwest Div.)
LF11	National Bank of Commerce
ML39	Ambassador Manor Nursing & Rehab Center
ML47	University Village Retirement Community
ML50	Burgundy Place
ML51	Colonial Manor Nursing & Rehab Center
IL96	Prairie Rose
IL97	Inhofe Plaza
WW5	Sewer Lift Station
WW8	Southside Lift Station (Raw Sewage Pump House)
WW9	Southside Waste Water Treatment Plant

Table 4–42c: Keystone Release of 450,000 cfs

Type	Number of Parcels	Improvement Value	Contents Value	Total Value
Residential	9,604	$934,457,570	$467,228,785	$1,401,686,355
Commercial	466	$227,214,500	$113,607,250	$340,821,750
Industrial	194	$105,927,000	$52,963,500	$158,890,500
Critical Facilities	58	-	-	-
Total	10,322	$1,267,599,070	$633,799,535	$1,901,398,605

Table 4–43c: City of Tulsa Keystone Dam 450,000 cfs Release Critical Facilities

ID	*Name*
CC37	NACT Headstart & Day Care
CC46	Victory Christian School
CC47	Victory Kids Care
CC48	Victory Mother's Day Out
CF1	City Garage
CF8	Juvenile Delinquency Project
CG6	Tulsa County Deputy Sheriff
CG14	Tulsa County Juvenile Detention Center
FD1	Communication Area for Fire Dept.
FD2	Fire Dept. Dog Kennel
FD3	Tulsa Fire Station #9
FD4	Garage & Fuel Facility
FD8	Tulsa Fire Station #13
FD13	Tulsa Fire Station #18

ID	Name
FD34	Tulsa Fire Hazardous Materials
FD36	Tulsa Fire Dept. Supply
FD37	Tulsa Fire Dept. Training
HO7	Oklahoma Surgical Hospital
IL54	4100 Apartments
IL76	LaFortune Tower
IL96	Prairie Rose
IL97	Inhofe Plaza
JMS1	Jenks Middle School
PD2	Fuel Island – UDSW
PD8	Tulsa Police Dept. (Southwest Div.)
PW1	Chemical Storage Building
PW3	Equipment Mgmt.
PW4	Field Customer Services
PW5	Fuel Facility
PW6	Portable Building
PW8	Storage Shed
PW10	Structural Maintenance
PW11	Surplus Facility
PW12	Tire Shop
PW13	W&M South Yard Storage Building
PW14	W&M South Yard Office / Stock Building
PW15	Warehouse / Materials Stockroom
UV3	OSU College of Osteopathic Medicine
JC12	Tulsa Technology Center – Riverside
LF9	Tulsa National Bancshares
LF11	National Bank of Commerce
LF12	Sooner Southwest Bancshares
ML31	Tulsa Jewish Retirement & Health Care Center
ML39	Ambassador Manor Nursing & Rehab Center
ML47	University Village Retirement Community
ML50	Burgundy Place
ML51	Colonial Manor Nursing & Rehab Center
PS3	Evangelistic Temple School
PS17	School of Saint Mary
PS24	Victory Christian School
SG3	Medical Examiner
TES20	Eugene Field Elementary School
TES34	Mark Twain Elementary School
TES35	Marshall Elementary School
TES56	Wright Elementary School
TMS12	Madison Middle School
WW5	Sewer Lift Station
WW8	Southside Lift Station (Raw Sewage Pump House)
WW9	Southside Waste Water Treatment Plant

Table 4–42d: Keystone Dam Max Discharge Property Exposure

Type	Number of Parcels	Improvement Value	Contents Value	Total Value
Residential	11,552	$1,193,572,625	$596,786,313	$1,790,358,938
Commercial	636	$288,698,200	$144,349,100	$433,047,300
Industrial	212	$111,034,600	$55,517,300	$166,551,900
Critical Facilities	64	-	-	-
Total	12,464	$1,593,305,425	$796,652,713	$2,389,958,138

Table 4–43d: City of Tulsa Keystone Dam Max. Discharge Critical Facilities

ID	*Name*
CC34	McClure Head Start
CC37	NACT Headstart & Day Care
CC46	Victory Christian School
CC47	Victory Kids Care
CC48	Victory Mother's Day Out
CF1	City Garage
CF8	Juvenile Delinquency Project
CG6	Tulsa County Deputy Sheriff
CG14	Tulsa County Juvenile Detention Center
FD1	Communication Area for Fire Dept.
FD2	Fire Dept. Dog Kennel
FD3	Tulsa Fire Station #9
FD4	Garage & Fuel Facility
FD8	Tulsa Fire Station #13
FD13	Tulsa Fire Station #18
FD34	Tulsa Fire Hazardous Materials
FD36	Tulsa Fire Dept. Supply
FD37	Tulsa Fire Dept. Training
FG11	USPS – Robert Jenkins Post Office
HO7	Oklahoma Surgical Hospital
IL54	4100 Apartments
IL76	LaFortune Tower
IL78	Tulsa Pythian Manor West
IL96	Prairie Rose
IL97	Inhofe Plaza
JMS1	Jenks Middle School
PD2	Fuel Island – UDSW
PD8	Tulsa Police Dept. (Southwest Div.)
PW1	Chemical Storage Building
PW3	Equipment Mgmt.
PW4	Field Customer Services

ID	Name
PW5	Fuel Facility
PW6	Portable Building
PW8	Storage Shed
PW10	Structural Maintenance
PW11	Surplus Facility
PW12	Tire Shop
PW13	W&M South Yard Storage Building
PW14	W&M South Yard Office / Stock Building
PW15	Warehouse / Materials Stockroom
UV3	OSU College of Osteopathic Medicine
JC12	Tulsa Technology Center – Riverside
LF9	Tulsa National Bancshares
LF11	National Bank of Commerce
LF12	Sooner Southwest Bancshares
ML31	Tulsa Jewish Retirement & Health Care Center
ML39	Ambassador Manor Nursing & Rehab Center
ML47	University Village Retirement Community
ML50	Burgundy Place
ML51	Colonial Manor Nursing & Rehab Center
PS3	Evangelistic Temple School
PS10	Metro Christian Academy
PS17	School of Saint Mary
PS24	Victory Christian School
SG3	Medical Examiner
TES20	Eugene Field Elementary School
TES34	Mark Twain Elementary School
TES35	Marshall Elementary School
TES37	McClure Elementary School
TES56	Wright Elementary School
TMS12	Madison Middle School
WW5	Sewer Lift Station
WW8	Southside Lift Station (Raw Sewage Pump House)
WW9	Southside Waste Water Treatment Plant

Table 4–42e: Keystone Dam Break Property Exposure

Type	Number of Parcels	Improvement Value	Contents Value	Total Value
Residential	13,044	$1,379,885,675	$689,942,838	$2,069,828,513
Commercial	919	$350,770,100	$175,385,050	$526,155,150
Industrial	255	$112,745,600	$56,372,800	$169,118,400
Critical Facilities	67	-	-	-
Total	14,285	$1,843,401,375	$921,700,688	$2,765,102,063

Table 4–43e: City of Tulsa Keystone Dam Break Critical Facilities

ID	Name
CC34	McClure Head Start
CC37	NACT Headstart & Day Care
CC46	Victory Christian School
CC47	Victory Kids Care
CC48	Victory Mother’s Day Out
CF1	City Garage
CF8	Juvenile Delinquency Project
CG6	Tulsa County Deputy Sheriff
CG14	Tulsa County Juvenile Detention Center
FD1	Communication Area for Fire Dept.
FD2	Fire Dept. Dog Kennel
FD3	Tulsa Fire Station #9
FD4	Garage & Fuel Facility
FD8	Tulsa Fire Station #13
FD13	Tulsa Fire Station #18
FD24	Tulsa Fire Station #29
FD34	Tulsa Fire Hazardous Materials
FD36	Tulsa Fire Dept. Supply
FD37	Tulsa Fire Dept. Training
FG11	USPS – Robert Jenkins Post Office
HO7	Oklahoma Surgical Hospital
IL54	4100 Apartments
IL76	LaFortune Tower
IL78	Tulsa Pythian Manor West
IL96	Prairie Rose
IL97	Inhofe Plaza
JMS1	Jenks Middle School
PD2	Fuel Island – UDSW
PD8	Tulsa Police Dept. (Southwest Div.)
PW1	Chemical Storage Building
PW3	Equipment Mgmt.
PW4	Field Customer Services
PW5	Fuel Facility
PW6	Portable Building
PW8	Storage Shed
PW10	Structural Maintenance
PW11	Surplus Facility
PW12	Tire Shop
PW13	W&M South Yard Storage Building
PW14	W&M South Yard Office / Stock Building
PW15	Warehouse / Materials Stockroom
UV3	OSU College of Osteopathic Medicine

ID	Name
JC12	Tulsa Technology Center – Riverside
LF9	Tulsa National Bancshares
LF11	National Bank of Commerce
LF12	Sooner Southwest Bancshares
ML31	Tulsa Jewish Retirement & Health Care Center
ML39	Ambassador Manor Nursing & Rehab Center
ML47	University Village Retirement Community
ML50	Burgundy Place
ML51	Colonial Manor Nursing & Rehab Center
PS3	Evangelistic Temple School
PS10	Metro Christian Academy
PS17	School of Saint Mary
PS24	Victory Christian School
SG3	Medical Examiner
TES18	Eliot Elementary School
TES20	Eugene Field Elementary School
TES34	Mark Twain Elementary School
TES35	Marshall Elementary School
TES37	McClure Elementary School
TES56	Wright Elementary School
TMS12	Madison Middle School
WD20	Tower Site
WW5	Sewer Lift Station
WW8	Southside Lift Station (Raw Sewage Pump House)
WW9	Southside Waste Water Treatment Plant

4.12.2.3 Critical Facilities

Dams

Figure 4–22 shows critical facilities in the areas vulnerable to a Keystone Dam break. There are 67 critical facilities in the area that would be affected by failures of Keystone Dam or the subsequent Tulsa Arkansas River levees.

Levees

Critical facilities protected by the levees include 3 schools, and 8 Tulsa Fire Department facilities. The Sun Oil Refinery, which could also be considered a critical facility, but is not included in this value, is also located behind the levees on the west side of the Arkansas River. Properties within the City of Tulsa protected by the levees, including contents, totals more than $84 million. The areas of inundation due to levee failure are shown on the map in Figure 4–22. Property values for the areas behind the levees are detailed in Table 4–44 with Critical Facilities in Table 4-45.

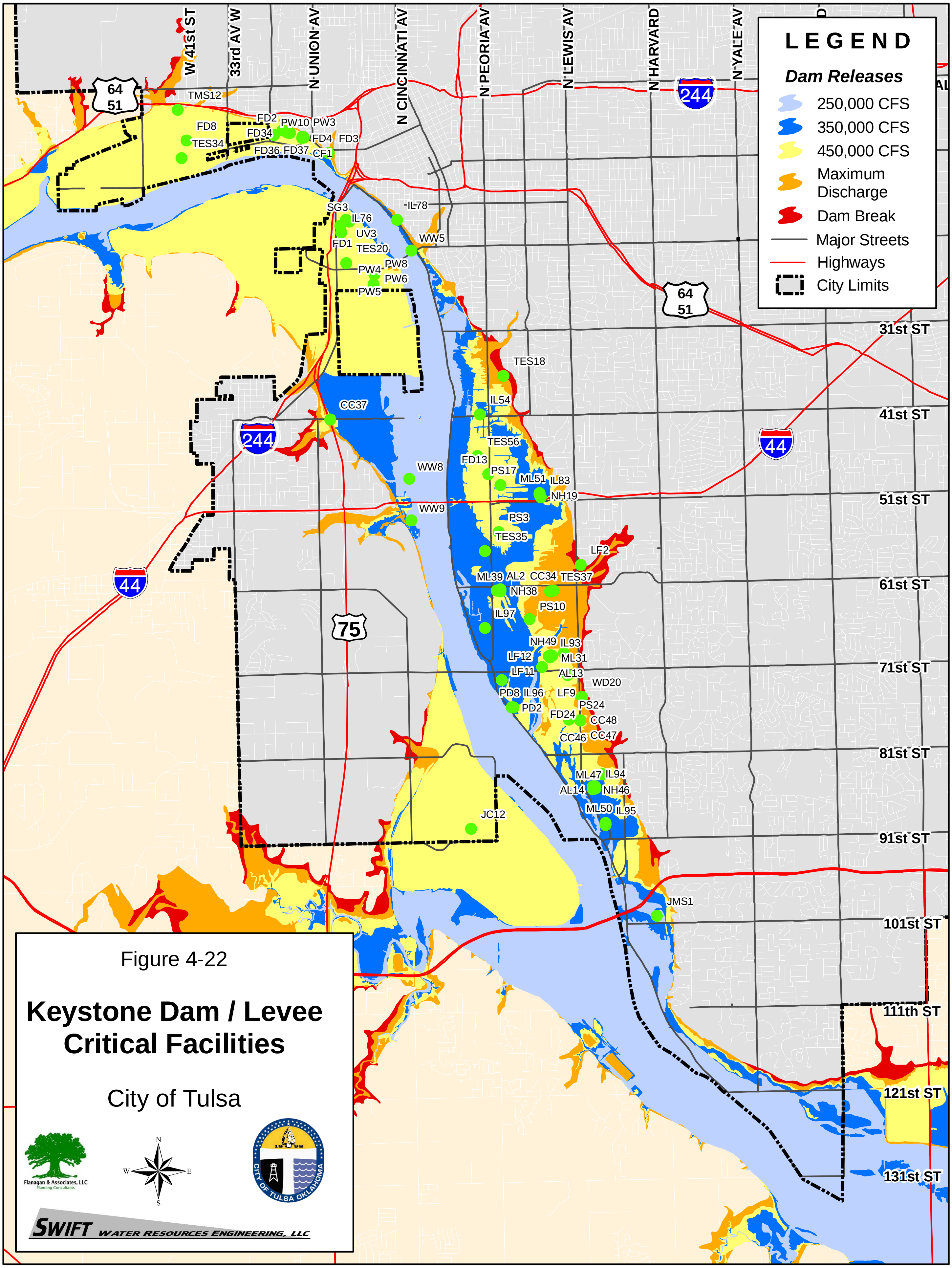


Figure 4-22

Keystone Dam / Levee Critical Facilities

City of Tulsa

Table 4–44: Levee Failure Property Exposure

Type	Number of Parcels	Improvement Value	Contents Value	Total Value
Residential	2,271	$ 84,536,320	$42,268,160	$126,804,480
Commercial	149	$ 14,652,600	$7,326,300	$21,978,900
Industrial	106	$ 48,264,100	$24,132,050	$72,396,150
Total	2,526	$147,453,020	$73,726,510	$221,179,530

Table 4–45: City of Tulsa Levee Failure Critical Facilities

ID	*Name*
CF1	City Garage
CF8	Juvenile Delinquency Project
CG6	Tulsa County Deputy Sheriff
CG14	Tulsa County Juvenile Detention Center
FD1	Communication Area for Fire Dept.
FD2	Fire Dept. Dog Kennel
FD3	Tulsa Fire Station #9
FD4	Garage & Fuel Facility
FD8	Tulsa Fire Station #13
FD34	Tulsa Fire Hazardous Materials
FD36	Tulsa Fire Dept. Supply
FD37	Tulsa Fire Dept. Training
IL76	LaFortune Tower
PW1	Chemical Storage Building
PW3	Equipment Mgmt.
PW4	Field Customer Services
PW5	Fuel Facility
PW6	Portable Building
PW8	Storage Shed
PW10	Structural Maintenance
PW11	Surplus Facility
PW12	Tire Shop
PW13	W&M South Yard Storage Building
PW14	W&M South Yard Office / Stock Building
PW15	Warehouse / Materials Stockroom
UV3	OSU College of Osteopathic Medicine
JC12	Tulsa Technology Center – Riverside
SG3	Medical Examiner
TES20	Eugene Field Elementary School
TES34	Mark Twain Elementary School
TMS12	Madison Middle School

4.12.2.4 Infrastructure

A Keystone Dam Failure would affect Interstate 244, a major interstate highway, and the 21st street bridge, a major bridge over the Arkansas River, connecting West Tulsa to the rest of the city. The Cherokee Yard, a major intermodal regional transportation hub for the BNSF corporation, and the railroad bridge at 11th street would also be impacted by the failure.

4.12.3 Dam/Levee Failure Scenario

The worst-case scenario for a catastrophic dam/levee event can be illustrated in Section 4.12.2 – Vulnerabilities. Tables 4-42c and 4-42c illustrate properties and critical facilities affected by a 450,000 cfs discharge. A Maximum Discharge event is illustrated by Tables 4-42d and 4-43d.

A catastrophic failure of Keystone Dam and anticipated subsequent levee failures is illustrated in Tables 4-42e and 4-43e. The maps in Figures 4-21 and 4-22 show the Keystone Dam Break Inundation Areas and the vulnerable Critical Facilities.

4.12.4 Future Trends

Many Tulsans have said the riverbanks and even the river itself should be developed to provide an economic base in Central Tulsa. On the other hand, many people have said they want to retain the existing and evolving River Parks to provide a beautiful band of green that is extensively and enthusiastically used by thousands of Tulsans and generally prized as one of the city's best features. Others see the river as a treasure-trove of natural resources that should be preserved at all costs.

Given the inherent dangers along a river that drains nearly 75,000 square miles of land area, the future hazards along the Arkansas River will be determined by the balance of development and management that the community chooses. Various planning exercises offer possibilities for redefining local commitment to economic development, resource preservation, and hazard management along the river.

This analysis of future trends rests on several development plans:

- The Arkansas River Corridor Plan developed by the Indian Nations Council of Governments;
- The Comprehensive Plan (currently being updated by the City of Tulsa);
- Adopted Master Drainage Plans (currently proposed for major updates);
- Tulsa County Vision 2025 plans and proposals (which include river-development projects such as low-water dams);
- Infrastructure plans and projects, including the Gilcrease Expressway and a proposal for light rail in central Tulsa.

The riverfront future may hinge on how Tulsa defines the term "development" along the river. The future may be very different if "development" is defined as building parks and recreation areas, rather than lowland homes and businesses.

No additional control structures are currently planned that would improve the river's flood potential and recent Corps' analyses have concluded that no significant control structures (such as raising the height of the levees) would be feasible for the river. Therefore, the future depends in large measure on how man decides to manage and use the floodplain lands throughout Tulsa's segment of the Arkansas Valley.

Figure 4–23 shows areas that may be considered future development areas.

4.12.4.1 Population

Virtually all of the current proposals would be expected to increase the number of people at risk in the Arkansas River lowlands. For this plan, it is assumed that management decisions will be based on FEMA's 100-year floodplain standard. Therefore, the numbers of people in all categories – living, working, going to school, traveling through, with special needs, etc. – will increase, exposing more people to risk from larger events (such as the 1986 flood).

4.12.4.2 Buildings

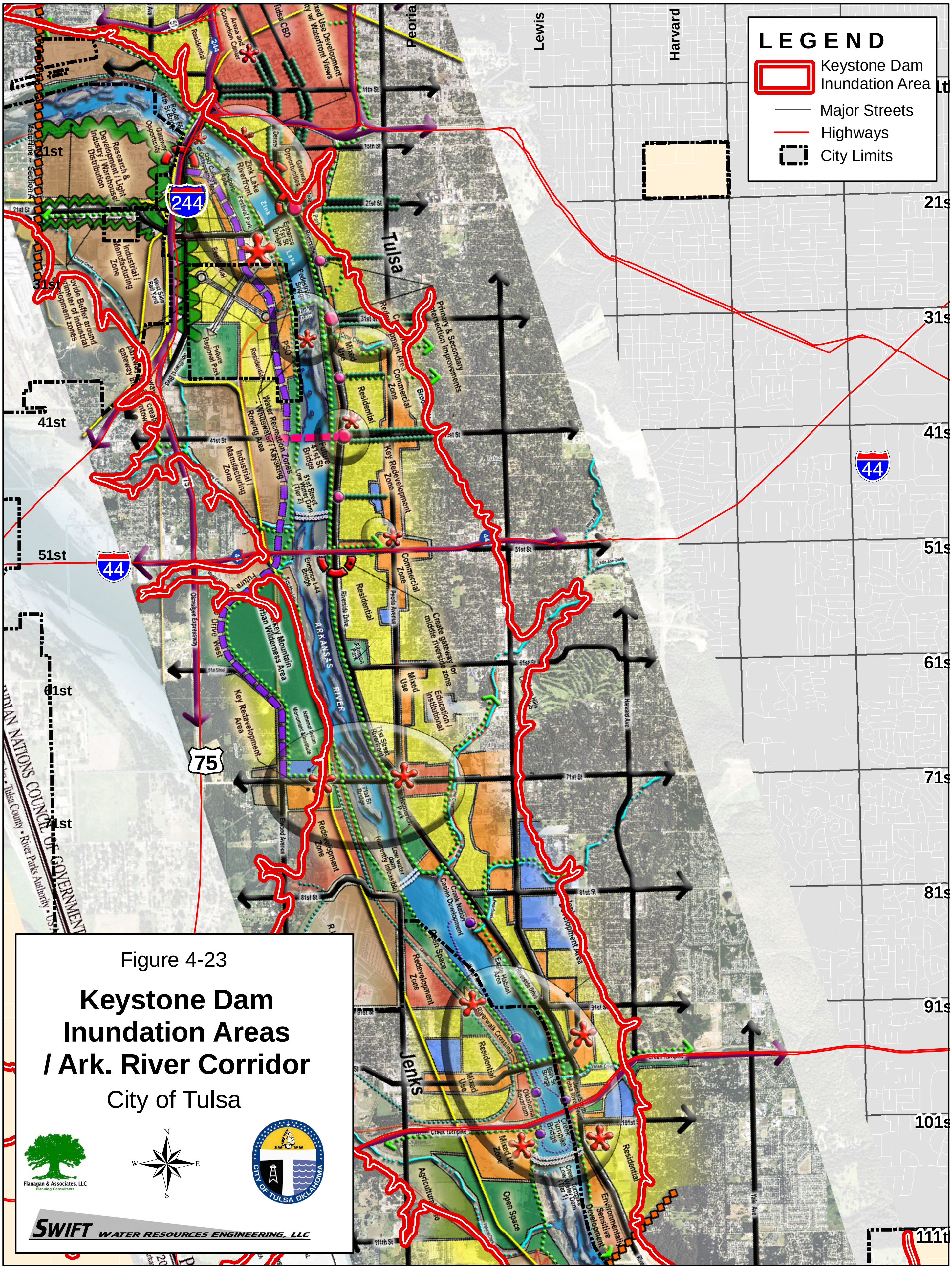
Similarly, all of the current proposals would be expected to increase the number of buildings at risk in the Arkansas River lowlands. For this plan, it is assumed that building decisions will be based on the FEMA 100-year floodplain standard. Therefore, the numbers of buildings will increase, exposing more buildings to risk from larger events such as the 1986 flood. If the 100-year floodplain standard were to be revised, the number of new structures at risk could be substantially reduced.

4.12.4.3 Critical Facilities

Current riverfront development proposals do not focus on critical facilities, so it is anticipated that the number of critical facilities would not increase in the river lowlands in the future. The future may hinge on whether leaders consider hazard management in expansion decisions for schools, detention facilities, social service agencies, health clinics, and other critical facilities. Again, it is anticipated that these decisions will be based on only the FEMA 100-year floodplain standard.

4.12.4.4 Infrastructure

Generally, all the current plans would increase the investment in infrastructure in the river lowlands. For example, proposals all include new roads, the Gilcrease Expressway, new low-water dams and bridges, utilities, parks and walking trails. If higher standards than the FEMA 100-year floodplain are used, and if infrastructure impacts on the floodplain are carefully considered, infrastructure decisions might decrease future risks to valley properties and populations.


LEGEND
Keystone Dam Inundation Area
Major Streets
Highways
City Limits
Peoria
Lewis
Harvard
Tulsa
Jenks
21st
31st
41st
51st
61st
71st
81st
91st
101st
111th
244
44
75
ARKANSAS RIVER
Figure 4-23
Keystone Dam Inundation Areas / Ark. River Corridor
City of Tulsa
Flanagan & Associates, LLC
SWIFT WATER RESOURCES ENGINEERING, LLC

4.12.5 Conclusion

Tulsa is exposed to risk of flooding from failure of four high-hazard upstream dams. These dams are Keystone, Yahola, Warrenton, and A.B. Jewell. The dam posing the greatest threat to Tulsa is Keystone. There would be 48,000 people, 14,285 improved properties, and 67 critical facilities exposed to damage if Keystone Dam failed or suffered a major release. However, the Corps of Engineers believes that the potential for failure is low because Keystone is operated by the Corps and is inspected at least once each year.

Forced releases of large amounts of water can be a significant flood hazard. This was exemplified by the 1986 Keystone Reservoir water releases that caused downstream flooding.

People, property, critical facilities, and infrastructure downstream of dams and behind levees could be subject to devastating danger and damage in the event of failure. The most important factor for public safety is the timeliness, the effectiveness of warning given to vulnerable populations, and the amount of pre-event public education and planning. Dams and levees often convey a false sense of security, allowing people to think they will always be protected, so dam and levee safety is not usually high in the public consciousness. The recent failures of the New Orleans and the Mississippi River levees may serve to focus more attention on these risks.

A related threat to Tulsa is posed by the Arkansas River levees, built in 1945 and protecting 2,271 residences, 149 commercial properties and 106 industrial parcels ($147,453,020 in property). Failure of the levees along the Arkansas River would have a devastating impact upon the City of Tulsa and Tulsa County.

The worst-case event, failure of Keystone Dam and the Arkansas River levees, could impact 14,285 parcels with improvements within the city limits of Tulsa, create a severe risk for an estimated 48,000 people, cause an estimated $ 1,843,401,375 in damage to an estimated 14,285 buildings including 67 critical facilities. In addition, it could produce widespread power outages, and release of hazardous chemicals.

4.12.5.1 Data Limitations

Census figures are insufficient to identify the number of people with disabilities, or with limited knowledge of English, who would be extremely vulnerable in an event that would have a short warning time.

Tulsa is in the process of developing a new Comprehensive Plan. The current plan is approximately 30 years old, so new development data is necessarily incomplete or highly speculative.

4.12.5.2 Update Changes

Identified significant changes made from the 2003 City of Tulsa Multi-Hazard Mitigation Plan are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008.

4.12.5.3 Sources

Arkansas River Corridor Master Plan. Indian Nations Council of Governments, 2005. www.incog.org

Arkansas River Watershed, Tulsa and West Tulsa Levees, Arkansas River, Oklahoma – Definite Project Report. War Department, US Engineers Office, Tulsa Oklahoma, October 1942, revised September 1943.

Community Risk Assessment, City of Tulsa and Tulsa County, Oklahoma. For Tulsa Project Impact by INCOG, Nov 2001.

Flood Hazard Mitigation Report, Flood Events, September 29, 1986; October 1, 1986; October 4, 1986. Wright Water Engineers Inc. and R.D. Flanagan & Associates for City of Tulsa Department of Stormwater Management, December 18, 1986.

Maher, Walied (Oklahoma Water Resources Board). Telephone and email interviews June 2, 2008.

Multi-Hazard Identification and Risk Assessment, p. 254–261. Federal Emergency Management Agency, 1997.

Oklahoma Strategic All-Hazards Mitigation Plan. Oklahoma Department of Emergency Management, 2007.

Partners in Dam Safety, at Web address: www.damsafety.org/resources/?p=08f31c3e-78f8-491c-87b8-09f4d5652692. FEMA, National Dam Safety Program, Dam Safety Progress Through Partnerships.

Report on the Feasibility of Repair of the Tulsa and West Tulsa Local Protection Project. US Army Corps of Engineers, March 1991.

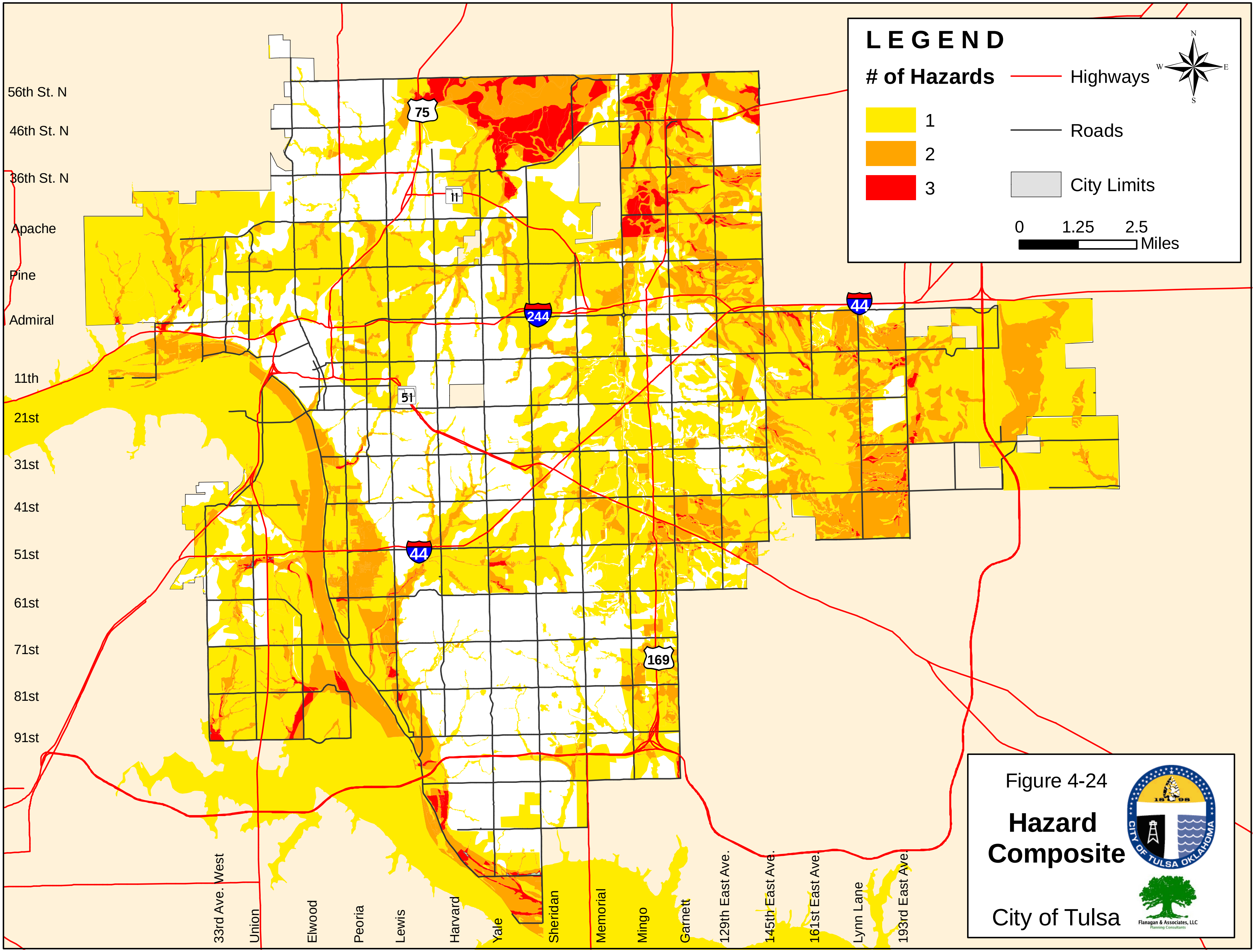
Rooftop to River: Tulsa's Approach to Floodplain and Stormwater Management, "Setting and History: Learning the Hard Way," p. 1–7 and at Web address: www.smartcommunities.ncat.org/articles/rooftop/index.shtml. City of Tulsa, 1994.

Water Management Analysis Report, Flood of September – October 1986, Northeastern Oklahoma and Southeastern Kansas. US Army Corps of Engineers Tulsa District, August 1987.

4.13 Hazard Composite

Most natural hazards- tornadoes, high winds, lightning, hail storms, winter storms, extreme heat, drought, and earthquakes- are not geographic area specific, and can impact the entire community equally and randomly.

Other natural hazards, such as floods, dam and levee failures, wild fires, and expansive soils, are geographic area specific, and the vulnerable areas of the community can be identified. The Hazard Composite map in Figure 4-24 identifies the areas of the City of Tulsa that are vulnerable to geographic specific hazards.


LEGEND
# of Hazards
1
2
3
Highways
Roads
City Limits
0 1.25 2.5 Miles
N
S
E
W
56th St. N
46th St. N
36th St. N
Apache
Pine
Admiral
11th
21st
31st
41st
51st
61st
71st
81st
91st
33rd Ave. West
Union
Elwood
Peoria
Lewis
Harvard
Yale
Sheridan
Memorial
Mingo
Garnett
129th East Ave.
145th East Ave.
161st East Ave.
Lynn Lane
193rd East Ave.
75
11
244
44
51
169
Figure 4-24
Hazard Composite
City of Tulsa

Chapter 5: Mitigation Goals and Objectives

This chapter identifies the hazard mitigation goals set by the City of Tulsa and discusses the mitigation projects, or measures, to be taken to achieve those goals.

Included in this Chapter:

The Research, Review, and Prioritization Process
Mitigation Categories
5.1 Hazard Mitigation Goals
5.1.1 Mission Statement
5.1.2 Mitigation Goal
5.1.3 Goals for All Natural Hazards
5.2 Hazard-Specific Goals and Objectives

The Research, Review, and Prioritization Process

The Hazard Mitigation Planning Committee (HMPC) and supporting staff identified and prioritized the measures that will help protect the lives and property of the citizens of Tulsa.

Initially, Goals from the 2003 City of Tulsa Hazard Mitigation Plan were reviewed and evaluated by the Technical Advisory Committee based on both progress and actions taken based on the 2003 plan, and on development or review of other pertinent City of Tulsa plans. Goals that were deemed to be effective and pertinent to the current plan were retained and incorporated into the 2009 plan.

National literature and sources were researched to identify best practices mitigation measures for each hazard. These measures were documented, and staff screened several hundred recommended mitigation actions and selected those that were most appropriate for the Tulsa area.

The HMPC reviewed the measures recommended by staff and revised, added, deleted, and approved measures for each hazard. The HMPC and staff prioritized the measures through a prioritization exercise using STAPLEE criteria recommended by FEMA. Table 5-1 lists these criteria. The results were tabulated and the individual measures were ranked by priority. The measures were then grouped into categories.

Table 5–1: STAPLEE Prioritization and Review Criteria

Evaluation Category	Sources of Information
Social	Members of Local, County and State Government were members of the Hazard Mitigation Planning Committee and had input throughout the planning process. Existing community plans were used wherever possible. Members of the Media were contacted and invited to attend all HMPC meetings.

Evaluation Category	Sources of Information
Technical	The following Persons/Agencies were consulted as to the technical feasibility of the various projects: Tulsa City Council, Tulsa Public Works Department, Oklahoma State University Extension Service, Soil Conservation Service, National Weather Service, the Corps of Engineers, County and State Health Departments, and Oklahoma Forestry Service. All of these had their comments and suggestions incorporated.
Administrative	Staffing for proper implementation of the plan currently will rely on existing members of the various agencies involved. Technical assistance is available from contractors and various State Agencies. Some local jurisdictions have incorporated Hazard Mitigation efforts into their Capital Improvement Plans. The Stormwater Drainage & Hazard Mitigation Advisory Board has agreed to an annual review and assessment of the Plan and its progress. Operations Costs are under discussion by the relevant department heads.
Political	A representative of the Tulsa City Council and the Mayor or her representative attended the HMPC meetings and were consulted on all aspects of the Plan.
Legal	Members of the HMPC discussed legal issues with the City Council, and it was their opinion that no significant legal issues were involved in the projects that were selected by the HMPC.
Economic	Economic issues were the predominant issues discussed by all concerned, with an emphasis on cost/benefit review. Each entity felt that the projects selected would have a positive effect in that the projects would attract business and recreation to the area as well as help the community be better prepared for a disaster. Funding for the various projects was the major concern as local budgets were not capable of fulfilling the needs due to the economic down turn. Reliance on outside grants will be relied on heavily for completion of some projects.
Environmental	Oklahoma Department of Environmental Quality, Oklahoma Forestry Service, and the Oklahoma Water Resources Board were all consulted as to the environmental impact of the various projects and it was felt that there would be no negative impact. Local governments are currently considering zoning of environmentally sensitive areas.

Mitigation Categories

The measures that communities and individuals can use to protect themselves from, or mitigate the impacts of, natural and man-made hazards fall into six categories:

- Public Information and Education
- Preventive Measures
- Structural Projects
- Property Protection
- Emergency Services, and
- Natural Resources Protection

This chapter is organized by mitigation category, with the HMPC mitigation mission statement and goals listed first in section 5.1.

Tulsa's hazard mitigation planning process involves citizens in every phase

5.1 Hazard Mitigation Goals

5.1.1 Mission Statement

To create a disaster-resistant community and improve the safety and well-being of Tulsa by reducing deaths, injuries, property damage, environmental and other losses from natural and technological hazards in a manner that advances community goals, quality of life, and results in a more livable, viable, and sustainable community.

5.1.2 Mitigation Goal

To identify community policies, actions and tools for long-term implementation in order to reduce risk and future losses stemming from natural and technological hazards that are likely to impact the community.

5.1.3 Goals for All Natural Hazards

- Minimize loss of life and property from natural hazard events.
- Protect public health and safety.
- Increase public awareness of risk from natural hazards.
- Reduce risk and effects of natural hazards.
- Identify hazards and assess risk for local area.
- Ascertain historical incidence and frequency of occurrence.
- Determine increased risk from specific hazards due to location and other factors.
- Improve disaster prevention.
- Improve forecasting of natural hazard events.
- Limit building in high-risk areas.
- Improve building construction to reduce the dangers of natural hazards.
- Improve government and public response to natural hazard disasters.

5.2 Hazard-Specific Goals and Objectives

Flood	
GOAL: ***To reduce injuries and loss of life; trauma; damage to property, equipment and infrastructure; community disruption; and economic, environmental, and other losses caused by floods and flash floods.***	
Objective 1.	**Public Information & Education.** Improve public awareness of flood and flash flood hazards in general and at specific high-risk locations; and give people knowledge about measures they can use to protect themselves, their property and their community.
Objective 2.	**Preventive Measures.** Expand mapping, regulations, and loss-prevention programs in areas with high risks and catastrophic potential, such as local portions of multi-jurisdictional riverine floodways and floodplains where additional safety considerations are warranted because Tulsa does not have jurisdiction to regulate upstream and downstream runoff, blockages, or other actions that can affect Tulsans' safety.
Objective 3.	**Structural Projects.** Obtain funding for and implement projects that can reduce flood and drainage hazards, with consideration for comprehensive solutions in accord with watershed-wide management plans.
Objective 4.	**Property Protection.** Identify and protect people, structures, critical facilities, and critical infrastructure that are vulnerable to flood and flash flood hazards.
Objective 5.	**Emergency Services.** Identify the needs and implement additional emergency operations plans and services for areas at high risk of flooding, including additional prediction and forecasting capability, emergency alerts, and evacuation plans.
Objective 6.	**Natural Resource Protection.** Protect and enhance natural floodplain and stormwater resources by adopting and implementing sustainable flood-management policies that have few or no negative impacts and have positive environmental effects whenever possible.

Tornado	
GOAL: ***To reduce injuries and loss of life; trauma; damage to property, equipment and infrastructure; community disruption; and economic, environmental and other losses caused by tornadoes.***	
Objective 1.	**Public Information & Education.** Improve public awareness of tornado hazards, in general and in specific high-risk situations; and give people knowledge about measures they can use to protect themselves, their property, and their community.
Objective 2.	**Preventive Measures.** Prevent or reduce tornado losses by strengthening buildings and by publicizing, training, and creating market options for fortified new construction, retrofits, code changes and code-plus innovations.
Objective 3.	**Structural Projects.** Provide safe tornado shelters, SafeRooms, and fortified buildings for vulnerable populations, including children; offer training and incentives to encourage people of means to include shelters and SafeRooms in new and retrofit building projects.
Objective 4.	**Property Protection.** Identify and protect people, structures, and critical infrastructure that are vulnerable to tornado hazards, with emphasis on critical facilities.
Objective 5.	**Emergency Services.** Identify the needs for and implement additional emergency operations plans and services to expand tornado safety, including Community Emergency Response Team training.

Tornado	
Objective 6.	**Natural Resource Protection.** Take advantage of opportunities for tornado programs and policies that reduce negative environmental impacts. Examples include sustainable programs for debris management and recycling, and fortified construction with environmentally friendly materials.

High Wind	
GOAL: ***To reduce injuries and loss of life; trauma; damage to property, equipment and infrastructure; community disruption; and economic, environmental and other losses caused by high winds.***	
Objective 1.	**Public Information & Education.** Improve public awareness of high-wind hazards, in general and in specific high-risk situations; and give people knowledge about measures they can use to protect themselves, their property, and their community.
Objective 2.	**Preventive Measures**. Prevent or reduce tornado losses by strengthening buildings and by publicizing, training, and creating market options for fortified new construction, retrofits, code changes and code-plus innovations.
Objective 3.	**Structural Projects.** Provide fortified buildings for critical public facilities and vulnerable populations, including children; offer training and incentives to encourage people of means to build stronger structures in new and retrofit building projects.
Objective 4.	**Property Protection.** Identify and protect people, structures, and critical infrastructure that are vulnerable to high winds, with emphasis on critical facilities.
Objective 5.	**Emergency Services.** Identify needs for and implement additional emergency operations plans and services to expand safety in dangerous windstorms, including Community Emergency Response Team training.
Objective 6.	**Natural Resource Protection.** Take advantage of opportunities for high-wind programs and policies that reduce negative environmental impacts. Examples include sustainable programs for debris management and recycling, and fortified construction with environmentally friendly materials.

Lightning	
GOAL: ***To reduce injuries, loss of life, and damage to property, equipment and infrastructure caused by Lightning strikes.***	
Objective 1.	**Public Information & Education.** Improve public awareness of Lightning hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	**Preventive Measures.** Identify the costs and the benefits of loss-prevention programs, such as whole building surge protection, with consideration for uncalculated benefits such as data or work productivity loss.
Objective 3.	**Structural Projects**. Provide for necessary construction, renovation, retrofitting or refurbishment of city infrastructure to protect vulnerable populations from the effects of lightning strikes.
Objective 4.	**Property Protection**. Identify ways to protect structures, infrastructure, and critical facilities and their occupants from damage caused by lightning strikes.
Objective 5.	**Emergency Services**. Establish or expand emergency services protocols that adequately address response scenarios in the event of incidents with the possibility of severe lightning.

Lightning	
Objective 6.	**Natural Resource Protection**. Ensure that lightning damage mitigation policies have no negative impacts and, whenever possible, provide positive enhancements to the environment.

Hail	
GOAL: ***To reduce the high costs of property and infrastructure damage caused by Hailstorms.***	
Objective 1.	**Public Information and Education.** Improve public awareness of Hailstorm hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	**Preventive Measures**. Identify the costs and the benefits of loss-prevention ordinances, such as building codes, with consideration for uncalculated benefits such as employee downtime or loss of city services.
Objective 3.	**Structural Projects**. Identify costs and benefits of loss-prevention programs, such as covered vehicle parking, with consideration for uncalculated benefits such as averting response delays and business losses.
Objective 4.	**Property Protection.** Identify, fund, and implement projects to protect people and public and private property from losses in hail events, including critical infrastructure such as utilities or public vehicles.
Objective 5.	**Emergency Services**. Establish or expand emergency services protocols that adequately address response scenarios in the event of severe hail events.
Objective 6.	**Natural Resource Protection**. Ensure that Hail mitigation policies have no negative impacts and, whenever possible, provide positive enhancements to the environment. Encourage homeowners, for example, to use Class 4 roofing made of recycled materials.

Winter Storms	
GOAL: ***To reduce injuries and loss of life; trauma; loss of critical utilities; damage to property, equipment and infrastructure; community disruption; and economic, environmental and other losses caused by winter storms. Winter hazards can include extreme temperatures, ice and snow, high winds, and cascading hazards such as loss of utilities.***	
Objective 1.	**Public Information & Education.** Improve public awareness of winter storm hazards and give people knowledge about measures they can use to protect themselves, their property and their community.
Objective 2.	**Preventive Measures.** Identify costs and the benefits of loss-prevention programs such as burying power lines to reduce utility outages or building snow-load roofs, with consideration for uncalculated benefits such as averting environmental and business losses.
Objective 3.	**Structural Projects.** Identify, fund, and implement measures, such as winterization retrofits to homes, critical facilities, transportation systems and infrastructure, to avert or reduce losses from winter storms. Provide additional protection, such as generators and emergency shelters, for agencies and facilities that serve vulnerable populations.
Objective 4.	**Property Protection.** Identify, fund, and implement projects to protect people and public and private property from losses in winter storms.

Winter Storms	
Objective 5.	**Emergency Services.** Identify and expand emergency services for people who are at high risk in winter storms, such as the homeless, elderly, disabled, and oxygen-dependent people.
Objective 6.	**Natural Resource Protection.** Evaluate options and take advantage of opportunities for sustainable winter-storm policies and programs to reduce negative environmental impacts; examples include programs for debris management, streets snow removal, tree trimming and replacement, energy conservation, and winterization.

Heat	
GOAL: ***To reduce heat-related illnesses, loss of life, and exacerbation of other hazards such as drought and expansive soils caused by extreme Heat conditions.***	
Objective 1.	**Public Information and Education.** Improve public awareness of extreme heat hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	**Preventive Measures.** Identify and protect people and critical infrastructure that are vulnerable to extreme heat conditions.
Objective 3.	**Structural Projects.** Provide for necessary construction, renovation, retrofitting or refurbishment of city properties to protect vulnerable populations from the effects of extreme heat.
Objective 4.	**Property Protection.** Implement construction and retrofitting measures to minimize the risk to public properties and their occupants caused by extreme heat.
Objective 5.	**Emergency Services.** Ensure that the Heat Emergency Action Plan is followed and that heat alerts are issued in a timely manner. Establish or expand emergency services protocols that adequately address response scenarios in the event of extreme heat.
Objective 6.	**Natural Resources Protection.** Ensure that extreme Heat mitigation policies have no negative impacts and, whenever possible, provide positive enhancements to the environment, such as the creation and development of urban green spaces.

Drought	
GOAL: ***To reduce the impact of Drought on property, infrastructure, natural resources and local government response functions.***	
Objective 1.	**Public Information and Education.** Improve public awareness of Drought and measures by which people can protect themselves, their property, and their community.
Objective 2.	**Preventive Measures.** Identify and protect resources and critical infrastructure that are vulnerable to Drought.
Objective 3.	**Structural Projects.** Provide for necessary construction, renovation, retrofitting or refurbishment to protect vulnerable structures from the effects of drought.
Objective 4.	**Property Protection.** Implement measures to minimize the risk to public property caused by drought events.
Objective 5.	**Emergency Services.** Establish or expand emergency services protocols that adequately address response scenarios in the event of drought.

Drought	
Objective 6.	**Natural Resource Protection.** Ensure that Drought mitigation policies have no negative impacts and, whenever possible, provide positive enhancements to the environment.

Expansive Soil	
GOAL: To reduce the damage and economic losses caused by expansive soils on property and local infrastructure.	
Objective 1.	**Public Information & Education.** Improve public awareness of expansive-soil hazards, with both general and site-specific information, and provide knowledge about available measures by which people can protect their property and their community.
Objective 2.	**Preventive Measures.** Avoid expansive-soils locations, whenever possible. Explore options for loss-mitigation from expansive soils, including building codes and code-plus options. Examine expansive soils before building critical facilities and infrastructure.
Objective 3.	**Structural Projects.** Identify and implement measures to reduce or avert expansive-soils damages and losses to structures and infrastructure, with emphasis on critical facilities and utilities.
Objective 4.	**Property Protection.** Identify and protect resources and critical infrastructure that are vulnerable to expansive soils.
Objective 5.	**Emergency Services.** Survey emergency and critical facilities for potential expansive-soil problems; repair and retrofit as needed; and consider soils when building emergency facilities.
Objective 6.	**Natural Resource Protection.** Protect and enhance natural resources by adopting and implementing sustainable expansive-soils policies that have few or no negative impacts and have positive environmental effects whenever possible.

Wildfire	
GOAL: *To reduce injuries, loss of life, and damage to property, equipment and infrastructure caused by Wildfires.*	
Objective 1.	**Public Information & Education.** Improve public awareness of Wildfire hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	**Preventive Measures.** Identify and protect populations, structures, and critical infrastructure that are vulnerable to Wildfires.
Objective 3.	**Structural Projects**. Include wildfire considerations in landscaping, public park, and other properties that would fall into wildland-urban interface or other areas of wildfire risk. Include infrastructure improvements that support effective firefighting.
Objective 4.	**Property Protection**. Implement building materials and techniques in retrofitting or in new construction to minimize the risk to public property caused by earthquakes.
Objective 5.	**Emergency Services**. Establish or expand emergency services protocols that adequately address response scenarios in wildfire events.
Objective 6.	**Natural Resource Protection.** Ensure that Wildfire mitigation policies have no negative impacts and, whenever possible, provide positive enhancements to the environment.

Earthquake	
GOAL: ***To reduce injury, loss of life, and damage to property, equipment and infrastructure caused by Earthquakes.***	
Objective 1.	**Public Information and Education.** Improve public awareness of Earthquake hazards and measures by which people can protect themselves, their property and their community.
Objective 2.	**Preventive Measures.** Identify and protect populations, structures, and critical infrastructure that are vulnerable to Earthquakes.
Objective 3.	**Structural Projects.** Provide for necessary construction, renovation, retrofitting or refurbishment to protect vulnerable structures from the effects of earthquakes.
Objective 4.	**Property Protection.** Implement building materials and techniques in retrofitting or in new construction to minimize the risk to public properties and their occupants caused by earthquakes.
Objective 5.	**Emergency Services.** Establish emergency services protocols that adequately address response scenarios in the event of earthquake.
Objective 6.	**Natural Resource Protection.** Take advantage of opportunities for tornado programs and policies that reduce negative environmental impacts. Examples include sustainable programs for debris management and recycling, and fortified construction with environmentally friendly materials.

Dam and Levee Break	
GOAL: ***To reduce injuries and loss of life; trauma; damage to property, equipment, critical facilities, and infrastructure; community disruption; and economic, environmental, and other losses caused by partial or total dam and levee failures.***	
Objective 1.	**Public information & education**. Improve public awareness of dam and levee break hazards, in general and at specific high-risk locations; and give people knowledge about measures they can use to protect themselves, their property, and their community.
Objective 2.	**Preventive measures.** Expand mapping, regulations, and loss-prevention programs in areas with high risks, including extension of flood insurance regulations behind high-risk levees; updated risk mapping downstream of high-risk dams; and pre-disaster evacuation and hazard-mitigation programs.
Objective 3.	**Structural projects.** Analyze safety of existing high-risk dams and levees, including maintenance programs and funding; and implement highest-priority measures to strengthen the structures and reduce risks.
Objective 4.	**Property protection measures.** Identify and protect people, structures, critical facilities, and critical infrastructure that are vulnerable to dam and levee break hazards.
Objective 5.	**Emergency services.** Identify needs for and implement additional emergency operations plans and services in areas at high risk from dam and levee breaks, including additional prediction and forecasting capability, emergency alerts, and evacuation plans.
Objective 6.	**Natural resource protection.** Protect and enhance natural resources by adopting and implementing sustainable dam and levee break policies that have few or no negative impacts and have positive environmental effects whenever possible. Include analysis of downstream impacts on environment and wildlife in dam and levee planning.

Chapter 6: Action Plan & Mitigation Measures

Included in this Chapter:
6.1 Action Plan

The City of Tulsa has reviewed and analyzed the risk assessment studies for the natural hazards events that may impact the community. The Tulsa Mitigation Technical and Citizens Advisory Committees prioritized and developed an Action Plan for those mitigation measures considered most effective for the community. This chapter identifies those high priority actions to achieve the Community's mitigation goals, the lead agency responsible for implementation of each action item, an anticipated time schedule, estimated cost opinion, identification of possible funding sources, and any resources, such as maps or tables which might be in another Chapter.

Table 6–1: Measures per Hazard

Hazard	Measures Addressing	Hazard	Measures Addressing
Floods	17	Extreme Heat	10
Tornadoes	16	Drought	3
High Wind Events	16	Expansive Soil	4
Lightning	11	Wildfires	10
Hail	7	Earthquakes	11
Winter Storms	13	Dam/Levee Failures	16

6.1 Action Plan

Table 6–2: Tulsa Prioritized Mitigation Measures

Hazard:	***Floods, Extreme Heat, Wildfires, Winter Storms, Dam/Levee Failure***
1.	**Incorporate an Emergency Telephone Notification System (ETNS) into the Tulsa Emergency Communications Center**
Lead:	Tulsa Emergency Communications Dept.
Time Schedule:	2 years
Estimated Cost:	$495,300. $2.25/address setup x 203,000 addresses. Plus $0.19/address upkeep for first year.
Source of Funding:	HMGP, ongoing Communications Center funding

Work Product/ Expected Outcome:	Acquire an "Emergency Telephone Notification System" (frequently referred to as Reverse 9-1-1) with which a community can send out a mass telephone announcement to targeted numbers in the 9-1-1 system, effectively supplementing a community's other warning systems. This is useful during a geographic-specific threat, such as a hazmat release, wildfire threat, etc., and can even be used for missing persons, Amber Alerts, and other non-disaster incidents. The ETNS would be integrated with the 9-1-1 GIS system to maintain updated information and data.
Resources:	Section B.5.4 – Emergency Telephone Notification Systems
Hazard:	***Floods, Tornadoes, High Winds, Lightning, Hail, Winter Storms, Wildfires, Earthquakes, Dam/Levee Failure***
2.	**Construct a new Emergency Operations Center**
Lead:	Tulsa Area Emergency Management Agency
Time Schedule:	3 years
Estimated Cost:	$9 Million. $6.0 Mil for structure. $3 Mil for supplies and communications equipment.
Source of Funding:	City of Tulsa and Tulsa County budgets, private funding, HMGP
Work Product/ Expected Outcome:	Build and equip a new Emergency Operations Center, to be located on the Tulsa County Fairgrounds property, to replace the aging and inadequate EOC currently located in the basement of the Tulsa Police/Courts Building. The new 15,000 sq. ft. EOC would be developed to FEMA 361 standards. HMGP funding would be used to supplement normal construction costs with the additional costs for increasing the "armoring" of the facility to meet the FEMA 361 standards for Community SafeRooms.
Hazard:	***Floods, Tornadoes, High Winds, Lightning, Winter Storms, Earthquakes, Dam/Levee Failure***
3.	**Develop a Master Generator Plan for the City of Tulsa**
Lead:	Tulsa Area Emergency Management Agency (TAEMA)
Time Schedule:	18 months
Estimated Cost:	$35,000
Source of Funding:	HMGP
Work Product/ Expected Outcome:	Develop a plan for identifying, prioritizing and implementing generator needs for critical response facilities. The plan would include working with the Corps of Engineers to perform a power audit for facilities identifying the power requirements for critical functions. In addition, the plan would outline needs and potential costs for generator pads, automatic transfer switches, and sources for generators. It would identify existing generator capabilities and whether those were adequate for

	response needs. It would also identify funding sources and lead personnel responsible.
Resources:	Critical Facilities – Table 1-11, Figures 1-14 thru 1-21. Appendix G. Section B.2.12 – Standby Electric Generators.
Hazard:	***Tornadoes, High Winds***
4.	**Develop a SafeRoom plan for City of Tulsa facilities**
Lead:	City of Tulsa Public Works Planning Department
Time Schedule:	1 year
Estimated Cost:	\$33,630. \$65/facility x 425 facilities. Plus admin and plan production costs.
Source of Funding:	HMGP
Work Product/ Expected Outcome:	Evaluate City facilities to determine where providing a SafeRoom meeting the FEMA 361 standards would increase the capabilities of the city's being able to more effectively respond to a major disaster. Parameters such as level of critical operations, number of staff, degree of critical response operations, and current building architecture would all factor into the prioritization of incorporating a SafeRoom as either a retrofit, as part of a remodel or expansion of existing facilities, or in the development of new City facilities.
Resources:	City of Tulsa Facilities – Table 1-11, Figures 1-14 & 1-15. Appendix G.
Hazard:	***Tornadoes, High Winds***
5.	**Individual SafeRoom rebate program**
Lead:	City of Tulsa Development Services (Inspections)
Time Schedule:	3 years or until funds exhausted
Estimated Cost:	\$2,000,000
Source of Funding:	HMGP
Work Product/ Expected Outcome:	Provide rebates in amounts up to \$2,000 (or 75% of cost, whichever is less) for individuals to put SafeRooms or other storm shelters in their residences. Either the shelter (if pre-built) or the installer (if built from raw materials) would be required to be certified by the National Storm Shelter Association (NSSA) in order to guarantee compliance with the FEMA 320 standards. This would fund a minimum of 1,000 SafeRooms/Storm Shelters in the City of Tulsa. B.3.1 – Safe Rooms.
Hazard:	***Lightning***
6.	**Install Lightning Warning & Alert Systems in public recreation areas**
Lead:	City of Tulsa Parks & Recreation Department, Public Works Department

Time Schedule:	3 years
Estimated Cost:	$360,000. Approx. $6,000/system x 60.
Source of Funding:	HMGP
Work Product/ Expected Outcome:	Place lightning detection and warning systems (such as ThorGard or Boltek) in City of Tulsa public recreation areas, to include soccer fields, athletic complexes, and City swimming pools. The program would also include writing a Lightning Safety Plan for City recreation facilities and providing information and education on how to respond to potential alarms. These fully automated systems include a lightning threat detector, strobe light and 360° warning horn, and a fully-automated programmable computer to pre-set various options for different types of facilities, such as times of operation, degrees of sensitivity, and appropriate sounding of an "all clear" signal if desired.
Resources:	Section B.2.10 – Lightning Warning Systems.
Hazard:	***Floods, Tornadoes, High Winds, Lightning, Hail, Winter Storms, Extreme Heat, Drought, Expansive Soil, Wildfires, Earthquakes, Dam/Levee Failure***
7.	**Public Education & Information Program Development**
Lead:	Tulsa Partners Inc.
Time Schedule:	3 years
Estimated Cost:	$75,000
Source of Funding:	HMGP. Other foundation grants.
Work Product/ Expected Outcome:	Provide funding to develop outreach programs to reach schools, libraries, civic organizations, neighborhood groups, and other opportunities. This would also include the development and production of PSA's and the production or purchase of educational videos and other materials to support them. This program would be managed and implemented by Tulsa Partners in cooperation with the Tulsa Area Emergency Management Agency, Tulsa Fire Department, and other agencies involved in public disaster education and information.
Resources:	Section B.1.1 – Public Information Program Strategy.
Hazard:	***Floods, Tornadoes, High Winds, Hail, Winter Storms, Extreme Heat, Wildfires, Earthquakes, Dam/Levee Failure***
8.	**Develop a Special Needs registry through the 9-1-1 databases to assist with educating, alerting, evacuating, or responding to vulnerable populations during disaster**
Lead:	MMRS

Time Schedule:	18 months
Estimated Cost:	$150,000
Source of Funding:	HMGP, HRSA
Work Product/ Expected Outcome:	Special Needs populations, such as people with physical or developmental disabilities, the extremely elderly, people dependent on auxiliary medical equipment, and others, frequently require extraordinary efforts in providing preparedness activities, alerts and warnings, and response and recovery. Developing a database of these extremely vulnerable populations will assist all preparedness and response agencies in providing services. Successful programs that have been developed in Houston, San Antonio and Florida could serve as models for the Tulsa program. Funding would cover the acquisition of a new database program or programming for the modification of an existing program, administrative costs for the process, equipment (computer, fax, phone line, etc.), marketing costs to get the word out, development of signup processes (web based, mail in forms, phone intake), training for personnel, and other associated activities.
Resources:	Vulnerable Populations – Figures 1-5 thru 1-10. Section 1.2.5.1 – Vulnerable Populations.
Hazard:	***Floods, Tornadoes, High Winds, Lightning, Winter Storms, Earthquakes, Dam/Levee Failure***
9	**Provide for back-up power sources for City water treatment plants to avoid water shortages during extended power outages**
Lead:	City of Tulsa Public Works
Time Schedule:	1 year
Estimated Cost:	$130,000. $65,000 x 2, including installation.
Source of Funding:	HMGP, Local
Work Product/ Expected Outcome:	Provide an alternate back-up power source to at least one pump at each of the two freshwater treatment plants, which would allow for the pumping of up to 10,000 gpm per plant during extended power outages. This will be done following the completion of the citywide Master Generator Plan from Mitigation Measure #1.
Hazard:	***Winter Storms, High Winds, Tornadoes, Earthquakes***
10.	**Provide backup power generators to five additional city fueling facilities**
Lead:	Equipment Maintenance Department of Public Works
Time Schedule:	1 year

Estimated Cost:	$200,000 $40,000 / unit (which includes installation).
Source of Funding:	HMGP, Local
Work Product/ Expected Outcome:	During the ice storm of December 2007, most privately owned fuel outlets in the City were unable to access their underground tanks. This measure would provide generator power to five additional city fueling facilities in order to assure continuity of vehicle operations during extended power outages. Currently, only one out of the City's seven fueling stations has this capability with funding for a second already budgeted. Required for each of the five remaining is a 60 kW trailer-mounted, liquid-cooled, diesel Kohler Model 60KRC, along with installation of an automatic power transfer panel for each. This will be done following the completion of the citywide Master Generator Plan from Mitigation Measure #1.
Hazard:	***Floods, Dam/Levee Failures***
11.	**Implement structural and non-structural flood mitigation measures for flood-prone properties, as recommended in the basin-wide master drainage plans**
Lead:	Public Works
Time Schedule:	Ongoing
Estimated Cost:	$511,489,000. Current comprehensive plan measures adjusted for inflation.
Source of Funding:	Local General Obligation Bond Issues, Local Capital Improvements Sales Taxes, Stormwater Utility Fee, Fee-in-lieu-of Detention funds, U.S. Army Corps of Engineers projects, HMGP.
Work Product/ Expected Outcome:	In order to ensure a community where all property and infrastructure is protected to the 100-year Base Flood Elevation, Tulsa's Flood and Stormwater Management Plan looks at two ways to reduce and prevent flood damage to properties. One way is called "structural" and involves building detention ponds, dikes, or other structures to keep the water away from the property. Another way is called "non-structural" and involves relocation or demolition so that the property is "removed" from the hazard.
Resources:	Section B.2.4 – Floodplain Management

Hazard:	***Floods, Tornadoes, High Winds, Lightning, Hail, Winter Storms, Heat, Wildfires, Earthquakes, Dam/Levee Failure***
12.	**Develop enhanced Emergency Planning for Special Needs populations in the City of Tulsa Emergency Operations Plan and other planning documents**
Lead:	Tulsa Area Emergency Management Agency
Time Schedule:	3 years
Estimated Cost:	$15,000
Source of Funding:	HMGP, HRSA, private grant funding
Work Product/ Expected Outcome:	Special Needs populations, (such as people with physical or developmental disabilities, the extremely elderly, people dependent on auxiliary medical equipment, and others) will require additional measures in order to support alerts and warnings, evacuation, and medical response. By working with local advocacy groups, and by identifying weakness and gaps in the City's emergency planning, the increased capability of the enhanced plan will enable emergency responders to more effectively support the most vulnerable segments of the population.
Resources:	Vulnerable Populations – Figures 1-5 thru 1-10. Section 1.2.5.1 – Vulnerable Populations.
Hazard:	***Floods, Dam/Levee failure***
13.	**Acquire and remove Repetitive Loss Properties and repeatedly flooded properties where the City's Repetitive Loss and master drainage plans identify acquisition to be the most cost effective and desirable mitigation measure**
Lead:	Public Works
Time Schedule:	Ongoing
Estimated Cost:	$58,000,000
Source of Funding:	Local sales tax and bond issues, HMGP, PDM, FMA, Severe Repetitive Loss (SRL), Repetitive Loss Claims (RLC) Grants
Work Product/ Expected Outcome:	Acquisition and removal of all buildings from the floodplain where acquisition is deemed to be the most cost-effective means of flood mitigation and protection. The National Flood Insurance Program keeps track of insurance claims made for flood damages. Properties where claims of $1,000 or more have occurred at least twice in the past 10 years are called "Repetitive Loss Properties." In addition, the City of Tulsa keeps track of properties that suffer repeated damages that are less than $1,000 each.
Resources:	Appendix H: Repetitive Loss Properties.

Hazard:	***Floods, Dam/Levee failure***
14.	**Develop a Comprehensive Levee evaluation and repair Plan**
Lead:	City of Tulsa Public Works Planning Department
Time Schedule:	2 years
Estimated Cost:	$2,000,000
Source of Funding:	HMGP, Local, USACE
Work Product/ Expected Outcome:	Preliminary evaluations performed by the Corps of Engineer in 2007-08 on the City of Tulsa levees have revealed a number of deficiencies in the system. They have also determined what would be involved in completing a comprehensive study to further define these needs, and to develop a program for funding and implementing corrections to those deficiencies. This program would need to be done in cooperation and collaboration with Tulsa County and the surrounding communities that rely upon the levee system for protection.
Resources:	Table 4-41: Tulsa Dams and Levees. Table 4-45: Levee Failure Property Exposure. Table 4-46: Levee Failure Critical Facilities.
Hazard:	***Floods, Dam/Levee failure***
15.	**Develop a Levee Public Education and Evacuation Plan for at-risk areas of the community**
Lead:	Tulsa Area Emergency Management Agency
Time Schedule:	2 years
Estimated Cost:	$30,000.
Source of Funding:	HMGP, Local
Work Product/ Expected Outcome:	There are a number of highly populated residential areas of the City located behind the levee systems. This measure would provide a two-pronged approach to protecting that population: (1) a public education and information program targeting those vulnerable households, and (2) a formal evacuation plan as an addendum to the City of Tulsa Emergency Operations Plan. Funding would include the creation of area-specific, hazard-specific educational literature and distribution.
Resources:	Table 4-41: Tulsa Dams and Levees. Table 4-45: Levee Failure Property Exposure
Hazard:	***Floods, Tornadoes, High Winds, Lightning, Hail, Winter Storms, Extreme Heat, Wildfires, Earthquakes, Dam/Levee Failure***
16.	**Disaster Resistant Business Program**
Lead:	Tulsa Partners' Disaster Resistant Business Council
Time Schedule:	3 years

Estimated Cost:	$80,000. $25,000/year program costs + $5,000 for 1,000 Open for Business Manuals
Source of Funding:	HMGP, Local Funding
Work Product/ Expected Outcome:	Provide materials and administrative support for a comprehensive Business Continuity Planning program for the City of Tulsa, to include presentations to business, non-profits and professional groups, Chamber of Commerce events, United Way events, etc. The program would include an annual one-day conference with an overview on developing a Business Continuity Plan and breakout sessions addressing specific BCP issues. The goal is to reach 1,000 representatives of small/medium businesses and non-profits.
Resources:	Figure B.1.10: Business Continuity Planning & Mitigation
Hazard:	***Expansive Soils***
17.	**Consider establishing an administrative procedure or change in City codes for requiring builders to check for expansive soils when they apply for permits for new residential construction and for using foundations that mitigate expansive soil damages when in a moderate or high-risk area.**
Lead:	City of Tulsa Development Services Permit Center
Time Schedule:	1 year
Estimated Cost:	Minimal
Source of Funding:	Existing budget
Work Product/ Expected Outcome:	Investigate potential code changes or construction incentives to builders and developers for using mitigation techniques, such as post-tension slab on grade, drilled pier or other resistant foundations, on new residential construction in areas of moderate or high risk from expansive soils.
Resources:	Figures 4-30 thru 4-36: Expansive Soils.
Hazard:	***Floods, Dam/Levee Failure***
18.	**Continue to update and revise Basin-wide Master Drainage Plans where changed conditions warrant.**
Lead:	City of Tulsa Public Works
Time Schedule:	Ongoing
Estimated Cost:	$5,000,000
Source of Funding:	HMGP, PDM, FMA, Local matching funds.
Work Product/ Expected Outcome:	Many of the City’s MDPs are outdated and need to be revised. Master Drainage Plans will be developed for newly annexed areas of the City,

	and the 38 existing Basin-wide Master Drainage Plans will be updated with new hydrology, hydraulics, topography, surveyed First Finished Floor Elevations for structures in the floodplain, and revised recommended structural and non-structural mitigation measures to solve the flooding problems.
Resources:	Table 2-2: Master Drainage Plans and Basins.
Hazard:	***Floods, Tornadoes, High Winds, Lightning, Hail, Winter Storms, Extreme Heat, Drought, Expansive Soil, Wildfires, Earthquakes, Dam/Levee Failure***
19.	**Develop multi-lingual Disaster Education PSA's and educational videos**
Lead:	Tulsa Area Emergency Management Agency
Time Schedule:	1 year
Estimated Cost:	$40,000
Source of Funding:	HMGP
Work Product/ Expected Outcome:	Develop PSA's (15-second and 30-second, both audio and video) in Spanish, Vietnamese and American Sign Language (ASL) addressing seasonal disaster safety issues. Develop 8-10 minute education videos in each language providing information on how to develop a personal/family disaster plan and disaster supply kit. TAEMA will administer this grant in coordination with the Language & Culture Bank of Tulsa, which includes representation from several cultural, ethnic, and social service organizations.
Resources:	Figures 1-7 & 1-8 – Ethnic Populations. Section 1.2.5.1 – Vulnerable Populations.
Hazard:	***Floods, Tornadoes, High Winds, Lightning, Winter Storms, Extreme Heat, Wildfires, Earthquakes, Dam/Levee Failures***
20.	**Develop a separate "public safety" information area in all public libraries and public recreation facilities to disseminate disaster safety information appropriate to the area and the season**
Lead:	Tulsa Area Emergency Management Agency, Tulsa Partners
Time Schedule:	6 months, and Ongoing
Estimated Cost:	$16,800. 36 locations x $300/display grid plus $2,000/year for materials for 1st 3 years.
Source of Funding:	HMGP, partner organizations
Work Product/	Place a separate brochure grid in each of the 25 Public Library locations and the 11 Public Community Recreation Centers exclusively dedicated

Expected Outcome:	to Public Safety information, to include brochures and other educational materials on hazards that are specific to that area, the population that center serves (e.g., Hispanic literature at Martin Regional Library), and the season of the year (e.g., fire safety during Fire Safety month just prior to the highest risk time of year for house fires). Materials could be distributed monthly through regular distribution runs by the Library and Parks & Recreation departments. Costs above are not total educational material costs, since some materials are already distributed through other sources such as American Red Cross or Community Service Council.
Hazard:	***Tornadoes, High Winds***
21.	**Educate residents, building professionals and SafeRoom vendors on the ICC/NSSA "Standard for the Design and Construction of Storm Shelters" and consider incorporating into current regulatory measures**
Lead:	City of Tulsa Development Services (Inspections), Tulsa Area Emergency Management Agency
Time Schedule:	3 years
Estimated Cost:	$75,000
Source of Funding:	Existing sources
Work Product/ Expected Outcome:	Provide educational opportunities for residents on the ANSI accredited International Code Council 500-2008 "ICC/NSSA Standard for the Design and Construction of Storm Shelters," which will supersede the current NSSA standards for shelters. Review if adherence to this standard should be incorporated into zoning and regulatory measures adopted by the community. In addition, familiarize the building community and SafeRoom manufacturers on the availability of NSSA certification and the advantages of adopting it. This may involve bringing in speakers from the NSSA for educational sessions.
Resources:	Section B.3.1: Safe Rooms.
Hazard:	***Floods, Tornadoes, High Winds, Lightning, Hail, Winter Storms, Extreme Heat, Drought, Expansive Soil, Wildfires, Earthquakes***
22.	**Train/Educate builders, developers, architects and engineers in techniques of disaster-resistant homebuilding**
Lead:	Home Builders Association of Greater Tulsa, American Institute of Architects of Eastern Oklahoma, Tulsa Area Emergency Management Agency, Tulsa Partners
Time Schedule:	3 years. Ongoing
Estimated Cost:	$150,000
Source of Funding:	HMGP, ongoing agency training budgets, private industry support

Work Product/ Expected Outcome:	Develop a program in coordination with the Home Builders' Association of Greater Tulsa to educate all connected disciplines in the techniques, materials, and technologies available for building, and the economics of designing, building, and marketing, disaster resistant homes. This would be focused around the Fortified Home standards developed by the Institute for Business & Home Safety (IBHS), the Blueprint for Safety guidelines developed by the Federal Alliance for Safe Homes (FLASH), and other appropriate protocols. In the course of this training, experts in this field from ICC, Texas Tech, manufacturers, and other entities could be brought in to provide advanced training.
Resources:	Section B.2.6: IBHS Fortified Home Program.
Hazard:	***Winter Storms, Tornadoes, High Winds***
23.	**Develop a comprehensive public education program on the dangers of carbon monoxide during extended power outages**
Lead:	EMSA
Time Schedule:	3 years
Estimated Cost:	$20,000
Source of Funding:	HMGP, Local Funding
Work Product/ Expected Outcome:	Prepare for a comprehensive "just-in-time" public education campaign during extended power outages on the dangers connected with both improper use of portable generators and alternative heating sources, such as fireplaces and stoves. A great many illnesses and some deaths in Oklahoma have been recorded due to both these causes. While many materials are available for this program, some may have to be developed that are Tulsa specific. This program would be done in collaboration with Tulsa Area Emergency Management Agency, the Tulsa Health Department, the Tulsa Fire Department, PSO, and other concerned agencies.
Hazard:	***Tornadoes, High Winds***
24.	**Develop a model SafeRoom project for a Mobile Home Park in the City of Tulsa**
Lead:	TAEMA, Tulsa Partners
Time Schedule:	2 years
Estimated Cost:	$90,500 $181/sq. ft x 100 people x 5 sq. ft./person
Source of Funding:	HMGP
Work Product/ Expected Outcome:	Work with an existing Mobile Home Park to place a community shelter onsite that could be available to be viewed by other interested parties, with the goal of encouraging other MH Parks to duplicate this type of

	facility on their property and residents of other mobile home parks to request it. The SafeRoom could serve a dual purpose as a community room for Park residents. The above cost is based on an estimated 100-person occupancy structure designed to FEMA 361 standards.
Hazard:	***Extreme Heat***
25.	**Supplement the current Heat Coalition program to loan window air conditioners to an extremely medically vulnerable population during the summer months**
Lead:	Community Service Council Heat Coalition
Time Schedule:	1 year
Estimated Cost:	$17,000. $100-$150/air conditioner x 100 units, plus training and installation materials and related costs.
Source of Funding:	HMGP, existing budget
Work Product/ Expected Outcome:	At the current time, the Tulsa Heat Coalition cannot fill all the requests they receive to provide loaned window air conditioners to low-income individuals who are bed- or chair-ridden due to health concerns. This measure would add 100 A/C units and increase the Coalition's ability to administer this proven program. The City of Tulsa would assist the Heat Coalition with an aggressive volunteer installer recruitment program, which would include expanding existing installation/equipment maintenance training.
Hazard:	***Extreme Heat***
26.	**Review the safety of Playground materials during extreme heat events**
Lead:	City of Tulsa Parks & Recreation, Safe Kids Coalition
Time Schedule:	1 year
Estimated Cost:	$25,000. Staff time and administrative support.
Source of Funding:	HMGP, private foundation grants
Work Product/ Expected Outcome:	It has been demonstrated that many playground surfaces, whether paving surfaces or surfaces of playground equipment, can reach dangerously high temperatures during hot weather. In studies in other communities, equipment has been identified with a surface temperature of over 140 degrees on days when the maximum temperature was only 80 degrees Fahrenheit. When the temperature exceeds 100, surface temperatures were sufficient to instantly produce physical injury on contact. Infrared handheld temperature sensors used to detect "hot spots" would enable representatives of the Safe Kids Playground Safety Committee or members of the Parks Department to easily identify current danger areas. Appropriate plans to replace, protect, or modify those dangerous areas

	could then be developed.
Hazard:	***Wildfire***
27.	**Implement a Firewise Community Education and Information Program**
Lead:	Tulsa Fire Department
Time Schedule:	3 years
Estimated Cost:	$7,500
Source of Funding:	HMGP, Community Wildfire Planning Grant
Work Product/ Expected Outcome:	Implement a wildfire safety program using materials from Firewise Community USA. The program would include the training of educators and inspectors, identification of high-risk neighborhoods and buildings, and developing agreed-upon, area-specific solutions to the fire issues. The State Firewise Specialist will review and then work with the community to seek project implementation funds, if necessary. There are approximately 1,000 homes in the high-risk areas of the Tulsa urban-wildland interface. The goal is that a subdivision could be identified during this process that would seek Firewise certification through their Home Owners' Association and serve as a model for other homeowner's groups in the Tulsa area.
Hazard:	***Floods, Dam/Levee Failure***
28.	**Provide stricter floodplain regulations along the Arkansas River corridor.**
Lead:	Department of Public Works & Storm Drainage and Hazard Mitigation Advisory Board
Time Schedule:	2009
Estimated Cost:	$25,000
Source of Funding:	Local, USACE
Work Product/ Expected Outcome:	The City of Tulsa will identify and map the 1986 Arkansas River Flood, and adopt those flood limits as the City's Regulatory Floodplain on the Arkansas River within the City-Limits of the City of Tulsa.
Hazard:	***Floods, Dam/Levee Failure***
29.	**Consider establishing an administrative procedure or change in City codes for requiring builders to develop a site drainage plan ensuring "no adverse impact" when they apply for permits for new residential construction.**
Lead:	City of Tulsa Development Services (Inspections)
Time Schedule:	1 year

Estimated Cost:	Minimal
Source of Funding:	None
Work Product/ Expected Outcome:	Investigate potential code changes or construction incentives to builders and developers for identifying and mitigating against adverse drainage issues on new residential construction. Frequently new construction will produce adverse impacts on other properties downstream or downhill from the property. This program would ensure that builders and developers perform due diligence in their initial planning.
Hazard:	***Floods, Dam/Levee Failure***
30.	**Continue National Flood Insurance Program (NFIP) and Community Rating System (CRS) Participation**
Lead:	City of Tulsa Department of Public Works and Development Services (Inspections)
Time Schedule:	1 year
Estimated Cost:	$568,000
Source of Funding:	Local
Work Product/ Expected Outcome:	Continue to meet minimum NFIP requirements and exceed those requirements by participating in the CRS program

Chapter 7: Plan Maintenance and Adoption

This chapter includes a discussion of the plan maintenance process and documentation of the adoption of the plan by the Tulsa City Council.

7.1 Monitoring, Evaluating, and Updating the Plan

Included in this Chapter:

7.1 Monitoring, Evaluating, and Updating the Plan
7.2 Public Involvement
7.3 Incorporating the Multi-Hazard Mitigation Plan

The City of Tulsa will ensure that a regular review and update of the Multi-Hazard Mitigation Plan occurs. The Hazard Mitigation Planning Committee (HMPC) will continue to meet on a semi-annual basis, or as conditions warrant, to oversee and review updates and revisions to the plan. The City of Tulsa Sr. Special Projects Engineer will continue to head the Staff Technical Advisory Committee, which will monitor and oversee the day-to-day implementation of the plan. The Plan will be updated and resubmitted to the State and FEMA for approval prior to the 5-year approval period expiration, as per FEMA requirements.

Monitoring the Plan- Monitoring of the Plan, the Action Plan, and Mitigation Measures is the responsibility of the Emergency Manager, Special Projects Engineer, and Floodplain Administrator. Departments responsible for implementation of the Action Plan and the Mitigation Measures will update their Progress Reports on an annual basis, and report to the HMPC on progress and/or impediments to progress of the mitigation measures.

Evaluating the Plan- The *City of Tulsa Multi-Hazard Mitigation Plan* will be continually evaluated by the Project Manager, and a report will be made to the HMPC twice each year. The evaluation will assess:

- Adequacy of adopted Goals and Objectives in addressing current and future expected conditions;
- Whether the nature and magnitude of the risks have changed;
- Appropriateness of current resources allocated for implementation of the Plan;
- To what extent the outcomes of the Mitigation Measures occurred as expected;
- Whether agencies, departments and other partners participated as originally anticipated.

Many Action Items recommended in this plan have already been incorporated into the City's Capital Improvements Plan process. These programs will continue to be monitored and updated on an annual basis, if not more often.

Updating the Plan- The *City of Tulsa Multi-Hazard Mitigation Plan* will be updated according to the following schedule:

1. Revise and Update- the City will incorporate revisions to the plan document identified during the monitoring and evaluation period, as well as items identified in the previous Crosswalk.
2. Submit for Review- the revised plan will be submitted to ODEM and FEMA through the State Hazard Mitigation Officer for review and approval, and to FEMA no later than six (6) months prior to the end of the original performance period.
3. Final Revision and Adoption- if necessary, the plan will be revised per ODEM and FEMA remarks, adopted by the Tulsa City Council, and the updated plan sent to FEMA prior to the expiration of the 5-year approval period.

7.2 Public Involvement

The City of Tulsa is committed to involving the public directly in updating and maintaining the Multi-Hazard Mitigation Plan.

Copies of the Plan will be maintained at the public library, and the plan will be placed on the website of the City of Tulsa.

Small area-specific meetings will be held on no less than a semi-annual basis at Public Libraries or other public venues. A public meeting will be held prior to submission of the update of the *City of Tulsa Multi-Hazard Mitigation Plan*. This meeting will be advertised to the general citizenry. This meeting will be held to update citizens on the progress that has been made in implementing the plan and related capital projects. The meetings will also be used to distribute literature and inform and educate citizens as to actions they can take to mitigate natural hazards, save lives, and prevent property damage. Input from the citizens will be solicited as to how the mitigation process can be more effective.

7.3 Incorporating the Multi-Hazard Mitigation Plan

The City of Tulsa’s local planning mechanisms available for incorporating the recommendations and requirements of the Hazard Mitigation Measures are listed below.

Incorporation by the City of Tulsa

The *City of Tulsa Multi-Hazard Mitigation Plan* will be adopted by the Tulsa City Council as an amendment to the City’s Comprehensive Plan. The Tulsa City Council will adopt the plan as a guide to City mitigation activities. Appropriate Action Items and Mitigation Measures from the plan will be incorporated into the following plans and codes:

- **Capital Improvements Plan and planning process** - The City of Tulsa Capital Improvements Plan identifies and prioritizes municipal capital improvements. The CoT MHM Update Plan has reviewed the Capital Improvements Plan, and taken their plan into account in identifying future growth areas of the City of Tulsa.

- **City of Tulsa Building Code**
- **Tulsa Emergency Operations Plan**
- **City of Tulsa Water and Sewer Plan**
- **City of Tulsa Comprehensive Plan -** The City of Tulsa Planning Department, with assistance of Freganese Associates, are in the process of updating Tulsa's Comprehensive Plan. Information developed in the Tulsa Multi-Hazard Plan Update– flood hazard areas, expansive soils, future growth areas –were used in the Planitulsa Plan Update.
- **Pearl District Plan -** The City of Tulsa Planning Department and the Pearl District Association have developed a re-development plan for the Pearl District, adjacent to and east of Downtown Tulsa. The Pearl District planners and the Tulsa Hazard Mitigation Plan Update planners have worked closely together in the development of both plans. Resolution of the flooding problems has been a major objective.
- **Elm Creek Master Drainage Plan -** The City of Tulsa Department of Public Works, Tulsa Planning Department, Tulsa Park Department, the Kendall/Whittier Association and the Pearl District Association have developed a Master Drainage Plan to identify solutions to the flooding problems in the Elm Creek Basin. The Elm Creek planners and Tulsa HM Update planners worked together to coordinate and integrate both plans. The Elm Creek MDP was adopted by City Council in October 2008.
- **Citywide Master Drainage Plan -** The City of Tulsa has, since 1976, developed Comprehensive Master Drainage Plans for all 31 major drainage basins within the City of Tulsa. These basin plans have been consolidated into a City-Wide Master Drainage Plan. The Tulsa HM Plan Update has taken the flood-hazard areas identified in the City-Wide Plan into account in the development of the Flood and Dam Failure sections of the Tulsa Multi-Hazard Mitigation Plan Update.
- **Repetitive Loss Plan -** The City of Tulsa Repetitive Loss Plan identifies properties that have suffered repeated flood losses, insured by the National Flood Insurance Program (NFIP), in excess of $1,000, with a 10-year period. The Plan also identifies Repetitive Loss Area Properties located in the same vicinity/area which may have also been flooded, but may not have filed insurance claims. This plan identifies the most cost-effective solutions to the flooding problems. The program also sends official notification to each property annually, informing them of their hazardous location, and the availability of flood insurance. This Repetitive Loss Plan is integrated into the Hazard Mitigation Plan Update.
- **Non-Structural Mitigation Plan -** The City of Tulsa Non-Structural Mitigation Plan, lists all flood-prone properties identified in the 31 Master Drainage Plans, where non-structural solutions, i.e., acquisitions, flood-proofing, elevation, are recommended. These recommendations have been taken into account in the preparation of the HM Plan Update.
- **Tulsa Public Schools Multi-Hazard Mitigation Plan -** The Tulsa Public Schools Multi-Hazard Mitigation Plan funds were obligated by FEMA in September, 2008. The development of the TPSMHM Plan will take the data and recommendations developed in the CoT HM Update into account during their on-going planning process.

- **Tulsa County Multi-Hazard Mitigation Plan -** Tulsa County has developed a multi-Hazard Mitigation Plan, due to be completed in May, 2009. This plan has taken the information developed in the CoT HM Plan Update, and the CoT HM Plan Update has taken the Tulsa County Plan information into account in the development of their respective plans.
- **City of Tulsa Community Rating System Plan -** The City of Tulsa Multi-Hazard Mitigation Plan has taken all aspects of the Tulsa CRS Plan into account during the HM Update Plan. The CoT Multi-Hazard Mitigation Plan is an integral part of the CoT CRS Plan.
- **City-County Heat Emergency Action Plan -** Tulsa City and County, in conjunction with the Community Service Council have developed an Extreme Heat Emergency Plan. This Plan took the CoT HM Plan (2004) into account in the development of the Heat Response Plan. The CoT MHM Plan Update also took the Heat Response Plan into account in the development of the Extreme Heat section of the Plan.
- **Tulsa Metropolitan Area Major Street and Highway Plan -** The TMA Major Street and Highway Plan identifies the locations and types of major streets and highways within the Tulsa Metropolitan Area. This plan was taken into account, and provided the base for maps used in the Tulsa Multi-Hazard Mitigation Plan update, and for locations of future street and highways and the hazard associated with their location.
- **City of Tulsa Technical Hazards Mitigation Plan -** The City of Tulsa Technical Hazards Mitigation Plan (TTHMP) was developed as a Phase II Multi-Hazard Mitigation Plan for the City of Tulsa, and included man-made and technical hazards. The TTHMP utilized information and maps developed in the CoT MHMP as base. The CoT MHMP Update did not consider man-made and technological hazards in the Update.

The process to include the adopted Mitigation Measures into other local planning mechanisms includes the following:

1. Mitigation Measures will be assigned to the appropriate departments for planning and implementation within 90 days of the final adoption of the plan.
2. The responsible departments will report to the HMPC on an annual basis as to the progress made on each measure, identifying successes and impediments to their implementation.

To be included on the following pages of this chapter are the Resolution of Adoption of the *City of Tulsa*:

1. Tulsa Planning Commission
2. Tulsa City Council

RESOLUTION NO. ____

A RESOLUTION ADOPTING THE CITY OF TULSA MULTI-HAZARD MITIGATION PLAN – 2009 UPDATE

WHEREAS, the City of Tulsa and its environs are subject to danger and damage from flooding, tornadoes, high winds, lightning, storms, transportation hazards, hazardous materials, and other natural hazards; and

WHEREAS, several different agencies, organizations and businesses have programs that can address these hazards or their impact, but there is an overriding need for a comprehensive, coordinated plan to assess the problems faced by the City and the measures that are and can be brought to bear on them; and

WHEREAS, the City of Tulsa participates in the National Flood Insurance Program; and

WHEREAS, the City of Tulsa has approximately 2200 structures in the Special Flood Hazard Area (SFHA);

WHEREAS, the City Council of Tulsa was awarded a Pre-Disaster Hazard Mitigation Grant Program planning grant in the amount of $150,000 to develop a multi-hazard mitigation plan which addresses natural hazards as well as a Historic Preservation Pilot Study; and

WHEREAS, the 2000 Stafford Act mandates that communities must have an adopted, approved hazard mitigation plan before they can apply for funds from the Pre-Disaster or Post-Disaster Hazard Mitigation Grant Program, Flood Mitigation Assistance Program, Severe Repetitive Loss Program, and Repetitive Flood Claims Program; and

WHEREAS, the Tulsa City Council designated the Stormwater Drainage and Hazard Mitigation Board as the Hazard Mitigation Citizens Advisory Committee and the reviewing body of the planning process to include required public hearings and recommendations to the City Council in association with the information gathering and adoption of the Multi-Hazard Mitigation Plan; and

WHEREAS, the Stormwater Drainage and Hazard Mitigation Board considered said multi-hazard mitigation plan, after due and proper notice, and in public hearing on _____, has determined that it is in the best interest of the citizens of the City of Tulsa to recommend approval of such a plan to the Tulsa City Council subject to the changes described at the public hearing and incorporated within the document.

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF TULSA, OKLAHOMA:

That the *City of Tulsa Multi-Hazard Mitigation Plan – 2009 Update,* as presented to the City Council and on file with the City Clerk, together with any and all graphic representations referenced in this Multi-Hazard Mitigation Plan and changes recommended by the Stormwater Drainage and Hazard Mitigation Board, are hereby approved and adopted as the *City of Tulsa Multi-Hazard Mitigation Plan – 2009 Update*.

PASSED AND APPROVED BY THE CITY COUNCIL OF THE CITY OF TULSA, OKLAHOMA, THIS ___ DAY OF ____, 2009.

____
Kathy Taylor, Mayor

ATTEST:

____
City Clerk

Appendix A: Glossary of Terms

Anchoring: Special connections made to ensure that a building will not float off, blow off or be pushed off its foundation during a flood or storm.

Base Flood: Flood that has a 1 percent probability of being equaled or exceeded in any given year. Also known as the 100-year flood.

Base Flood Elevation (BFE): Elevation of the base flood in relation to a specified datum, such as the National Geodetic Vertical Datum of 1929. The Base Flood Elevation is used as the standard for the National Flood Insurance Program.

Basement: Any floor level below grade.

Bedrock: The solid rock that underlies loose material, such as soil, sand, clay, or gravel.

Building: A structure that is walled and roofed, principally above ground and permanently affixed to a site. The term includes a manufactured home on a permanent foundation on which the wheels and axles carry no weight.

Community Rating System (CRS): A National Flood Insurance Program (NFIP) that provides incentives for NFIP communities to complete activities that reduce flood hazard risk. When the community completes specified activities, the insurance premiums of policyholders in these communities are reduced.

Computer-Aided Design And Drafting (CADD): A computerized system enabling quick and accurate electronic 2-D and 3-D drawings, topographic mapping, site plans, and profile/cross-section drawings.

Consequences: The damages, injuries, and loss of life, property, environment, and business that can be quantified by some unit of measure, often in economic or financial terms.

Contour: A line of equal ground elevation on a topographic (contour) map.

Critical Facility: Facilities that are critical to the health and welfare of the population and that are especially important during and following hazard events. Critical facilities include shelters, police and fire stations, schools, childcare centers, senior citizen centers, hospitals, disability centers, vehicle and equipment storage facilities, emergency operations centers, and city hall. The term also includes buildings or locations that, if damaged, would create secondary disasters, such as hazardous materials facilities, vulnerable facilities, day care centers, nursing homes, and housing likely to contain occupants who are not very mobile. Other critical city infrastructure such as telephone exchanges and water treatment plants are referred to as lifelines. See Lifelines.

***Dam Breach Inundation Area*:** The area flooded by a dam failure or programmed release.

***Debris*:** The scattered remains of assets broken or destroyed in a hazard event. Debris caused by a wind or water hazard event can cause additional damage to other assets.

***Development*:** Any man-made change to real estate.

***Digitize*:** To convert electronically points, lines, and area boundaries shown on maps into x, y coordinates (e.g., latitude and longitude, universal transverse mercator (UTM), or table coordinates) for use in computer applications.

***Duration*:** How long a hazard event lasts.

***Earthquake*:** A sudden motion or trembling that is caused by a release of strain accumulated within or along the edge of earth's tectonic plates.

***Emergency*:** Any hurricane, tornado, storm, flood, high water, wind-driven water, tidal wave, tsunami, earthquake, volcanic eruption, landslide, mudslide, snowstorm, drought, fire, explosion, or other catastrophe in any part of the United States which requires federal emergency assistance to supplement State and local efforts to save lives and protect property, public health and safety, or to avert or lessen the threat of a disaster. Defined in Title V of Public Law 93-288, Section 102(1).

***Emergency Operations Center (EOC)*:** A facility that houses communications equipment that is used to coordinate the response to a disaster or emergency.

***Emergency Operations Plan (EOP)*:** Sets forth actions to be taken by State or local governments for response to emergencies or major disasters.

***Emergency Response Plan*:** A document that contains information on the actions that may be taken by a governmental jurisdiction to protect people and property before, during, and after a disaster.

***Extent*:** The size of an area affected by a hazard or hazard event.

***Fault*:** A fracture in the continuity of a rock formation caused by a shifting or dislodging of the earth's crust, in which adjacent surfaces are differentially displaced parallel to the plane of fracture.

***Federal Emergency Management Agency (FEMA)*:** The independent agency created in 1978 to provide a single point of accountability for all Federal activities related to disaster mitigation and emergency preparedness, response and recovery.

***FIPS*:** Stands for Federal Information Processing Standards. Under the Information Technology Management Reform Act (Public Law 104-106), the Secretary of Commerce approves standards and guidelines that are developed by the National Institute of Standards and Technology (NIST) for Federal computer systems. These standards and guidelines are issued by NIST as Federal Information Processing Standards (FIPS) for use government-wide. NIST develops FIPS when there are compelling Federal government requirements such as for security and interoperability and there are no acceptable industry standards or solutions.

Fire Potential Index (FPI)**:** Developed by United States Geological Survey (USGS) and United States Forest Service (USFS) to assess and map fire hazard potential over broad areas. Based on such geographic information, national policy makers and on-the-ground fire managers established priorities for prevention activities in the defined area to reduce the risk of managed and wildfire ignition and spread. Prediction of fire hazard shortens the time between fire ignition and initial attack by enabling fire managers to pre-allocate and stage suppression forces to high fire risk areas.

Flash Flood**:** A flood event occurring with little or no warning where water levels rise at an extremely fast rate.

Flood**:** A general and temporary condition of partial or complete inundation of normally dry land areas from (1) the overflow of inland or tidal waters, (2) the unusual and rapid accumulation or runoff of surface waters from any source, or (3) mudflows or the sudden collapse of shoreline land.

Flood Depth**:** Height of the flood water surface above the ground surface.

Flood Elevation**:** Elevation of the water surface above an established datum, e.g. National Geodetic Vertical Datum of 1929, North American Vertical Datum of 1988, or Mean Sea Level.

Flood Hazard Area**:** The area shown to be inundated by a flood of a given magnitude on a map.

Flood Insurance Rate Map (FIRM)**:** Map of a community, prepared by the Federal Emergency Management Agency, which shows both the special flood hazard areas and the risk premium zones applicable to the community.

Flood Insurance Study (FIS)**:** A study that provides an examination, evaluation, and determination of flood hazards and, if appropriate, corresponding water surface elevations in a community or communities.

Flood Mitigation Assistance Program (FMA)**:** A planning and project implementation grant program funded by the National Flood Insurance Program. Provides pre-disaster grants to State and local governments for both planning and implementation of mitigation strategies. Grant funds are made available from NFIP insurance premiums, and therefore are only available to communities participating in the NFIP.

Flood of Record**:** The highest known flood level for the area, as recorded in historical documents.

***Floodplain*:** Any land area, including watercourse, susceptible to partial or complete inundation by water from any source.

***Floodproofing*:** Protective measures added to or incorporated in a building to prevent or minimize flood damage. “Dry floodproofing” measures are designed to keep water from entering a building. “Wet floodproofing” measures minimize damage to a structure and its contents from water that is allowed into a building.

***Floodway*:** The stream channel and that portion of the adjacent floodplain which must remain open to permit conveyance of the base flood. Floodwaters are generally the swiftest and deepest in the floodway. The floodway should remain clear of buildings and impediments to the flow of water.

***Freeboard*:** A margin of safety added to a protection measure to account for waves, debris, miscalculations, lack of scientific data, floodplain fill, or upstream development.

***Frequency*:** A measure of how often events of a particular magnitude are expected to occur. Frequency describes how often a hazard of a specific magnitude, duration, and/or extent typically occurs, on average. Statistically, a hazard with a 100-year recurrence interval is expected to occur once every 100 years on average, and would have a 1 percent chance – its probability – of happening in any given year. The reliability of this information varies depending on the kind of hazard being considered.

***Fujita Scale of Tornado Intensity*:** Rates tornadoes with numeric values from F0 to F5 based on tornado wind speed and damage sustained. An F0 indicates minimal damage such as broken tree limbs or signs, while an F5 indicates severe damage sustained.

***Functional Downtime*:** The average time (in days) during which a function (business or service) is unable to provide its services due to a hazard event.

***Geographic Area Impacted*:** The physical area in which the effects of the hazard are experienced.

***Geographic Information System (GIS)*:** A computer software application that relates physical features on the earth to a database to be used for mapping and analysis.

***Ground Motion*:** The vibration or shaking of the ground during an earthquake. When a fault ruptures, seismic waves radiate, causing the ground to vibrate. The severity of the vibration increases with the amount of energy released and decreases with distance from the causative fault or epicenter, but soft soils can further amplify ground motions.

***Hazard*:** A source of potential danger or adverse condition. An event or physical condition that has the potential to cause fatalities, injuries, property and infrastructure damage, agriculture loss, damage to the environment, interruption of business, or other types of harm or loss. Hazards, as defined in this study, will include naturally occurring events such as floods, dam failures, levee failures, tornadoes, high winds, hailstorms, lightning, winter storms, extreme heat, drought, expansive soils, urban fires, wildfires that strike populated areas, and earthquakes. A natural event is a hazard when it has the potential to harm people or property. For purposes of this study, hazardous materials events are also included.

***Hazard Event*:** A specific occurrence of a particular type of hazard.

***Hazard Identification*:** The process of defining and describing a hazard, including its physical characteristics, magnitude and severity, probability and frequency, causative factors, and locations or areas affected.

***Hazard Mitigation*:** Sustained actions taken to reduce or eliminate long-term risk to human life and property from natural and technological hazards and their effects. Note that this emphasis on long-term risk distinguishes mitigation from actions geared primarily to emergency preparedness and short-term recovery.

***Hazard Mitigation Grant Program (HMGP)*:** Authorized under Section 404 of the Stafford Act; a FEMA disaster assistance grant program that funds mitigation projects in conformance with post-disaster mitigation plans required under Section 409 of the Stafford Act. The program is available only after a Presidential disaster declaration.

***Hazard Mitigation Plan*:** The plan resulting from a systematic evaluation of the nature and extent of vulnerability to the effects of natural hazards present in society that includes the actions needed to minimize future vulnerability to hazards. Section 409 of the Stafford Act requires the identification and evaluation of mitigation opportunities, and that all repairs be made to applicable codes and standards, as condition for receiving Federal disaster assistance. Enacted to encourage identification and mitigation of hazards at all levels of government.

***Hazard Profile*:** A description of the physical characteristics of hazards and a determination of various descriptors including magnitude, duration, frequency, probability, and extent. In most cases, a community can most easily use these descriptors when they are recorded and displayed as maps.

***HAZUS (Hazards U.S.)*:** A GIS-based nationally standardized earthquake loss estimation tool developed by FEMA.

***Hydrology*:** The science of dealing with the waters of the earth. A flood discharge is developed by a hydrologic study.

***Infrastructure*:** The public services of a community that have a direct impact on the quality of life. Infrastructure includes communication technology such as phone lines or Internet access, vital services such as public water supplies and sewer treatment facilities, and includes an area's transportation system such as airports, heliports; highways, bridges, tunnels, roadbeds, overpasses, railways, bridges, rail yards, depots, and waterways, canals, locks, and regional dams.

Insurance Service Office, Inc. (ISO)**:** An insurance organization that administers several programs that rate a community's hazard mitigation activities.

Intensity**:** A measure of the effects of a hazard event at a particular place.

Landslide**:** Downward movement of a slope and materials under the force of gravity.

Lifelines**:** Systems necessary for human life and urban function, especially during emergencies. Transportation and utility systems, as well as emergency service facilities are considered the lifelines of a community. Transportation systems include interstate, US, and state highways, roadways, railways, waterways, ports, harbors, and airports. Utility systems consist of electric power, gas and liquid fuels, telecommunications, water, and wastewater. Emergency service facilities include Emergency Alert System communication facilities, hospitals, and the police and fire departments.

Liquefaction**:** The phenomenon that occurs when ground shaking causes loose soils to lose strength and act like viscous fluid. Liquefaction causes two types of ground failure: lateral spread and loss of bearing strength.

Lowest Floor**:** Under the NFIP, the lowest floor of the lowest enclosed area (including basement) of a structure.

Magnitude**:** A measure of the strength of a hazard event. The magnitude (also referred to as severity) of a given hazard event is usually determined using technical measures specific to the hazard.

Mitigation**:** Sustained action taken to reduce or eliminate the long-term risk to human life and property from natural and technological hazards and their effects. Note that this emphasis on long-term risk distinguishes mitigation from actions geared primarily to emergency preparedness and short-term recovery (Burby, 1998).

National Flood Insurance Program (NFIP)**:** A federal program created by Congress in 1968 that provides the availability of flood insurance to communities in exchange for the adoption and enforcement of a minimum floodplain management ordinance specified in 44 CFR §60.3. The ordinance regulates new and substantially damaged or improved development in identified flood hazard areas.

National Geodetic Vertical Datum of 1929 (NGVD)**:** Datum established in 1929 and used in the NFIP as a basis for measuring flood, ground, and structural elevations, previously referred to as Sea Level Datum or Mean Sea Level. The Base Flood Elevations shown on most of the Flood Insurance Rate Maps issued by the Federal Emergency Management Agency are referenced to NGVD.

National Weather Service (NWS)**:** Prepares and issues flood, severe weather, and coastal storm warnings and can provide technical assistance to Federal and state entities in preparing weather and flood warning plans.

Oklahoma Department of Civil Emergency Management (ODCEM)**:** The State department responsible for hazard mitigation, community preparedness, emergency response, and disaster recovery.

Oklahoma Water Resources Board (OWRB)**:** The State agency responsible for administration of the National Flood Insurance Program, and the dam safety program.

Planimetric**:** Describes maps that indicate only man-made features like buildings.

Planning**:** The act or process of making or carrying out plans; the establishment of goals, policies and procedures for a social or economic unit.

Planning for Post-Disaster Reconstruction**:** The process of planning (preferably prior to an actual disaster) those steps the community will take to implement long-term reconstruction with one of the primary goals being to reduce or minimize its vulnerability to future disasters. These measures can include a wide variety of land-use planning tools, such as acquisition, design review, zoning, and subdivision review procedures. It can also involve coordination with other types of plans and agencies but is distinct from planning for emergency operations, such as restoration of utility services and basic infrastructure.

Preparedness**:** Activities to ensure that people are ready for a disaster and respond to it effectively. Preparedness requires figuring out what will be done if essential services break down, developing a plan for contingencies, and practicing the plan.

Probability**:** A statistical measure of the likelihood that a hazard event will occur.

Project Impact**:** A program that encourages business, government agencies and the public to work together to build disaster-resistant communities.

Reconstruction**:** The long-term process of rebuilding the community's destroyed or damaged buildings, public facilities, or other structures.

Recovery**:** The process of restoring normal public or utility services following a disaster, perhaps starting during but extending beyond the emergency period to that point when the vast majority of such services, including electricity, water, communications, and public transportation have resumed normal operations. Recovery activities necessary to rebuild after a disaster include rebuilding homes, businesses and public facilities, clearing debris, repairing roads and bridges, and restoring water, sewer and other essential services. Short-term recovery does not include the reconstruction of the built environment, although reconstruction may commence during this period.

Recurrence Interval**:** The time between hazard events of similar size in a given location. It is based on the probability that the given event will be equaled or exceeded in any given year.

***Repetitive Loss Property*:** A property that is currently insured for which two or more National Flood Insurance Program losses (occurring more than ten days apart) of at least $1000 each have been paid within any 10-year period since 1978. While Repetitive Loss Properties constitute only 2% of insured properties, they account for 40% of flood damage claims against the NFIP.

***Replacement Value*:** The cost of rebuilding a structure. This is usually expressed in terms of cost per square foot, and reflects the present-day cost of labor and materials to construct a building of a particular size, type and quality.

***Retrofitting*:** Modifications to a building or other structure to reduce its susceptibility to damage by a hazard.

***Richter Scale*:** A numerical scale of earthquake magnitude devised by seismologist C.F. Richter in 1935.

***Risk*:** The estimated impact that a hazard would have on people, services, facilities, and structures in a community; the likelihood of a hazard event resulting in an adverse condition that causes injury or damage. Risk is often expressed in relative terms such as a high, moderate or low likelihood of sustaining damage above a particular threshold due to a specific type of hazard event. It also can be expressed in terms of potential monetary losses associated with the intensity of the hazard.

***Risk Assessment*:** A process or method for evaluating risk associated with a specific hazard and defined in terms of probability and frequency of occurrence, magnitude and severity, exposure and consequences. Also defined as: "The process of measuring the potential loss of life, personal property, housing, public facilities, equipment, and infrastructure; lost jobs, business earnings, and lost revenues, as well as indirect losses caused by interruption of business and production; and the public cost of planning, preparedness, mitigation, response, and recovery. (Burby, 1998).

***Riverine*:** Of or produced by a river.

***Scale*:** A proportion used in determining a dimensional relationship; the ratio of the distance between two points on a map and the actual distance between the two points on the earth's surface.

***Scarp*:** A steep slope.

***Scour*:** Removal of soil or fill material by the flow of flood waters. The term is frequently used to describe storm-induced, localized conical erosion around pilings and other foundation supports where the obstruction of flow increases turbulence.

***Seismicity*:** Describes the likelihood of an area being subject to earthquakes.

***Special Flood Hazard Area (SFHA)*:** An area within a floodplain having a 1 percent or greater chance of flood occurrence in any given year (100-year floodplain); represented on Flood Insurance Rate Maps by darkly shaded areas with zone designations that include the letter A or V.

***Stafford Act*:** The Robert T. Stafford Disaster Relief and Emergency Assistance Act, PL 100-107 was signed into law November 23, 1988 and amended the Disaster Relief Act of 1974, PL 93-288. The Stafford Act is the statutory authority for most Federal disaster response activities, especially as they pertain to FEMA and its programs.

***State Hazard Mitigation Team*:** Composed of key State agency representatives, the team evaluates hazards, identifies strategies, coordinates resources, and implements measures that will reduce the vulnerability of people and property to damage from hazards. The Oklahoma State Hazard Mitigation Team is convened by the Oklahoma Department of Civil Emergency Management (ODCEM), and includes the State departments of Agriculture, Climatological Survey, Commerce, Environmental Quality, Health, Human Services, Insurance, Transportation, Wildlife Conservation, Conservation Commission, Corporation Commission, Historical Society, Insurance Commission, Water Resources Board, Association of County Commissioners (AACCO), Oklahoma Municipal League (OML), Department of Housing and Urban Development (HUD), and the U.S. Army Corps of Engineers (USACE).

***State Hazard Mitigation Officer (SHMO)*:** The representative of state government who is the primary point of contact with FEMA, other state and Federal agencies, and local units of government in the planning and implementation of pre- and post-disaster mitigation activities.

***Stormwater Management*:** Efforts to reduce the impact of stormwater or snowmelt runoff on flooding and water quality.

***Stormwater Detention*:** The storing of stormwater runoff for release at a restricted rate after the storm subsides, or the flood crest passes.

***Substantial Damage*:** Damage of any origin sustained by a structure in a Special Flood Hazard Area whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage.

***Surface Faulting*:** The differential movement of two sides of a fracture – in other words, the location where the ground breaks apart. The length, width, and displacement of the ground characterize surface faults.

***Tectonic Plate*:** Torsionally rigid, thin segments of the earth's lithosphere that may be assumed to move horizontally and adjoin other plates. It is the friction between plate boundaries that cause seismic activity.

***Topographic*:** Characterizes maps that show natural features and indicate the physical shape of the land using contour lines. These maps may also include man-made features.

***Tornado*:** A violently rotating column of air extending from a thunderstorm to the ground.

***Vulnerability*:** Describes how exposed or susceptible to damage an asset is. Vulnerability depends on an asset's construction, contents, and the economic value of its functions. Like indirect damages, the vulnerability of one element of the community is often related to the vulnerability of another. For example, many businesses depend on uninterrupted electrical power – if an electric substation is flooded, it will affect not only the substation itself, but a number of businesses as well. Often, indirect effects can be much more widespread and damaging than direct ones.

***Vulnerability Assessment*:** The extent of injury and damage that may result from a hazard event of a given intensity in a given area. The vulnerability assessment should address impacts of hazard events on the existing and future built environment.

***Wildfire*:** An uncontrolled fire spreading through vegetative fuels, exposing and possibly consuming structures.

***Zone*:** A geographical area shown on a Flood Insurance Rate Map (FIRM) that reflects the severity or type of flooding in the area.

Appendix B: Mitigation Strategies

The following items illustrate many of the broad mitigation strategies that communities, tribes, counties, and other entities can implement to help protect lives, property and the environment in their jurisdictions. The following grid lists the six basic mitigation categories outlined by FEMA (introduced in Chapter 2), the strategies that fall in those categories, and the hazards those strategies may be effective for.

Many of the strategies, while listed under one category, may have elements that include other categories as well. For example, almost all strategies have a Public Information & Education component, where homeowners and business owners are educated about possible measures they may take on their own.

Category	Mitigation Strategy		Hazards Impacted
Public Information & Education	B.1.1	Public Information Program Strategy	All Hazards
	B.1.2	Educational Programs	All Hazards
	B.1.3	Outreach Projects	All Hazards
	B.1.4	Technical Assistance	All Hazards
	B.1.5	Map Information	All Hazards
	B.1.6	Library	All Hazards
	B.1.7	Web Sites	All Hazards
	B.1.8	Real Estate Disclosure	Flood, Expansive Soils
	B.1.9	Firewise Communities	Wildfire
	B.1.10	Business Continuity Planning & Mitigation	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Heat, Wildfire, Earthquake, Dam Break
Preventive Measures	B.2.1	Planning	All Hazards
	B.2.2	Zoning	All Hazards
	B.2.3	Floodplain Development Regulations	Flood, Dam Break
	B.2.4	Stormwater Management	Flood, Dam Break
	B.2.5	Building Codes	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Expansive Soil, Wildfire, Earthquake
	B.2.6	IBHS Fortified Home Program	Flood, Tornado, High Wind, Lightning, Hail, Wildfire, Earthquake
	B.2.7	Smoke Detectors	Fires
	B.2.8	Hurricane Fasteners	Tornado, High Wind, Earthquake
	B.2.9	Mobile Home Tie-Downs	Tornado, High Wind
	B.2.10	Lightning Warning Systems	Lightning
	B.2.11	Power Outages from Winter Storms	Winter Storm, Lightning
	B.2.12	Standby Electric Generators	Tornado, High Wind, Lightning, Winter Storm
	B.2.13	Critical Facility Protection	All Hazards
	B.2.14	Extreme Heat Protection	Extreme Heat
	B.2.15	Proper Storage and Disposal of Hazardous Materials	Floods
	B.2.16	Water Conservation	Drought
	B.2.17	Open Space Preservation	Flood, Drought, Dam Break

Category	Mitigation Strategy		Hazards Impacted
Structural Projects	B.3.1	Safe Rooms	Tornado, High Wind
	B.3.2	School Safe Rooms	Tornado, High Wind
	B.3.3	Reservoirs &Detention	Flood
	B.3.4	Levees & Floodwalls	Flood, Dam Break
	B.3.5	Channel Improvements	Flood, Dam Break
	B.3.6	Crossings & Roadways	Flood, Dam Break
	B.3.7	Drainage & Storm Sewer Improvements	Flood, Dam Break
	B.3.8	Drainage System Maintenance	Flood, Dam Break
Property Protection	B.4.1	The City's Role	All Hazards
	B.4.2	Insurance	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Wildfire, Earthquake, Dam Break
	B.4.3	Acquisition & Relocation	Flood
	B.4.4	Building Elevation	Flood, Dam Break
	B.4.5	Barriers	Flood, Dam Break
	B.4.6	Retrofitting	Flood, Tornado, High Wind, Lightning, Hail, Expansive Soil, Wildfire, Earthquake
	B.4.7	Impact Resistant Windows & Doors	Tornado, High Wind, Hail
	B.4.8	Lightning Protection Systems	Lightning
	B.4.9	Surge and Spike Protection	Lightning
	B.4.10	Landscaping for Wildfire Prevention	Wildfire
Emergency Services	B.5.1	Threat Recognition	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Heat, Drought, Wildfire, Earthquake, Dam Break
	B.5.2	Warning	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Heat, Drought, Wildfire, Earthquake, Dam Break
	B.5.3	9-1-1 & 2-1-1	All Hazards
	B.5.4	Emergency Telephone Notification Systems (ETNS)	Flood, Winter Storm, Heat, Wildfire
	B.5.5	Response	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Heat, Drought, Wildfire, Earthquake, Dam Break
	B.5.6	Emergency Operations Plan (EOP)	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Wildfire, Earthquake, Dam Break
	B.5.7	Incident Command System (ICS)	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Wildfire, Earthquake, Dam Break
	B.5.8	Mutual Aid / Interagency Agreements	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Wildfire, Earthquake, Dam Break
	B.5.9	CERT (Community Emergency Response Teams)	Flood, Tornado, High Wind, Winter Storm, Heat, Wildfire, Earthquake, Dam Break
	B.5.10	Debris Management	Flood, Tornado, High Wind, Winter Storm, Wildfire, Earthquake
	B.5.11	Critical Facilities Protection	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Wildfire, Earthquake, Dam Break

Category	Mitigation Strategy		Hazards Impacted
	B.5.12	Site Emergency Plans	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Wildfire, Earthquake, Dam Break
	B.5.13	Post-Disaster Recovery & Mitigation	Flood, Tornado, High Wind, Lightning, Hail, Winter Storm, Wildfire, Earthquake, Dam Break
	B.5.14	StormReady Communities	Flood, Tornado, High Wind, Hail, Winter Storm
Natural Resource Protection	B.6.1	Wetland Protection	Flood, Wildfire
	B.6.2	Erosion and Sedimentation Control	Flood, Wildfire
	B.6.3	River Restoration	Flood, Wildfire
	B.6.4	Best Management Practices	Flood
	B.6.5	Dumping Regulations	Flood, Tornado, High Winds, Winter Storm

B.1 Public Information and Education

A successful public information and education program involves both the public and private sectors. Public information and education activities advise and educate citizens, property owners, renters, businesses, and local officials about hazards and ways to protect people and property from them. Public information activities are among the least expensive mitigation measures, and at the same time are often the most effective thing a community can do to save lives and property. All mitigation activities – preventive, structural, property protection, emergency services, and natural resource protection – begin with public information and education.

B.1.1 Public Information Program Strategy

Getting Your Message Out

Professional advertising agencies may be willing to help get the message out regarding disaster preparedness and mitigation at little or no cost. They have a vested interest in their community and want to keep it safe. The same holds true for the media. The local newspaper, radio or television will contribute to keeping a safe and prepared community. Invite them to, and let them participate in special events, meetings, practice exercises, etc.

Education alliance partners, such as a restaurants, convenience stores or the library, can put preparedness tips on tray liners or sacks, distribute brochures or allow you to erect a display with disaster information of local interest.

Many other options are available such as including brochures with utility bills, presentations at local gatherings, billboards, direct mailing and websites.

Summer camps, and other educational programs for children, can teach a new generation about nature, natural hazards, and preservation

General

Numerous publications on tornadoes, thunderstorms, lightning, winter storms and flooding are available through NOAA. Up to 300 copies of most publications can be ordered from your local National Weather Service, NOAA Outreach Unit or American Red Cross. Many of the brochures can be downloaded from www.nws.noaa.gov/om/brochures.shtml.

For a nominal fee the American Red Cross offers videos on general preparedness, winter storms, chemical emergencies, hurricanes and earthquakes.

The National Weather Service issues watches and warnings for tornadoes, severe thunderstorms, floods, winter storms and extreme heat that may include “Call to Action” statements. The messages appear on the NWS telephone line, the local weather service office website and on television stations carrying Emergency Alert System messages.

Communities can encourage residents to prepare themselves by stocking up with necessary items and planning for how family members should respond if any of a number of possible emergency or disaster events strike.

Hazard Brochures
Area agencies or the American Red Cross have available the book *Repairing Your Flooded Home* and fliers *Are You Ready for a Flood?* and *Avoiding Flood Damage*. For a summary of what to do after a tornado see www.redcross.org/services/disaster/0,1082,0_502_,00.html. The brochure *Taking Shelter From the Storm: Building a Safe Room Inside Your Home* is available from FEMA. A copy of the brochure can be requested from the FEMA website www.fema.gov/fima/tsfs02.shtm. *Are You Ready for a Tornado?* is available from the American Red Cross, FEMA and the National Oceanic and Atmospheric Administration. Area agencies or the American Red Cross have available the fliers *Are You Ready For a Heat Wave? Are You Ready For a Winter Storm?* and *Are You Ready For a Thunderstorm?*

After reviewing the possible and locally implemented public information activities covered in the previous sections, the Public Information Outreach Strategy Team prepared a Public Information Program Strategy. Following the Community Rating System format, the strategy consists of the following parts:

The local hazards, discussed in Chapter 4 of this plan

a. The safety and property protection measures appropriate for the hazards, discussed in Chapter 5 and this Appendix.
b. Hazard-related public information activities currently being implemented in the community, including those by non-government agencies (discussed in Chapter 2)
c. Goals and Objectives for the community's public information program (covered in Chapter 5)
d. Outreach projects that will reach the goals (see Chapter 6, Action Items and Table 6-1.)
e. A process for monitoring and evaluating the projects (see Chapter 7)

B.1.2 Educational Programs

A community's most important natural resource is its children. They will inherit the resources, infrastructure and development built by earlier generations at great cost and effort. They will also face the same natural forces that bring floods, tornadoes, storms and other hazards.

Environmental education programs can teach children about natural hazards, the forces that cause them, and the importance of protecting people, property and nature, such as watersheds and floodplains. Educational programs can be undertaken by schools, park and recreation departments, conservation associations, and youth organizations, such as the Boy Scouts, Campfire Girls and summer camps. An activity can be complex enough as to require course curriculum development, or as simple as an explanatory sign near a river.

Educational programs designed for children often reach adults as well. Parents often learn innovative concepts or new ideas from their children. If a child comes home from school with an assignment in water quality monitoring, the parents will normally become interested in finding out about it as well.

There are many programs that provide information and curriculum materials on nature and natural hazards. On FEMA website www.fema.gov/kids/ kids can learn about having a family disaster plan, what kids might feel in and following a disaster, what the different disasters are, what to do during a disaster, take quizzes and play games. There is also information on how to get a free video, brochures and other fun stuff.

Another site, for students and educators on water resources, is the USGS "Water Science for Schools" wwwga.usgs.gov/edu/. The American Red Cross has a 24-page *Disaster Preparedness Coloring Book* for kids age 3-10. The coloring book is available online and can be printed from www.redcross.org/pubs/dspubs/genprep.html.

Youth programs and activities often include posters, coloring books, games, and references. Hands-on models that allow students to see the effects of different land use practices are also available through local natural resources conservation districts.

B.1.3 Outreach Projects

Mapping and library activities are not of much use if no one knows they exist. An outreach project can remedy this. Sending notices to property owners can help introduce the idea of property protection and identify sources of assistance.

Outreach projects are the first step in the process of orienting property owners to property protection and assisting them in designing and implementing a project. They are designed to encourage people to seek out more information in order to take steps to protect themselves and their properties.

The most effective types of outreach projects are mailed or otherwise distributed to flood-prone property owners or to everyone in the community. Other approaches include the following:

- Articles and special sections in newspapers
- Radio and TV news releases and interview shows
- Hazard protection video for cable TV programs or to loan to organizations

- Presentations at meetings of neighborhood, civic or business groups
- Displays in public buildings or shopping malls
- Floodproofing open houses

Research has proven that outreach projects work. However, awareness of the hazard is not enough. People need to be told what they can do about the hazard, so projects should include information on safety, health, and property protection measures. Research has also shown that a properly run local information program is more effective than national advertising or publicity campaigns.

B.1.4 Technical Assistance

While general information helps, most property owners do not feel ready to take major steps, like retrofitting their buildings, without help or guidance. Local building department staff members are experts in construction. They can provide free advice, not necessarily to design a protection measure, but to steer the owner onto the right track.

Building, public works, and engineering staff members visit properties and offer suggestions. Most can recommend or identify qualified or licensed companies, an activity that is especially appreciated by owners who are unsure of the project or the contractor.

Technical assistance can be provided in one-on-one sessions with property owners or can be provided through seminars. For instance, seminars or “open houses” can be provided on retrofitting structures, selecting qualified contractors, and carrying out preparedness activities.

B.1.5 Map Information

Many benefits stem from providing map information to inquirers. Residents and businesses that are aware of the potential hazards can take steps to avoid problems and reduce their exposure to flooding, dam failure or releases, expansive soils, and other hazards that have a geographical distribution. Real estate agents and house hunters can find out if a property is flood-prone and whether flood insurance may be required.

Maps provide a wealth of information about past and potential hazards. Geographic Information Systems, sometimes called smart maps, provide efficiency and add to capabilities of many government services. County assessors, public works, parks and recreation, and 911 services are all typical departments capable of applying GIS applications to improve their services. GIS allows trained users to complete comprehensive queries, extract statistical information, and completely manage all relevant spatial information and the associated attribute information that pertain to those departments.

Flood maps

Several legal requirements are tied to FEMA’s Flood Insurance Rate Maps (FIRMs) and Flood Insurance Study Maps. These include building regulations and the mandatory purchase of flood insurance. FEMA provides floodplain and FIRM information as a mitigation service. The City can help residents submit requests for map amendments and revisions when these are needed to show that a building is outside the mapped floodplain.

Although FEMA maps are accurate, users and inquirers must remember that maps are not perfect. They display only the larger flood-prone areas that have been studied. In some areas, watershed developments make even recent maps outdated. Those inquiring about flood maps must be reminded that being outside the mapped floodplain is no guarantee that a property will never flood. In fact, many properties that flood are not located in a designated floodplain.

By taking the initiative locally to accurately map problem areas with information not already on FEMA maps, a community can warn residents about potential risks that may not have been anticipated. Upgrading maps provides a truer measure of risks to a community.

Other Hazard Data

Other data that can be shown on maps include those hazards that are distributed geographically. These include:

- Dam breach inundation areas
- Levee failure inundation areas
- Expansive soils
- Wildfire risk zones
- Earthquake risk zones
- Hazardous materials sites
- Wetlands

General location maps for many of these natural and man-made hazards have been developed by U. S. Army Corps of Engineers, Association of South Central Governments (ASCOG), Oklahoma Geological Survey, and R. D. Flanagan & Associates, several of which are included in this City of Tulsa Hazard Mitigation Plan study.

Flood zone determinations are available, free of charge, to any citizen through the Floodplain Administrator in the Tulsa County Commissioner's Office. If the determination is for a building permit, local ordinances must be followed.

B.1.6 Library

The City of Tulsa Public Libraries are places for residents to seek information on hazards, hazard protection, and protecting natural resources. Historically, libraries have been the first place people turn to when they want to research a topic. Interested property owners can read or check out handbooks or other publications that cover their situation. The libraries also have their own public information campaigns with displays, lectures, and other projects, which can augment the activities of the local government.

The local public library System maintains flood related documents required under the NFIP and CRS. The documents are available to the public in the library.

B.1.7 Web Sites

Today, Web sites are becoming more popular as research tools. They provide quick access to a wealth of public and private sites and sources of information. Through links to other Web sites, there is almost no limit to the amount of up to date information that can be accessed by the user.

The City of Tulsa Web site can be accessed at www.CityOfTulsa.org. FEMA's Mapping Web site is at www.fema.gov/business/nfip/mscjumppage.shtm. Additional web sites related to specific hazards are listed in the following table.

Web sites have become one of the most popular research tools

Table B–1: Multi-Hazard Mitigation Web Sites

Agency	Web Address
General	
Federal Emergency Management Agency	www.fema.gov
Oklahoma Dept. of Emergency Management	www.odcem.state.ok.us
Institute for Business and Home Safety	www.ibhs.org/
USGS – Hazards Page	www.usgs.gov/themes/hazard.html
Floods	
Oklahoma Water Resources Board	www.owrb.state.ok.us/
Oklahoma Floodplain Managers Association	www.okflood.org/
U.S. Army Corps of Engineers	www.usace.army.mil/
National Flood Insurance Program	www.fema.gov/nfip/whonfip.shtm
Stormwater Manager's Resource Center	www.stormwatercenter.net/
High Winds	
National Climatic Data Center	www.ncdc.noaa.gov/oa/ncdc.html
Lightning	
National Lightning Safety Institute	www.lightningsafety.com/nlsi_lls.html
Extreme Heat	
National Weather Service – Heat Index	www.hpc.ncep.noaa.gov/heat_index.shtml
Hail	
FLASH – Hail damage, protecting your home	www.flash.org/activity.cfm?currentPeril=5&activityID=164
Drought	
OWRB – Drought Monitoring Page	www.owrb.state.ok.us/supply/drought/drought_index.php
Expansive Soils	
US Department of Agriculture	www.usda.gov/
Natural Resource Conservation Service	www.nrcs.usda.gov/
Wildfires	
USGS Wildfires	www.usgs.gov/themes/wildfire.html

Agency	Web Address
Earthquakes	
U.S. Geological Survey	www.usgs.gov/
Oklahoma Geological Survey	www.okgeosurvey1.gov/home.html
National Geophysical Data Center	www.ngdc.noaa.gov/
Dam Failures	
Oklahoma Water Resources Board	www.owrb.state.ok.us/
US Army Corps of Engineers	www.usace.army.mil/
Grand River Dam Authority	www.grda.com/

B.1.8 Real Estate Disclosure

After a flood or other natural disaster, people often say they would have taken steps to protect themselves if they had known their property was exposed to a hazard.

Flood insurance is required for buildings located within the base floodplain if the mortgage or loan is federally insured. However, because this requirement has to be met only ten days before closing, applicants are often already committed to purchasing a property when they first learn of the flood hazard.

Flooding and other hazards are sometimes not disclosed until it is too late. Hazard maps can help homebuyers avoid surprises like this.

The "Residential Property Condition Disclosure Act" requires sellers to provide potential buyers with a completed, signed and dated "Residential Property Condition Disclosure Statement". Included in the statement are disclosures regarding flooding and flood insurance. For a copy of the "Residential Property Condition Disclosure Statement" see www.orec.state.ok.us/pdf/disclose3.pdf.

B.1.9 Firewise Communities

While incorporating components from several of the different mitigation strategies, Firewise primarily depends on homeowners taking actions to protect their own property, so Public Education and Information is key to the success of the Firewise program. While it is not possible, or in many cases even desirable, to prevent wildfires, it is certainly possible, by interrupting the natural flow of the fire, to assure that wildfires will not produce catastrophic home or crop losses. In the words of Judith Cook, Project Manager for Firewise Communities/USA, “We can modify our home ignition zones. We’re basically saying to the fire, ‘there’s nothing for you here!’”

Firewise Community USA is a project of the National Wildfire Coordinating Group. It recognizes communities that have gone through a process to reduce the dangers of wildfires along what is referred to as the Wildland-Urban Interface (WUI). Additional information on the Firewise Community program can be found at www.firewise.org/usa.

In order to become a Firewise Community, a community will:

1. Contact a Firewise Specialist. In Oklahoma, the Firewise Specialist may be reached through the Oklahoma Department of Agriculture, Forestry Services, at (405) 521-3864. The Specialist will coordinate with local fire officials to schedule a site visit and assess the community.
2. The community will create a Firewise Board that includes homeowners, fire professionals, and other stakeholders.
3. The Firewise Specialist will schedule a meeting with the Board to present the assessment report for review and acceptance.
4. The Board will use the report to create agreed-upon, area-specific solutions to the fire issues, which the Specialist will review and, if acceptable, will work with the community to seek project implementation funds, if necessary.

A home in the WUI surrounded by a "defensible" zone that helped protect it from damage during a wildfire outbreak

5. Local solutions will be implemented following a schedule designed by the local Board and the Specialist, A permanent Firewise task force or committee is created that will maintain the program into the future.
6. A completed plan and registration form will be submitted to Firewise Communities/USA for formal recognition of the Community.

B.1.10 Business Continuity Planning and Mitigation

While Business Continuity Planning (BCP) can include portions from many of the categories listed in this chapter, an integrated program for businesses is a frequently neglected component in a community's mitigation strategy. It has been demonstrated repeatedly that many businesses that close their doors following a disaster either fail to re-open, or struggle to remain open following the event. This is especially true of small to medium businesses that may rely on a limited number of locations and a narrow customer base, or may not have the economic reserves to recover from financial losses. The lack of ability to recover may be for several reasons:

- Absenteeism from employees who are affected or who have affected family members;
- Psychological trauma from losing co-workers;

- Loss of an irreplaceable executive or manager;
- Economic stress on the business from having to make repairs and replenish stock over and above what may be covered by insurance;
- Loss of revenue from having the doors closed for even a short period of time;
- Loss of the customer base, either from people who are forced to evacuate the area or who may not have immediate disposable income for the company's products;
- Loss of a critical customer or the vendor of a critical inventory item ("upstream" and "downstream" issues);
- Loss of critical data, either paper or electronic records;
- An interruption in community infrastructure (utilities, road access, media losses, etc.).

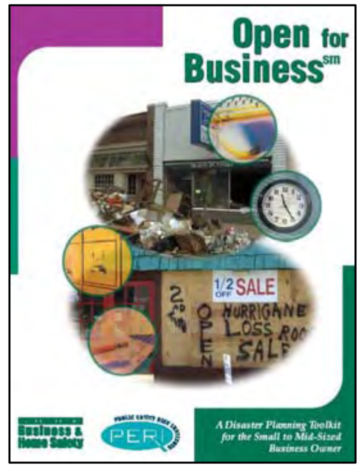
In addition, the loss of a business, even for a short period of time, may adversely affect the community in many ways, some of which may include:

- Loss of tax revenue for city services;
- Loss of jobs for community residents;
- Loss of access to the company's products (especially significant if the company supplies an essential service or product, such as construction equipment, medications, transportation, or groceries);
- Effective Business Continuity Planning (BCP) may include such activities as:
- Making regular back-ups of critical data and keeping it in an off-site location;

Insurance is a start, but won't cover the cost of lost sales, lost jobs and lost customers if a business is affected

- Maintaining accurate contact information (phone, e-mail, pager, etc.) on critical employees;
- Identifying potential off-site locations that can be used in case the primary location of the company is damaged or inaccessible;
- Reviewing all activities of a company and identifying which activities are critical and must resume right away, which are less critical and may not need to resume for a short period of time, and which activities can be put on hold for a longer period of time;
- Developing "canned" PR pieces that can be quickly disseminated in the event of an incident at the company;
- Having an honest conversation with insurers to determine that policies are sufficiently inclusive and appropriate for the business;

- Communicating with suppliers and critical customers on what their emergency response and business resumption plans include.



Business continuity planning can be facilitated by the community in a number of ways, primarily in the area of Public Information.

- The Chamber of Commerce may sponsor programs such as the Institute for Business & Home Safety's (IBHS) *Open For Business* presentation. For more information, see www.ibhs.org/business_protection.
- The American Red Cross has also teamed with the Federal Emergency Management Agency to produce the *Emergency Management Guide for Business and Industry*. More information is available at www.redcross.org/services/disaster/0,1082,0_606_,00.html.

Several professional groups such as the Association of Contingency Planners (www.acp-international.com/okla/) or ARMA, a professional organization of Records & Information Management professionals (www.arma.org) may be available in your area to assist with developing disaster preparedness and mitigation plans or exploring ways to safeguard critical records and information.

In addition, if a community is promoting Community Emergency Response Teams (CERT), business CERTs can be developed to respond to a disaster, not only within a neighborhood, but also within a business establishment. CERTs are trained in disaster organization, immediate disaster evaluation, immediate disaster first aid, light search and rescue, and light fire suppression. For more information on CERT, see www.citizencorps.gov/cert.

B.1.11 Conclusions

1. There are many ways public information programs can be used so people and businesses will be more aware of hazards they face and how they can protect themselves.
2. Most public information activities can be used to advise people about all hazards, not just floods.
3. Other public information activities require coordination with other organizations, such as schools and real estate agents.
4. There are several area organizations that can provide support for public information and educational programs.

B.1.12 Recommendations

The areas of greatest likelihood to strengthen the community in this area would include identifying and developing a Public Education and Outreach manager at the city offices, and coordinating with other agencies engaged in these kinds of activities. In addition, the recent ice storms have indicated a strong need for developing business continuity support for the small business community.

Refer to *Chapter 6: Action Plan* for a complete listing of all recommended mitigation measures by hazard and priority.

Refer to *Chapter 6: Action Plan and Mitigation Measures,* Table 6–1, for a complete listing of all recommended mitigation measures by hazard and priority.

Figure B–1: Public Service Notice for Flooding

Flood Safety

- Do not walk through flowing water. Drowning is the number one cause of flood deaths. Currents can be deceptive; six inches of moving water can knock you off your feet. Use a pole or stick to ensure that the ground is still there before you go through an area where the water is not flowing.
- Do not drive through a flooded area. More people drown in their cars than anywhere else. Don't drive around road barriers; the road or bridge may be washed out.
- Stay away from power lines and electrical wires. The number two flood killer after drowning is electrocution. Electrical current can travel through water. Report downed power lines to the Mayor's Action Line, 596-2100.
- Look out for animals that have been flooded out of their homes and who may seek shelter in yours. Use a pole or stick to poke and turn things over and scare away small animals.
- Look before you step. After a flood, the ground and floors are covered with debris including broken bottles and nails. Floors and stairs that have been covered with mud can be very slippery.
- Be alert for gas leaks. Use a flashlight to inspect for damage. Don't smoke or use candles, lanterns, or open flames unless you know the gas has been turned off and the area has been ventilated.
- Carbon monoxide exhaust kills. Use a generator or other gasoline-powered machine outdoors. The same goes for camping stoves. Charcoal fumes are especially deadly -- cook with charcoal outdoors.
- Clean everything that got wet. Flood waters have picked up sewage and chemicals from roads, farms, factories, and storage buildings. Spoiled food, flooded cosmetics, and medicine can be health hazards. When in doubt, throw them out.
- Take good care of yourself. Recovering from a flood is a big job. It is tough on both the body and the spirit and the effects a disaster has on you and your family may last a long time.

B.2 Preventive Measures

Preventive activities are designed to keep matters from occurring or getting worse. Their objective is to ensure that future development does not increase damages or loss of life, and that new construction is protected from those hazards. Preventive measures are usually administered by building, zoning, planning, and code enforcement offices. They typically include planning, zoning, open space preservation, building codes, drainage criteria, master drainage plans and floodplain development regulations, and stormwater management. These aspects of preventive measures are discussed in this section as follows:

B.2.1 Planning

B.2.2 Zoning

B.2.3 Open space preservation

B.2.4 Building codes

B.2.5 Floodplain development regulations

B.2.6 Stormwater management

The first three measures (planning, zoning, and open space preservation) work to keep damage-prone development *out* of hazardous or sensitive areas.

The next two measures (building codes and floodplain development regulations) impose standards on what is allowed to be built *in* the floodplain. These protect buildings, roads, and other facilities from flood damage and prevent the new development from making any existing flood problem worse. Building codes are also critical to mitigating the impact of non-flood hazards on new buildings.

Stormwater management addresses the runoff of stormwater from new developments onto other properties and into floodplains.

Small public meetings geared toward specific sections of the community proved fruitful in the development of the plan

B.2.1 Planning

While plans generally have limited authority, they reflect what the community would like to see happen in the future. Plans guide other local measures such as capital improvements and the development of ordinances. Planning can include, but is not limited to:

• Capital Improvement Plans	Infrastructure planning decisions can affect flood hazard mitigation. For example, decisions to extend roads or utilities to an area may increase exposure. Communities may consider structural flood protections such as levees or floodwalls.
• Zoning Ordinance Adoption or Amendments	Examples of zoning methods that affect flood hazard mitigation include: 1. Adopting ordinances that limit development in the floodplain. 2. Limiting the density of developments in the floodplain. 3. Requiring floodplains be kept as open space.
• Subdivision Ordinances or Amendments	Subdivision design standards can require elevation data collection during the platting process. Lots may be required to have buildable space above the base flood elevation.
• Building Code Adoption or Amendments	Requirements for building design standards and enforcement include: 1. A residential structure be elevated. 2. A non-residential structure be elevated or floodproofed.
• Conservation Easements	Conservation easements may be used to protect environmentally significant portions of parcels from development. They do not restrict all use of the land. Rather, they direct development to areas of land not environmentally significant.
• Transfer of Development Rights	In return for keeping floodplain areas in open space, a community may agree to allow a developer to increase densities on another parcel that is not at risk. This allows a developer to recoup losses from non-use of a floodplain site with gains from development of a non-floodplain site.
• Purchase of Easement / Development Rights	Compensating an owner for partial rights, such as easement or development rights, can prevent a property from being developed contrary to a community's plan to maintain open space. This may apply to undeveloped land generally or to farmland in particular.
• Stormwater Management Ordinances or Amendments	Stormwater ordinances may regulate development in upland areas in order to reduce stormwater run-off. Examples of erosion control techniques that may be employed within a watershed are include proper bank stabilization with sloping or grading techniques, planting vegetation on slopes, terracing hillsides, or installing riprap boulders or geotextile fabric.

• Multi-Jurisdiction Cooperation Within Watershed	Forming a regional watershed council helps bring together resources for comprehensive analysis, planning, decision-making, and cooperation.
• Comprehensive Watershed Tax	A tax can be used as a mitigation action in several ways: 1. tax funds may be used to finance maintenance of drainage systems or to construct reservoirs. 2. tax assessments may discourage builders from constructing in a given area. 3. taxes may be used to support a regulatory system.
• Post-Disaster Recovery Ordinance	A post-disaster recovery ordinance regulates repair activity, generally depending on property location. It prepares a community to respond to a disaster event in an orderly fashion by requiring citizens to: 1. obtain permits for repairs. 2. refrain from making repairs. 3. make repairs using standard methods.

B.2.2 Zoning

Tulsa's zoning ordinances regulate development by dividing the community into zones or districts and setting development criteria for each zone or district. Zoning ordinances are considered the primary tool to implement a comprehensive plan's guidelines for how land should be developed. They are in the process of revising their City Comprehensive Plan.

B.2.3 Floodplain Development Regulations

Most communities with a flood problem participate in the National Flood Insurance Program (NFIP). The NFIP sets minimum requirements for subdivision regulations and building codes. These are usually spelled out in a separate ordinance.

Experience showed that the National Flood Insurance Program's minimum standard is insufficient for developing urban communities such as Tulsa. The city's regulations exceed the NFIP's minimum national standards in several significant ways.

The Community Rating System (CRS) is a companion program to the NFIP. It rewards a community for taking actions over and above minimum NFIP requirements with the goal of further reducing flood damages in the community. The more actions a community takes, the lower the premiums for flood insurance within that community.

Subdivision regulations govern how land will be subdivided into individual lots, and set the construction and location standards for the infrastructure the developer builds to serve those lots, including roads, sidewalks, utility lines, storm sewers, and drainageways. They provide an additional vehicle for floodplain development rules. For example, some communities require that every subdivision in a floodplain provide a building site above the flood level for every lot and/or require streets to be at or no more than one foot below the base flood elevation.

Floodplains are only part of flood-management considerations. Water gathers and drains throughout entire watersheds, from uplands to lowlands. Each watershed is an interactive

> ***Minimum National Flood Insurance Program Regulatory Requirements***
>
> The National Flood Insurance Program (NFIP) is administered by the Federal Emergency Management Agency (FEMA). As a condition of making flood insurance available for their residents, communities that participate in the NFIP agree to regulate new construction in the area subject to inundation by the 100-year (base) flood.
>
> There are four major floodplain regulatory requirements. Additional floodplain regulatory requirements may be set by state and local law.
>
> 1. All development in the 100-year floodplain must have a permit from the community. The NFIP regulations define "development" as any manmade change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operations or storage of equipment or materials.
> 2. Development should not be allowed in the floodway. The NFIP regulations define the floodway as the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot. The floodway is usually the most hazardous area of a riverine floodplain and the most sensitive to development. At a minimum, no development in the floodway may cause an obstruction to flood flows. Generally an engineering study must be performed to determine whether an obstruction will be created.
> 3. New buildings may be built in the floodplain, but they must be protected from damage by the base flood. In riverine floodplains, the lowest floor of residential buildings must be elevated to or above the base flood elevation (BFE). Nonresidential buildings must be either elevated or floodproofed.
> 4. Under the NFIP, a "substantially improved" building is treated as a new building. The NFIP regulations define "substantial improvement" as any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the start of construction of the improvement. This requirement also applies to buildings that are substantially damaged.
>
> Communities are encouraged to adopt local ordinances that are more comprehensive or provide more protection than the state or Federal criteria. This is especially important in areas with older Flood Insurance Rate Maps that may not reflect the current hazard. Such ordinances could include prohibiting certain types of highly damage-prone uses from the floodway or requiring that structures be elevated 1 or more feet above the BFE. The NFIP's Community Rating System provides insurance premium credits to recognize the additional flood protection benefit of higher regulatory standards.

element of the whole. A change at one place can cause changes elsewhere, whether planned or inadvertent. Tulsa is continuing the process of the development or updating of comprehensive, basin-wide Master Drainage Plans that identify existing and potential future drainage and flooding problems to public facilities and private property.

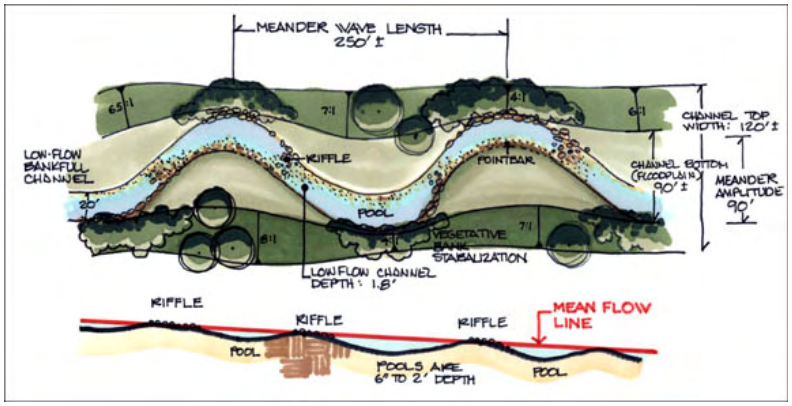
B.2.4 Stormwater Management

Development outside a floodplain can contribute significantly to flooding problems. Runoff is increased when natural ground cover is replaced by urban development. To prevent stormwater from flooding roads and buildings, developers construct storm sewers and improve ditches to carry the water away more efficiently.

As watersheds develop, runoff usually becomes deeper and faster and floods become more frequent. Water that once lingered in hollows, meandered around oxbows, and soaked into the ground now speeds downhill, shoots through pipes, and sheets off rooftops and paving.

Insurance purposes require that NFIP floodplain maps must be based on existing watershed development, but unless plans and regulations are based on future watershed urbanization, development permitted today may flood tomorrow as uphill urbanization increases runoff.

This combination of increased runoff and more efficient stormwater channels leads to increases in downstream storm peaks and changes in the timing when storm peaks move downstream. Unconstrained watershed development often will overload a community's drainage system and aggravate downstream flooding.



In addition to detention facilities, stormwater management plans can include restoring some channelized streams with meanders and native vegetation to slow runoff and prevent flash flooding

A second problem with stormwater is its impact on water quality. Runoff from developed areas picks up pollutants on the ground, such as road oil and lawn chemicals, and carries them to the receiving streams.

Tulsa enforces the NFIP minimum regulations and maps, in order to maintain eligibility for federal flood insurance.

Retention / Detention

Some communities with stormwater management regulations require developers to build retention or detention basins to minimize the increases in the runoff rate caused by impervious surfaces and new drainage systems. Generally, each development must not let stormwater leave at a higher rate than under pre-development conditions. Tulsa does require a drainage plan from new developments.

The Community Rating System (CRS) uses three factors to measure the impact of stormwater management regulations on downstream flooding:

1. What developments have to account for their runoff? If only larger subdivisions have to detain the increased runoff, the cumulative effect of many small projects can still produce greater flows to downstream properties.
2. How much water is managed? Historically, local stormwater management programs address smaller storms, such as the 2- or 10-year storms. The CRS reflects the growing realization nationally that the runoff from larger storms must be managed. It provides full credit only for programs that address all storms up to the 100-year storm.
3. Who is responsible to ensure that the facility works over time? Roads and sewers are located on dedicated public rights-of-way and the community assumes the job of maintaining them in the future. Stormwater management detention basins have traditionally stayed on private property and maintenance has been left up to owner. Often homeowners associations do not know how and do not have the capability to properly maintain these facilities. Half the CRS credit is based on whether the community assumes responsibility to ensure that the facilities are maintained.

Stormwater Detention Ponds manage the increased runoff from new developments, temporarily store flood waters, and can be used for community parks, recreation, and open-space

Watershed Approaches

The standard regulatory approach of requiring each development to manage stormwater to the same criteria has several shortcomings:

1. It does not account for differences in stream and watershed conditions (although the standards can be revised to reflect findings from watershed studies).
2. Municipalities within the same watershed may require different levels of control of stormwater.
3. There is no review of the downstream impacts from runoff or any determination of whether the usual standards compound existing flooding problems.
4. It results in many small basins on private property that may or may not be properly maintained.

The way to correct these deficiencies is to conduct a master study of the watershed to determine the appropriate standards for different areas and, sometimes, to identify where a larger central basin would be more effective and efficient than many smaller ones. The

CRS provides up to double the stormwater management regulations credit if communities adopt such master plans.

B.2.5 Building Codes

Hazard protection standards for all new and improved or repaired buildings can be incorporated into the local building code. These standards should include criteria to ensure that the foundation will withstand flood forces and that all portions of the building subject to damage are above, or otherwise protected from, flooding.

Building codes are also a prime mitigation measure for other natural hazards, especially earthquakes, tornadoes, windstorms and heat and cold. When properly designed and constructed according to code, the average building can withstand the impacts of most of these forces. The code could include provisions such as:

- Requiring sprinkler systems for fire protection in larger or public buildings,
- Regulating overhanging masonry elements that can fall during an earthquake,
- Ensuring that foundations are strong enough for earth movement and that all structural elements are properly connected to the foundation, and
- Making sure roofing systems will handle high winds and expected snow loads.

Tulsa has adopted and enforces 2006 International Building Codes (IBC), which include the International Residential Code, the Plumbing Code, Mechanical Code, Fire Code, and Residential and Fuel Gas Codes.

B.2.6 IBHS Fortified Home Program

What is a Fortified Home

The *Fortified…for Safer Living* home program gives builders and homeowners a set of criteria for upgrades that help reduce the risk of damage from natural disasters. The program raises a homes' overall safety above building code minimum requirements. During construction and upon completion a home is inspected and certified as a "Fortified…for Safer Living" home.

The combination of materials and techniques produces residences equipped to better resist hurricanes, tornadoes, fire and floods. The fortified home construction method produces homes that are comfortable while being resistant to natural disasters.

The following are features of a "Fortified…for Safer Living" home:

- The home and critical utilities are elevated by reinforced continuous piles a minimum of two feet above ground-level walls, stairs and Base Flood Elevation (BFE).
- The home is connected from the peak of the roof to the foot of the reinforced piles to form a continuous load path capable of withstanding 130 mph winds.
- Windows, doors and other openings are properly flashed and protected to withstand the impact of windborne debris without penetration of wind and water.
- The roof truss system has a 110 mph wind rated covering, a secondary moisture barrier, twice the required underlayment, thicker plywood deck sheathing and a stronger holding nail and nailing pattern.

- Other features include non-combustible roof materials, reinforced entry garage doors and landscaping techniques reducing wildfire and flooding vulnerability.
- A certified inspector verifies all required Fortified home products and materials are installed correctly in accordance with manufacturer's specifications for "Fortified…for Safer Living" program specifications.
- The home and property are also verified to be a low risk hazard for exposure to wildfire.

For more information about fortified homes, see www.concretehomescouncil.org/p_room/SBGFortified.pdf.

Economics of a Fortified Home

Cost (new home)

Depending on the quality of the material the buyer chooses, the cost to add fortified features could be as low as five percent of the total cost of a new home. See the following table, from the Institute of Business and Home Safety (IBHS) website at www.ibhs.org/research_library/view.asp?id=277, for a typical upgrade.

Table B–2: Cost Differentials for Fortified Home vs. standard Construction

As-built base home price: $151,500 (including lot and options, before "Fortified" upgrade).

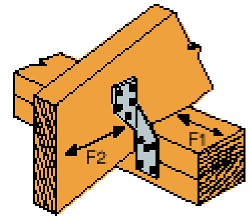
	Standard Home	*"Fortified" Home*	*Incremental Cost to "Fortify"*
Windows and doors	5,450*	$15,500** ($7,700)	$10,050 ($2,250)
Garage doors	$650	$1,250	$600
Roof decking	$650	$1,750	$1,100
Sealing roof joints	$0	$650	$650
Roof covering	$2,350	$3,350	$1,000
Concrete/steel down pours	$0	$500	$500
Fortified inspection costs	$0	$1,000	$1,000
		Total increment cost:	$14,900 ($7,100)
		% of base cost:	9.8% (4.7%***)

* Based on selection of PGT® window & door products.
** Fortified with PGT® WinGuard™ impact-resistant windows & doors.
*** Cost of panel shutters instead of impact-resistant windows.

Cost (existing home)

Many of the fortification techniques used to build new homes are too expensive as retrofits. Fortifying is much more expensive when a home is already built. However, there are creative ways to reduce costs and still fortify an existing home. Improving roof decking on an existing structure would cost about $5,000. For $50 a certain type of glue gun available in most hardware stores can retrofit a roof as effectively as if a new roof had been put on with wood screws.

Savings



In Florida, a fortified home can save homeowners over 20% in insurance premiums. A standard brick, stone, or masonry house in a coastal area, with a deductible of $500 and a 2% hurricane deductible, would generate an annual premium of $2,240. In contrast, the same home with the additional fortified construction features would pay an annual premium of $1,746, a savings of $504, or 22.5%. Also, underwriting guidelines may be relaxed for fortified homes. Insurers may make exceptions for fortified homes in areas where they wouldn't normally write policies.

Lower deductibles may be available. In Florida, policies covering wind damage typically have a deductible of 2% of the covered amount. On a $150,000 home the deductible would be $3,000. Fortified homeowners may be eligible for a flat deductible of $500.

As for intangible savings, personal photographs, important family documents and computer data are just a few of the items a fortified home may protect. Additionally there is the inconvenience and cost of other living arrangements while a home is being rebuilt.

For more information about one insurer's guidelines on insuring fortified homes see www.roughnotes.com/rnmag/august01/08p52.htm.

B.2.7 Smoke Detectors

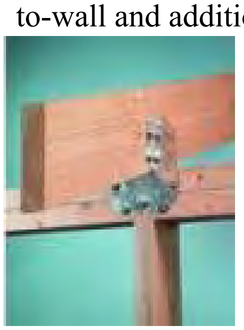
Smoke detectors save lives. Approximately two-thirds of fatal fires occur in the 10% of homes not protected with smoke detectors. You are twice as likely to die in a fire if you do not have a properly operating smoke detector.

There are two basic types of smoke detectors - photoelectric and ionization. Photoelectric smoke alarms generally are more effective at detecting slow-smoldering fires, fires that might smolder for hours before bursting into flames. Ionization smoke alarms are more effective at detecting fast-flaming fires, fires that consume materials rapidly and spread quickly.

Test smoke detectors every month, change the batteries twice per year, clean detectors at least once per year and replace smoke detectors every 10 years. For more facts about smoke detectors see www.firemar.state.ok.us/forms/lg-alarm.pdf.

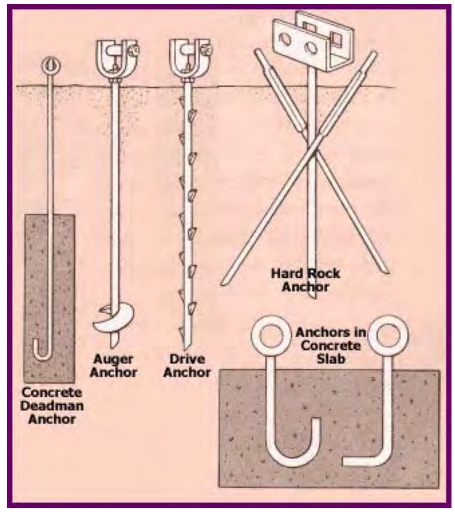
B.2.8 Hurricane Fasteners

A home's roof system is its most vulnerable and expensive component. Hurricane roof-to-wall and additional straps are metal connectors designed to hold a roof to its walls in



high winds. They make a home's roof-to-wall connection five-to-15 times stronger than traditional construction and can prevent damage in winds at least 75 mph. In many coastal communities, reinforcing connections are enforced as a code restriction for new homes. Although designed to protect roofs during the extended and violent winds of hurricanes, these fasteners have proven effective in preventing roof removal in tornado events. For more information on hurricane fasteners and straps and protecting your roof, go to www.nhc.noaa.gov/HAW2/pdf/hurricane_retrofit.pdf.

B.2.9 Mobile Home Tie-Downs



Tie-downs are devices that anchor or otherwise secure a mobile home to the ground in order to protect the mobile home and its surroundings from damage caused by wind and/or other natural forces. All tie-downs must comply with the specifications of the home manufacturer or, in the absence of such specifications, with standards set by the City Building Inspector.

Anchors are available for different types of soil conditions, including concrete slab. Auger anchors have been designed for both hard soil and soft soil. Rock anchors or drive anchors allow attachment to a rock or coral base. This type of anchor is also pinned to the ground with crossing steel stakes.

B.2.10 Lightning Warning Systems

There are two basic types of warning systems:

Strike Location and Identification Systems sense the electromagnetic pulse or the electrostatic pulse that accompanies a lightning discharge. Sensors and processing equipment work from those pulses or transients. These systems are most useful for tracking storms, locating a lightning strike and producing density plots of lightning activity by geographical area. They do not provide early warning of an impending storm.

Pre-storm Warning Systems sense the conditions that precede a storm. All severe storms create a related electrostatic field. This field provides a reliable storm signature that is peculiar to severe storms and can be related to the severity of the storm. That signature is present prior to lightning activity and provides a measurable parameter for pre-storm warning. The electrostatic field strength is directly related to the state of the storm and/or its proximity to the site. Therefore, an increase in the electrostatic field is an indicator of a storm moving into or building up over the area. The warning time is determined by the rate of buildup or the rate of movement of the storm.

Table B–3: Lightning Detection Options
From the National Lightning Safety Institute

Lightning Detection Options - Accuracy vs. Cost vs. Complexity			
Source of Information	**Accuracy**	**Cost**	**Complexity**
Hearing thunder	Danger is near	None	Simple
TV weather channel	General info.	None	Simple
Weather radios	General info.	Up to $40	Simple

Lightning Detection Options - Accuracy vs. Cost vs. Complexity			
Source of Information	**Accuracy**	**Cost**	**Complexity**
Handheld detectors	50-60% accurate	Up to $500	Somewhat
Boltek system (www.boltek.com)	70-80% accurate	Up to $1,500	Somewhat
ThorGuard system (www.thorguard.com)	85-90%	$1,000 - $6,500	Somewhat
WXLine system (www.WXLine.com)	90-95% accurate	Up to $7,000	Somewhat
Subscription service	95%+ accurate	Monthly fee	Simple

Essential companions to any type of lightning warning system include:

- A written Lightning Safety Policy;
- Designation of Primary Safety Person;
- Determination of when to suspend activities;
- Determination of Safe/Not Safe Shelters;
- Notification to Persons at Risk;
- Education: at a minimum consider posting information about lightning and the organization's safety program;
- Determination of when to resume activities.

The above options can be developed with many variations, up to and including all-in-one units that include a lightning threat detector, strobe light and 360° warning horn, and fully-automated programmable computer to pre-set various options for different types of facilities, such as times of operation, degrees of sensitivity, and appropriate sounding of an "all clear" signal.

B.2.11 Power Outages from Winter Storms

Power outages from winter storms can lead to an abundance of problems. Traffic can be disrupted with the loss of traffic signals. Homeowners without power will resort to candles or open flames for heat and light. Generators are noisy, produce potentially deadly exhaust and can cause power spikes damaging equipment. Kerosene heaters burn oxygen and increase the potential of asphyxiation and production of carbon monoxide. With fuel burning equipment there is a constant danger of fire or explosion, burns and breathing poisonous exhaust. In addition, the inability to heat a home increases the risk of pipes freezing.

Power lines can be protected and power outages prevented by:

- Replacing existing power lines with heavier T-2 line, shorter spans, and heavier poles and crossbars. It is estimated this will increase the overall strength of power distribution lines by 66%.

- Burying utility lines. This removes the risk of power outages due to ice accumulation or tree limbs bringing down power lines.
- Pruning trees away from power lines and enforcing policies regarding tree limb clearances.
- Designed-failure allowing for lines to fall or fail in small sections rather than as a complete system.

For a success story on windstorm power outage mitigation, see www.fema.gov/regions/v/ss/r5_n09.shtm. Options for alternate power sources are described at www.currentsolutionspc.com/doc/distributed.pdf.

When power outages occur the first imperative in emergency power planning is to equip essential facilities with permanent backup power, and to make sure existing backup sources are properly sized and maintained. Essential post-disaster services include:

- Medical care
- Drinking water supply
- Police and fire protection
- Refrigeration
- Communications
- Pollution control (especially wastewater treatment)
- Transportation (especially airports and seaports)
- Weather forecasting
- Temporary relief shelter
- Emergency response command and control

Backup systems should be sized to meet the requirements of a facility's necessary public services. Some facilities, such as wastewater treatment plants and hospitals, are so important that backup systems should be sized to carry full loads. All backup power systems should be covered by a complete and consistent planned maintenance program that includes regular inspection and operational testing.

B.2.12 Standby Electric Generators

Standby electric generators can provide an extra sense of security during unpredictable weather and resulting power outages. But even small, portable electric generators – if used improperly – can threaten resident safety and the safety of power company linemen working on the electrical system. For information on safely purchasing and using a residential generator, see www.redcross.org/services/disaster/0,1082,0_565_,00.html.

Before purchasing a generator, consider how it will be used. That will help ensure buying a generator that is correctly sized for the application in mind. Portable, gasoline-driven generators are designed to be used for appliances with cords connected to them. Typically, they are not designed to be connected to a home or building wiring. Citizens should not attempt to install these devices to an electrical panel.

Fixed Generators

Large, fixed generators generally are directly connected to building wiring to provide standby power during emergencies or power outages. However, the wiring needs to be properly installed by a qualified electrical contractor. Properly installing a “permanent” generator is extremely dangerous, and usually requires an electrical permit from the local electrical or building inspector's office. Picking an appropriate fixed-site emergency generator involves a number of issues including:

- Type of fuel – Usually a choice between natural gas or diesel, depending on the availability of either fuel in an emergency, and any possible regulations concerning on-site storage. Natural gas emits far fewer exhaust emissions, which may also be a factor.
- Proper voltage – It’s usually best for an emergency generator to match your standard incoming voltage, whether it’s single-phase 120/240 or three-phase 277/480, which is the more common commercial application.
- Power requirements – this will entail (a) identifying your critical functions, and (b) having an electrical professional rate the running/start-up kilowatt (kW) requirements for those functions. (See Table B-4 below for some basic power ratings for typical applications.)
- Cost – even a small (30-45 kW, 277/480 volt) natural gas standby generator can cost $10,000, plus expenses for installation and automatic transfer switches. Most emergency operations centers, 911 dispatch centers, and other critical facilities will need a generator with higher requirements.

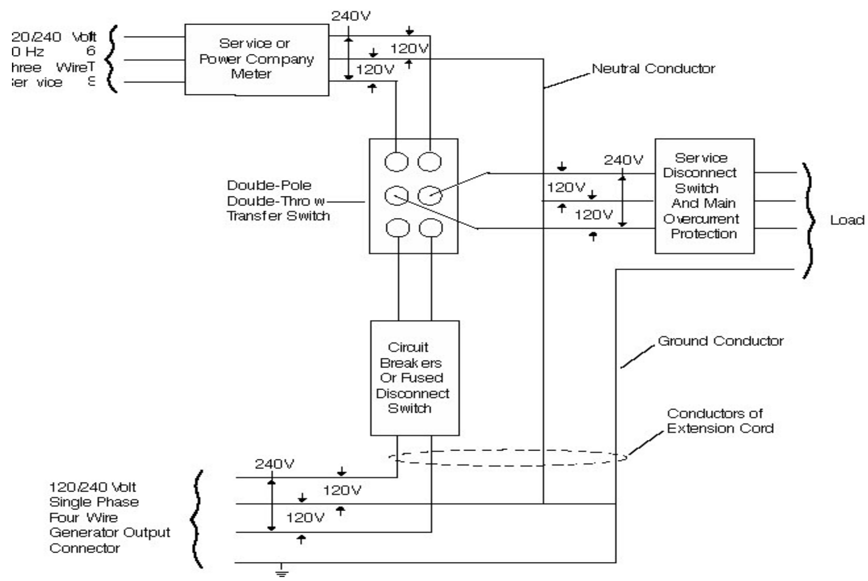
"Back feeding" - a dangerous condition

Improperly connecting a portable generator to electric wiring can produce “back feed” – a dangerous current that can electrocute or critically injure residents or others. Back feed into power lines from a generator could create “hot” power lines during an outage. Linemen who expect the line to be de-energized could be injured.

One good way to avoid back feeding is to install a double-pole, double throw transfer-switch gear. A qualified electrical contractor can install this transfer switch so that dangerous back feed can be prevented. “In accordance with the National Electrical Code, paragraph 700-6; Transfer equipment shall be designed and installed to prevent the inadvertent interconnection of normal and emergency sources of supply in any operation of the transfer equipment. Automatic transfer switches shall be electrically operated and mechanically held.” The transfer switch must be a break-before-make switch, which will “break” the electrical connection with commercial power lines before it “makes” the connection between the generator and wiring. The switch also will prevent utility power from damaging the generator when regular service is restored. An electrical diagram of an installation using a transfer switch appears in Figure B-2.

Since transfer switches can be expensive, another way to install a generator is to have a sub-panel with main breakers and power from the main panel or generator. Main panel breaker and generator breaker in sub-panel would have handles interlocked to prevent both from being opened and closed at the same time. This prevents back feed to commercial power when the generator is in use.

Figure B-2: Standby power equipment and



For commercial emergency installations, it is also critical that an electrical professional review what the standard and max loads will be on the system. An evaluation needs to be made as to what critical functions need to be operational – HVAC, communications, lighting, security, cooking capabilities, and so on. In health care facilities, assistive devices and water supply equipment can pull large quantities of power, which will need to be taken into account.

Typical wattage requirements are described in the following table:

Table B–4: Typical Wattage Requirements for Generator Usage

Item	Running Watts	Item	Running Watts
Air conditioner (12,000 BTU)	1,700	Furnace Fan (1/3 HP)	1,200
Battery Charger (20 A)	500	Light Bulb	100
Chain Saw	1,200	Microwave Oven	1,000
Circular Saw	1,000	Oil Burner on Furnace	300
Coffee Maker	1,000	Radio	50
Compressor (1 HP)	2,000	Refrigerator	600
Deep Freeze	500	Submersible Pump (1 HP)	2,000
Electric heater (small)	1,500	Sump Pump	600
Electric Range (1 element)	1,500	Television	300

Source: Above information adapted from American Electric Power, *A Word About Portable Electric Generators*, and Flathead Electric Cooperative, *Safely Installing Your Electric Generator, 2007.*

B.2.13 Critical Facility Protection

Critical facilities require a higher level of protection because they are vital public facilities, reduce pollution of floodwaters by hazardous materials, and ensure that the facilities will be operable during emergencies. The Community Rating System (CRS) provides credit for regulations protecting critical facilities from the 500-year flood.

Critical facilities should be constructed on properly compacted fill and have the lowest floor (including basement) elevated at least one foot above the elevation of the 500-year flood. A critical facility should have at least one access road connected to land outside the

500-year floodplain capable of supporting a 4,000-pound vehicle. The top of the road must be no lower than six inches (6”) below the elevation of the 500-year flood.

B.2.14 Extreme Heat Protection

Elderly, children, low-income individuals and people with compromised immune systems are more vulnerable to health risks due to intense climate changes, especially extreme heat.

Aging is often accompanied by chronic illnesses that may increase susceptibility to extreme environmental conditions. Poverty among elderly increases the risk.

Children are vulnerable due to their size, behavior and fact that they are growing and developing. Children living in poverty or without access to proper medical care are especially vulnerable.

Low-income individuals are less likely to be able to afford air-conditioning and have less access to health care.

Cancer, AIDS and diabetes compromise individual’s immune systems. Afflicted individuals are more susceptible to physical stresses such as those during extreme heat.

Steps to protect individuals from the heat include:

- Install window air-conditioners snugly and insulate spaces for a tighter fit.
- Hang shades, draperies, awnings or louvers on windows receiving morning or afternoon sun. Awnings or louvers can reduce heat entering the house by as much as 80%.
- Stay indoors as much as possible. If air conditioning is not available stay on the lowest floor out of the sunshine.
- Drink plenty of water and limit alcoholic beverages.
- Dress in light-colored, loose fitting clothes that cover as much skin as possible.
- Take a cool bath.
- Slow down.

Suggestions for a community heat emergency intervention plan include:

- Standardizing guidelines for providing warnings to the public, including not only the National Weather Service, but also Emergency Medical Services, the Health Department, Emergency Management and other recognized community agencies.
- The public must have access to the steps to take to lessen the likelihood of heat problems, such as staying in air-conditioning, if possible, and drinking plenty of fluids.
- A room air conditioner loan program for bed-ridden/chair-ridden individuals can assist those individuals who cannot physically leave their homes to visit an air-conditioned location each day.
- “Buddy systems” can be established where an individual is assigned to check on people at risk. The “buddy” should be trained to deal with heat related emergencies.

- Utility companies should not be allowed to terminate service during a heat emergency, even if individuals have not paid their bill.

For more information on extreme heat, mitigation and protection from the heat see www.fema.gov/hazards/extremeheat/heatf.shtm.

B.2.15 Proper Storage and Disposal of Hazardous Materials

Household chemicals and motor oil dumped down drains or directly onto the ground can work their way into the waterways and ground waters. Oil from a single oil change can ruin one million gallons of fresh water. Used crankcase oil has been reported to account for more than 40% of the oil pollution in waterways.

Most public and private vehicle maintenance facilities have well-developed systems to store their waste oil for recycling. However, "do-it-yourselfers" account for a large percentage of the oil changes in any community. Therefore, it is important for community recycling and solid waste management programs to include a system for waste oil collection and provide ways to collect and dispose of household chemicals.

Many counties and communities offer household pollutant collection events. Among the pollutants collected are oil-based paints, paint thinners, pesticides, fertilizers, cleansers, acids, ammunition, batteries, motor oil, and antifreeze. Residents are not charged for items collected. Events are typically funded by participating communities.

Containers of hazardous materials should not be located in a flood hazard area. If such a location is necessary hazardous material containers need to be anchored. Contents can contaminate water and multiply the damaging effects of flooding by causing fires or explosions, or by otherwise making structures unusable. Buoyant materials should be anchored. If they float downstream they may cause additional damage to buildings or bridges or may plug a stream resulting in higher flood heights.

The link www.earth911.org/zip.asp provides a list of hazardous waste recycling centers and used oil collection facilities based on zip code.

B.2.16 Water Conservation

97% of the earth's water is in the oceans and 2% is trapped in icecaps and glaciers. Only about 1% of the earth's water is available for human consumption. The water supply is taxed to supply all the competing interests: residential - including drinking and sanitation, manufacturing, environmental, agricultural, and recreational.

Conserving water conserves energy - gas, electric or both, reduces monthly water and sewer bills and postpones the construction of or eliminates the need to build expensive capital projects such as wastewater or water treatment plants that will need future maintenance.

Plumbing codes implemented in Phoenix Arizona in 1990 required low-flow faucets, show heads, and toilets. Since then water consumption per capita has decreased 27 percent. Other cities, such as Wilsonville, Oregon, have implemented an inverted block water rate structure charging customers higher rates as water consumption increases.

Public education can have the most significant impact. Household water conservation tips include:

- Updating plumbing fixtures with low-flow devices.
- Keeping a pitcher of water in the refrigerator instead of running the tap.
- Watering the yard and gardens in the morning or evening when temperatures are cooler to minimize evaporation.
- Collecting water used for rinsing and reusing it to water plants.
- Turning off the water while brushing teeth and shaving.
- Landscaping with drought-resistant, low water use plants.
- Using a hose nozzle and turning off the water while washing cars.

B.2.17 Open Space Preservation

Keeping the floodplain open and free from development is the best approach to preventing flood damage. Preserving open space is beneficial to the public in several ways. Preserving floodplains, wetlands, and natural water storage areas maintains the existing stormwater storage capacities of an area. These sites can also serve as recreational areas, greenway corridors and provide habitat for local flora and fauna. In addition to being preserved in its natural landscape, open space may also be maintained as a park, golf course, or in agricultural use.

B.2.18 Conclusions

1. Planning and zoning will help Tulsa develop the community proactively so that the resulting infrastructure is laid out in a coherent and safe manner.
2. Building codes for foundations, sprinkler systems, masonry, and structural elements such as roofs are prime mitigation measures for occurrences of floods, tornadoes, high winds, extreme heat and cold, lightning strikes, and earthquakes.
3. Public education (see Section B.1) can demonstrate preventive measures individuals and businesses can use to protect their own lives and facilities.
4. Tulsa participates in the NFIP and uses subdivision regulations to control the direction of floodplain development.
5. Deficiencies in stormwater management can be corrected by conducting a master study of watersheds to determine appropriate standards for different areas.

B.2.19 Recommendations

Refer to *Chapter 6: Action Plan*, for a complete listing of all recommended mitigation measures by hazard and priority.

B.3 Structural Projects

Structural projects are usually designed by engineers or architects, constructed by the public sector, and maintained and managed by governmental entities. Structural projects traditionally include stormwater detention reservoirs, levees and floodwalls, channel modifications, drainage and storm sewer improvements, and community tornado safe-rooms.

B.3.1 Safe Rooms

Safe rooms are specially constructed shelters intended to protect occupants from tornados and high winds. Constructed of concrete and steel, properly built safe rooms can provide protection against wind speeds of 250mph and airborne debris traveling as fast as 100mph.

A safe room can be incorporated into the construction of a new home, or can be retrofitted above or below ground into an existing home. The cost of constructing a safe room is between $2500 and $6000, depending on the room size, location and type of foundation on which the home is built. Safe rooms can function year-round as a usable area, such as a bathroom, closet or utility room.

The State of Oklahoma, FEMA and communities may offer reimbursement grants for construction of certain categories of Safe Rooms through the Hazard Mitigation Grant Program (HMPG).

FEMA 320, *Taking Shelter From the Storm: Building a Safe Room Inside Your Home* has specific designs for tornado and hurricane safe rooms. To obtain a copy of FEMA 320 refer to www.fema.gov/fima/tsfs02.shtm.

Dr. Ernst Kiesling, Civil Engineering Professor at Texas Tech University inspects a safe room in the aftermath of the May 8, 2003 tornadoes in Moore, Oklahoma.

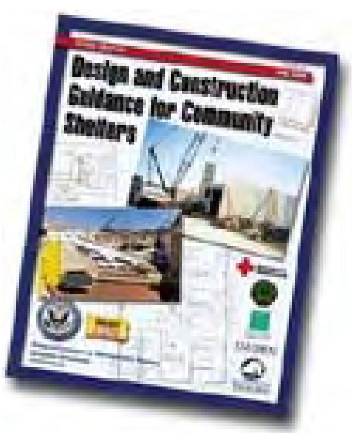
National Storm Shelter Association

The National Storm Shelter Association (NSSA) is an industry organization developed to ensure the highest quality of manufactured and constructed storm shelters. The NSSA has developed a program to verify that design, construction, and installation of storm shelters are in compliance with the most comprehensive and extensive safety standards available. Without full compliance with the standard, vulnerabilities may exist and safety may be compromised. Shelter-producing members of the NSSA submit shelter designs to the scrutiny of an independent third-party engineering company and have their shelters tested for debris impact resistance (FEMA 320 designs have been tested). In addition they will file a certificate of installation with NSSA for each shelter.

Upon building or installing a storm shelter, the member applies a seal to the shelter certifying that it is designed, built, and installed to meet the NSSA standard. Only the shelter producer or an agency that carefully inspects the shelter design, construction, and installation may certify compliance with an applicable standard. Claims of "FEMA Certified" or "Texas Tech Certified" are misleading since neither FEMA nor the Texas Tech Wind Science and Engineering Research Center (contributors to the FEMA standards for individual and community SafeRooms) certifies shelter quality. This program not only provides assurance to the user of a storm shelter that it has been built to a certain performance standard, but it shifts some responsibility from the community to provide verification from building inspectors for compliance and reduces building inspectors' training requirements. Additional information on the NSSA certification program can be obtained at www.nssa.cc.

B.3.2 School Safe Rooms

In the past, a school's interior areas, especially hallways, have been designated as the best place to seek refuge from violent storms. However, in 1999 the hallways of two schools in Sedgwick County, Kansas received significant damage which could have resulted in student casualties had school been in session.



FEMA 361 publication, *Design and Construction Guidance for Community Shelters*, provides guidelines for constructing school safe rooms. A community shelter strong enough to survive a violent storm can also be used as a cafeteria, gymnasium or other common area.

Schools, administration buildings and institutions of higher learning are required to have written plans and procedures in place for protecting students, faculty, administrators and visitors from natural and man-made disasters and emergencies. The requirement, directed by Oklahoma House Bill HB1512, was enacted May 29, 2003.

For more information about Sedgwick County's new school safe rooms go to www.fema.gov/mit/saferoom/casestudies.shtm. To receive a copy of FEMA 361, see www.fema.gov/pdf/hazards/nhp_fema361.pdf. For more information on HB1512, see www.lsb.state.ok.us/2003-04HB/HB1512_int.rtf.

B.3.3 Reservoirs and Detention

Reservoirs control flooding by holding high flows behind dams or in storage basins. After a flood peaks, water is released or pumped out slowly at a rate that the river can accommodate downstream. The lake created may provide recreational benefits or water supply (which could help mitigate a drought).

Reservoirs are suitable for protecting existing development downstream from the project site. Unlike levees and channel modifications, they do not have to be built close to or disrupt the area to be protected. Reservoirs are most efficient in deeper valleys where there is more room to store water, or on smaller rivers where there is less water to store. Building a reservoir in flat areas and on large rivers may not be cost-effective, because large areas of land have to be purchased.

Reservoirs provide storage of rainwater without the hazards of maintaining a dam

In urban areas, some reservoirs are simply manmade holes dug to store floodwaters. When built in the ground, there is no dam for these retention and detention basins and no dam failure hazard. Wet or dry basins can also serve multiple uses by doubling as parks or other open space uses.

B.3.4 Levees and Floodwalls

Probably the best-known flood control measure is a barrier of earth (levee) or concrete (floodwall) erected between the watercourse and the property to be protected. Levees and floodwalls confine water to the stream channel by raising its banks. They must be well designed to account for large floods, underground seepage, pumping of internal drainage, and erosion and scour.

Failure to maintain levees can lead to significant loss of life and property if they are stressed and broken or breached during a flood event. An inspection, maintenance and enforcement program helps ensure structural integrity.

Levees placed along the river or stream edge degrade the aquatic habitat and water quality of the stream. They also are more likely to push floodwater onto other properties upstream or downstream. To reduce environmental impacts and provide multiple use benefits, a setback levee (set back from the floodway) is the best project design. The area inside a setback levee can provide open space for recreational purposes and provide access sites to the river or stream.

B.3.5 Channel Improvements

By improving channel conveyance, more water is carried away at a faster rate. Improvements generally include making a channel wider, deeper, smoother or straighter. Some smaller channels in urban areas have been lined with concrete or put in underground pipes.

B.3.6 Crossings and Roadways

In some cases buildings may be elevated above floodwaters, but access to the building is lost when floodwaters overtop local roadways, driveways, and culverts or ditches.

Depending on the recurrence interval between floods, the availability of alternative access, and the level of need for access, it may be economically justifiable to elevate some roadways and improve crossing points.

Culverts like this one can constrict flow and cause backwater flooding

For example, if there is sufficient downstream channel capacity, a small culvert that constricts flows and causes localized backwater flooding may be replaced with a larger culvert to eliminate flooding at the waterway crossing point. The potential for worsening adjacent or downstream flooding needs to be considered before implementing any crossing or roadway drainage improvements.

B.3.7 Drainage and Storm Sewer Improvements

Man-made ditches and storm sewers help drain areas where the surface drainage system is inadequate, or where underground drainageways may be safer or more practical. Storm sewer improvements include installing new sewers, enlarging small pipes, and preventing back flows. Particularly appropriate for depressions and low spots that will not drain naturally, drainage and storm sewer improvements usually are designed to carry the runoff from smaller, more frequent storms.

Because drainage ditches and storm sewers convey water faster to other locations, improvements are only recommended for small local problems where the receiving stream or river has sufficient capacity to handle the additional volume and flow of water. To reduce the cumulative downstream flood impacts of numerous small drainage projects, additional detention or run-off reduction practices should be provided in conjunction with the drainage system improvements.

B.3.8 Drainage System Maintenance

The drainage system may include detention ponds, stream channels, swales, ditches and culverts. Drainage system maintenance is an ongoing program to clean out blockages caused by an accumulation of sediment or overgrowth of weedy, non-native vegetation or debris, and remediation of stream bank erosion sites.

Drainageways are inspected regularly for blockage from debris

“Debris” refers to a wide range of blockage materials that may include tree limbs and branches that accumulate naturally, or large items of trash or lawn waste accidentally or intentionally dumped into channels, drainage swales or detention basins. Maintenance of detention ponds may also require revegetation or repairs of a restrictor pipe, berms or overflow structure.

Maintenance activities normally do not alter the shape of a channel or pond, but they do affect how well a drainage system can do its job. Sometimes it is a very fine line that separates debris that should be removed from natural material that helps form habitat.

B.3.9 Conclusions

1. Reservoirs can hold high flows of water that can later be released slowly or retained for recreational purposes or drought mitigation.
2. Levees and floodwalls are not as effective overall because of possible underground seepage, erosion, degradation of aquatic habitat and water quality, and ineffectiveness in large floods.
3. Channel improvements allow more water to be carried away faster.
4. The effectiveness of elevating buildings depends on the availability of alternative access when flooding occurs.
5. Crossing and roadway drainage improvements must take into account additional detention or run-off reduction.
6. Drainage and storm sewer improvements carry runoff from smaller, more frequent storms.
7. Drainage system maintenance is an ongoing project of removing debris that decreases the effectiveness of detention ponds, channels, ditches, and culverts.

B.3.10 Recommendations

Refer to *Chapter 6: Action Plan*, for a complete listing of all recommended mitigation measures by hazard and priority.

B.4 Property Protection

Property protection measures are used to modify buildings or property subject to damage from various hazardous events. The property owner normally implements property protection measures. However, in many cases technical and financial assistance can be provided by a governmental agency. Property protection measures typically include acquisition and relocation, flood-proofing, building elevation, barriers, retrofitting, safe rooms, hail resistant roofing, insurance, and the like.

B.4.1 The City's Role

Property protection measures are usually considered the responsibility of the property owner. However, the City should be involved in all strategies that can reduce losses from natural hazards, especially acquisition. There are various roles the City can play in encouraging and supporting implementation of these measures.

Providing basic information to property owners is the first step in supporting property protection measures. Owners need general information on what can be done. They need to see examples, preferably from nearby.

Financial Assistance

Communities can help owners by helping to pay for a retrofitting project, just like they pay for flood control projects. Financial assistance can range from full funding of a project to helping residents find money from other programs. Some communities assume responsibility for sewer backups and other flood problems that arose from an inadequate public sewer or drain system.

Less expensive community programs include low interest loans, forgivable low interest loans and rebates. A forgivable loan is one that does not need to be repaid if the owner does not sell the house for a specified period, such as five years. These approaches do not fully fund the project but they cost the community treasury less and they increase the owner's commitment to the flood protection project.

Often, small amounts of money act as a catalyst to pique the owner's interest to get a self-protection project moving. Several Chicago suburbs have active rebate programs that fund only 20% or 25% of the total cost of a retrofitting project. These programs have helped install hundreds of projects that protect buildings from low flood hazards.

Acquisition Agent

The City can be a focal point for many acquisition projects. In most cases, when acquisition of a property is feasible, the City is the ultimate owner of the property, but in other cases, the school district or other public agencies can assume ownership and the attendant maintenance responsibilities.

Other Incentives: "Non-financial Incentives"

Sometimes only a little funding is needed to motivate a property owner to implement a retrofitting project. A flood insurance premium reduction will result if a building is elevated above the flood level. This reduction is not enough to take much of a bite out of the cost of the project, but it reassures the owner that he or she is doing the right thing. Other forms of floodproofing are not reflected in the flood insurance rates for residential properties, but they may help with the Community Rating System, which provides a premium reduction for all policies in the community.

Other incentives to consider are programs to help owners calculate the benefits and costs of a project and a "seal of approval" for retrofitted buildings. The latter would be given following an inspection that confirms that the building meets certain standards. There are many other personal but non-economic incentives to protect a property from flood damage, such as peace of mind and increased value at property resale.

B.4.2 Insurance

Insurance has the advantage that, as long as the policy is in force, the property is protected and no human intervention is needed for the measure to work. There are three types of insurance coverage:

NFIP Coordinator Dianna Herrera presenting a class on flood insurance requirements

1. The standard homeowner's, dwelling, and commercial insurance policies cover against the perils of wildfire and the effects of severe weather, such as frozen water pipes.
2. Many companies sell earthquake insurance as an additional peril rider on homeowner's policies. Individual policies can be written for large commercial properties. Rates and deductibles vary depending on the potential risk and the nature of the insured properties.
3. Flood insurance is provided under the National Flood Insurance Program.

Flood Insurance

Although most homeowner's insurance policies do not cover a property for flood damage, an owner can insure a building for damage by surface flooding through the National Flood Insurance Program (NFIP). Flood insurance coverage is provided for buildings and their contents damaged by a "general condition of surface flooding" in the area.

Building coverage is for the structure. Contents coverage is for the removable items inside an insurable building. A renter can take out a policy with contents coverage, even if there is no structural coverage.

Some people have purchased flood insurance because the bank required it when they got a mortgage or home improvement loan. Usually these policies just cover the building's structure and not the contents.

In most cases, a 30-day waiting period follows the purchase of a flood insurance policy before it goes into effect. The objective of this waiting period is to encourage people to keep a policy at all times. People cannot wait for the river to rise before they buy their coverage.

B.4.3 Acquisition and Relocation

Moving out of harm's way is the surest and safest way to protect a building from damage. Acquiring buildings and removing them is also a way to convert a problem area into a community asset and obtain environmental benefits.

The major difference between the two approaches is that acquisition is undertaken by a government agency, so the cost is not borne by the property owner, and the land is converted to public use, such as a park. Relocation can be either government or owner-financed.

Moving a home out of the floodplain is sometimes the only way to protect it from flooding

While almost any building can be moved, the cost goes up for heavier structures, such as those with exterior brick and stone walls, and large or irregularly shaped buildings. However, experienced building movers know how to handle any job.

Cost

An acquisition budget should be based on the median price of similar properties in the community, plus $10,000 to $20,000 for appraisals, abstracts, title opinions, relocation benefits, and demolition. Costs may be lower after a flood or other disaster. For example, the community may have to pay only the difference between the full price of a property and the amount of the flood insurance claim received by the owner.

One problem that sometimes results from an acquisition project is a "checkerboard" pattern in which nonadjacent properties are acquired. This can occur when some owners, especially those who have and prefer a waterfront location, prove reluctant to leave. Creating such an acquisition pattern in a community simply adds to the maintenance costs that taxpayers must support.

Relocation can be expensive, with costs ranging from $30,000 for a small wood frame building to over $60,000 for masonry and slab on grade buildings. Two story houses are more expensive to move because of the need to relocate wires and avoid overpasses. Additional costs may be necessary for acquiring a new lot on which to place the relocated building and for restoring the old site. Larger buildings may have to be cut and the parts moved separately. Because of all these complications, there are cases where acquisition is less expensive than relocation.

Where Appropriate

Acquisition and relocation are appropriate in areas subject to:

- Flash flooding
- Deep waters
- Dam break flooding
- Landslides

- Potential hazardous materials spills
- Other high hazard that affects a specific area

Acquisition and relocation are not appropriate for hazards like tornadoes or winter storms because there are no areas safe from the hazard. Relocation is also preferred for large lots that include buildable areas outside the hazardous area or where the owner has a new lot in a safer area.

Acquisition (followed by demolition) is preferred over relocation for buildings that are difficult to move, such as larger, slab foundation, or masonry structures, and for dilapidated structures that are not worth protecting.

B.4.4 Building Elevation

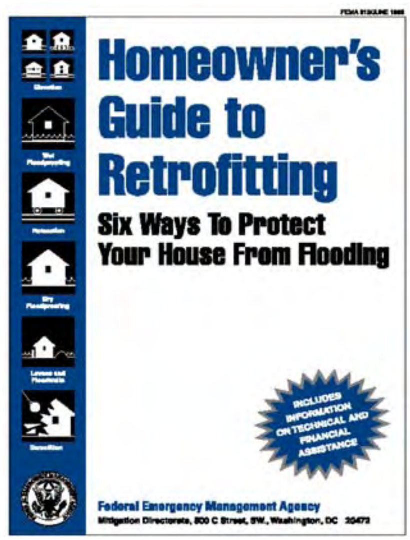
Raising a building above the flood level is the best on-site property protection method for flooding. Water flows under the building, causing little or no damage to the structure or its contents. Alternatives are to elevate on continuous foundation walls (creating an enclosed space below the building) or elevation on compacted earthen fill.

B.4.5 Barriers

Barriers keep surface waters from reaching a building. A barrier can be built of dirt or soil ("berm") or concrete or steel ("floodwall"). In cases of shallow flooding, regrading a yard can provide the same protection as a separate barrier.

B.4.6 Retrofitting

This term covers a variety of techniques for modifying a building to reduce its susceptibility to damage by one or more hazards.



FEMA guides are available to help homeowners retrofit their flood-prone properties

Where Appropriate

Some of the more common approaches are:

Floods and dam failures:

- Dry floodproofing keeps the water out by strengthening walls, sealing openings, or using waterproof compounds or plastic sheeting on walls. Dry floodproofing is not recommended for residential construction.
- Wet floodproofing, using water resistant paints and elevating anything that could be damaged by a flood, allows for easy cleanup after floodwaters recede. Accessory structures or garages below the residential structure are potential candidates for wet floodproofing.
- Installing drain plugs, standpipes or backflow valves to stop sewer backup.

Tornado:

- Constructing an underground shelter or in-building "safe room"
- Securing roofs, walls and foundations with adequate fasteners or tie downs

- Strengthening garage doors and other large openings

High winds:

- Installing storm shutters and storm windows
- Burying utility lines
- Using special roofing shingles designed to interlock and resist uplift forces
- Installing/incorporating backup power supplies

Hailstorms:

- Installing hail resistant roofing materials

Lightning:

- Installing lightning rods and lightning surge interrupters
- Burying utility lines
- Installing/incorporating backup power supplies

Winter storms:

- Adding insulation
- Relocating water lines from outside walls to interior spaces
- Sealing windows
- Burying utility lines
- Installing/incorporating backup power supplies

Extreme heat and drought:

- Adding insulation
- Installing water saver appliances, such as shower heads and toilets

Wild fires:

- Replacing wood shingles with fire resistant roofing
- Adding spark arrestors on chimneys
- Landscaping to keep bushes and trees away from structures
- Installing sprinkler systems
- Installing smoke alarms

Earthquake:

- Retrofitting structures to better withstand shaking.
- Tying down appliances, water heaters, bookcases and fragile furniture so they won't fall over during a quake.

Common Measures

From the above lists, it can be seen that certain approaches can help protect from more than one hazard. These include:

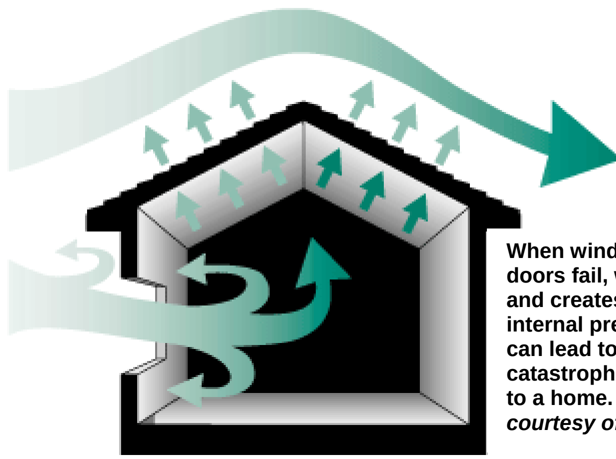
- Strengthening roofs and walls to protect from wind and earthquake forces.

- Bolting or tying walls to the foundation protect from wind and earthquake forces and the effects of buoyancy during a flood.
- Adding insulation to protect for extreme heat and cold
- Anchoring water heaters and tanks to protect from ground shaking and flotation
- Burying utility lines to protect from wind, ice and snow.
- Installing backup power systems for power losses during storms

Installing roofing that is hail resistant and fireproof.

B.4.7 Impact Resistant Windows and Doors

Doors and windows can be the most vulnerable components of your home. During high wind events, such as thunderstorms or tornadoes, wind-driven debris can easily penetrate unprotected or unreinforced windows and doors, breaching the secure envelope of the structure. The debris and rain may cause damage to interior furnishings or harm to residents, but the wind itself can create extreme pressures on the walls and ceiling, leading to catastrophic structural failure. This danger can be mitigated by the installation of impact-resistant windows and doors.



When windows and doors fail, wind enters and creates an internal pressure that can lead to catastrophic damage to a home. (*Drawing courtesy of Flash.org*)

Windows

Today's impact-resistant glass sandwiches a laminated inner layer made of polyvinyl butyral, a plastic, between two sheets of glass. Stronger than a car windshield, the glass might shatter if a heavy object crashes into it, but it won't break to bits. That makes wind less likely to penetrate the envelope of a home and create interior pressure severe enough to blow a roof off. Impact-resistant windows are only as strong, though, as the frame in which they rest. “An impact resistant window is tested as a unit that includes the glass, the frame as well as the attachment hardware and the installation method.” (*FLASH*)

The second type of impact-resistant glass uses a film applied to the surface. Impact-resistant film is placed over the glass to keep windows from shattering into sharp particles if broken. Since these films are added to the glass, they may not be as effective as a standard impact-resistant system. Their durability depends on how well the glass and protective laminate stay in the frame and window assembly. They will be effective against smaller objects, but larger pieces of debris may still take the window out of the frame. For more information on protective window films and other technologies, visit the Protecting People First Initiative (www.protectingpeople.org/arenspage.shtm) or the International Window Film Association (www.iwfa.com/iwfa/Consumer_Info/safety.html).

While costs for replacing window glass or using impact-resistant glass in new construction can be expensive, there are additional benefits that may be gained. Impact-resistant glass has been used successfully to reduce burglaries, vandalism and break-ins with both homes and businesses. In addition, using an impact-resistant glazing that is also more energy efficient can produce substantial energy savings. According to the Partnership for Advancing Housing Technology (PATH), a public-private partnership between leaders in the homebuilding, product manufacturing, and insurance industries and several Federal agencies:

> Special glass "…can be used to both make windows impact resistant and more energy efficient. Low-E and solar control low-E (also called spectrally selective) coatings can be used to boost the energy efficiency of windows. Low-E double pane windows, most common in cold and moderate climates, are more energy efficient than clear windows because the low-E coating reduces heat loss through the window.
>
> Solar control glass, also called Low E2, is a good glass for hot climates because, in addition to improving the insulating ability of windows, it also limits solar heat gain by blocking passage of infrared and some ultraviolet rays. Solar control glass allows a higher level of visible light to pass through a window with less solar heat gain reduction than tinted window coatings."

PATH gives a tentative cost estimate for using impact resistant glass systems in a model 2,250 sq. ft. home at $14,850. (www.pathnet.org/sp.asp?id=18692). In addition, residential users may view a window and door protection cost estimate tool at the FLASH.org site www.blueprintforsafety.org/tools/shuttertoolhome.aspx.

One manufacturer provides the following pricing table for commercial applications:

Table B–5: Impact Resistant Windows Cost Estimate Table

The following pricing table is for estimating purposes only. Changes in dimensions, glass types, finishes, hardware selection, volume discounts, and other variables could raise or lower prices. (Provided by CGI Windows, **www.cgiwindows.com**.)

APPROXIMATE IMPACT RESISTANT PRICING 2007 - COMMERCIAL GRADE ALUMINUM PRODUCTS

Product	W	x	H	Max. Design Pressure (PSF)	COS*
Series 238 - Casement Window	24"	x	48	+110 / -120	$400.12
Series 238 - Casement Window	30"	x	60	+110 / -120	$526.63
Series 238 - Casement Window	36"	x	60	+110 / -120	$593.31
Series 238 - Casement Window	32"	x	72	+85 / -85	$625.18
Series 360 - Single Hung Window	36"	x	72	+100 / -167.2	$593.80
Series 360 - Single Hung Window	54"	x	96"	+100 / -120	$1,274.27
Series 450 - Pair of Door	74 1/2"	x	96 3/4	+100 / -110	$2,425.69

Aluminum Finish: White, Bronze, or Driftwood ESP
Glass Type: 7/16" Laminated Glass Typical (Ann/Ann) / 5/16" Lami Glass at Single Hungs (Ann/Ann)
Glass Color: Clear, Gray, Bronze, Dark Gray (Turtle Code)

** Note: Cost excludes special items, colonial muntins, HS/HS Glass, Temp/Temp Glass, aluminum tube mullions, shipping, shop drawings, installation, permits, special engineering, windload calculations, etc.*

Garage Doors

Illustrating the dangers of unreinforced garage doors, in all but the house at upper left, these doors have been breached, leading to substantial roof damage – in some cases, completely removing a second floor. But in the home with an intact garage door, the roof is almost entirely undamaged.

Garage doors are particularly vulnerable, especially doublewide garage doors because of their long span and, frequently, lightweight materials. Reinforced garage door and track systems are available to help avoid that problem. Retrofit kits are also available to reinforce existing garage doors, but the retrofit kits do not provide the same level of protection as systems designed to be wind and impact-resistant. (*Source: Federal Alliance for Safe Homes – FLASH. www.flash.org.)*

B.4.8 Lightning Protection Systems

The purpose of a lightning protection system is to intercept lightning and safely direct its current to ground. If the system is properly designed, installed and maintained it can provide almost 100% protection to buildings.

The system for an ordinary structure includes at least air terminals (lightning rods), down conductors, and ground terminals. These three elements of the system must form a continuous conductive path for lightning current. Many systems of air terminals now may not even be connected to the building. They may be comprised of freestanding cables or towers above or next to the building.

National Fire Protection Association document NFPA 780, *Standard for the Installation of Lightning Protection Systems* describes lightning protection system installation requirements. NFPA 780 is available through www.nfpa.org/Codes/NFPA_Codes_and_Standards/List_of_NFPA_documents/NFPA_780.asp. Additional information on design and construction of lightning protection systems is available on www.montana.edu/wwwpb/pubs/mt8529ag.pdf.

B.4.9 Surge and Spike Protection

The average home has 2,200 or more power surges annually, 60% of which are generated within the home. Most surges are caused by motors starting in air conditioners, garage doors, refrigerators and other major appliances. Electronic appliances can be damaged or destroyed by over-voltage surges or spikes.

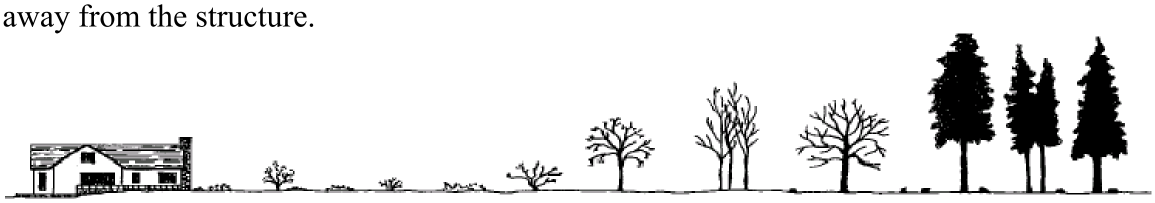
Whole house surge protectors offer the first line of defense against high-energy, high-voltage surges. These devices thwart the energy of the initial surge and reduce it before it reaches electrical appliances. In many cases this level of protection is enough to protect the home. Surge protectors should be sufficient to also provide "spike protection," which can defend against the extremely high spiking voltage created by lightning strikes. Many surge protectors, while effective against routine voltage fluctuations, may not defend against high level spikes.

Surge protection devices connected directly to appliances offer the second line of defense. They are the only defense against surges within the home as when, for example, a large appliance kicks in. The combination of whole house and point-of-use surge protection provides the best possible protection.

For more information on whole house and point-of-use surge protectors, refer to www.howstuffworks.com/surge-protector.htm.

B.4.10 Landscaping for Wildfire Prevention

The chance of losing property due to wildfire can be reduced using fire prevention landscaping techniques. The amount of cleared space around a home improves its ability to survive a wildfire. A structure is more likely to survive when grasses, trees and other common fuels are removed, reduced or modified to reduce a fire's intensity and keep it away from the structure.



Zone 1: Moist and trim. Turf, perennials, groundcovers and annuals form a greenbelt that is regularly watered and maintained. Shrubs and trees are located at least 10 feet from the house.

Zone 2: Low and sparse. Slow growing, drought-tolerant shrubs and groundcovers keep fire near ground level. Native vegetation can be retained if it is low growing, does not accumulate dry, flammable material and is irrigated.

Zone 3: High and clean. Native trees and shrubs are thinned and dry debris on the ground is removed. Overgrowth is removed and trees are pruned every 3-5 years.

Zone 4: Natural area. Native plants are selectively thinned. Highly flammable vegetation is replaced with less fire-prone species.

For comprehensive lists of steps to protect your home before, during and after a wildfire, see www.fema.gov/pdf/library/98surst_wf.pdf or www.cnr.uidaho.edu/extforest/F3.pdf.

B.4.11 Conclusions

1. Acquisition and relocation of property is the most effective for property protection in the case of hazards that are expected to occur repeatedly in the same locations. Acquisition followed by demolition is preferable.
2. Other methods of property protection for flooding include raising building elevations and building berms and floodwalls.
3. Building modifications are also appropriate for some hazards.
4. Property insurance has the advantage of protecting the property without human intervention.
5. The City can help in reducing losses from natural hazards by providing financial assistance, having an acquisition program, and other incentives.

B.4.12 Recommendations

Refer to *Chapter 6: Action Plan*, for a complete listing of all recommended mitigation measures by hazard and priority.

B.5 Emergency Services

Emergency services measures protect people during and after a hazard event. Locally, Tulsa Area Emergency Management coordinates these measures in cooperation with emergency management in nearby counties and communities. Measures include preparedness, threat recognition, warning, response, critical facilities protection, and post-disaster recovery and mitigation.

B.5.1 Threat Recognition

Threat recognition is the key. The first step in responding to a flood, tornado, storm or other natural hazard is being aware that one is coming. Without a proper and timely threat recognition system, adequate warnings cannot be disseminated.

Emergency Alert System (EAS)

Using digital technology to distribute messages to radio, television and cable systems, the EAS provides state and local officials with the ability to send out emergency information targeted to a specific area. The information can be sent electronically through broadcast stations and cable systems even if those facilities are unattended.

Floods

A flood threat recognition system provides early warning to emergency managers. A good system will predict the time and height of the flood crest. This can be done by measuring rainfall, soil moisture, and stream flows upstream of the community and calculating the subsequent flood levels.

Areas subject to flooding should be clearly posted

On larger rivers the National Weather Service hydrology office in Tulsa does the measuring and calculating, which is in the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA). Flood threat predictions are disseminated on the NOAA Weather Wire or NOAA Weather Radio. NOAA Weather Radio is considered by the federal government to be the official source for weather information.

The National Weather Service issues notices to the public, using two levels of notification:

Flood watch: conditions are right for flooding

Flood warning: a flood has started or is expected to occur

On smaller rivers, local rainfall and river gages are needed to establish a flood threat recognition system. The National Weather Service may issue a "flash flood watch." This means the amount of rain expected will cause ponding and other flooding on small streams and depressions. These events are sometimes so localized and rapid that a "flash flood warning" may not be issued, especially if no gages or other remote threat recognition equipment is available.

Meteorological Hazards

The National Weather Service is the prime agency for detecting meteorological threats, such as tornadoes, thunderstorms, and winter storms. As with floods, the Federal agency can only look at the large scale, e.g., whether conditions are appropriate for formation of a tornado. For tornadoes and thunderstorms, the county or municipalities can provide more site-specific and timely recognition by sending out spotters to watch the skies when the Weather Service issues a watch or warning.

NOAA All-Hazard Radios

The National Oceanographic and Atmospheric Administration (the parent agency for the National Weather Service) maintains a nationwide network of radio stations broadcasting continuous weather information direct from regional National Weather Service offices. The NWS broadcasts warnings, watches, forecasts, Amber Alerts and other hazard and safety information 24 hours a day. Post-event information is also broadcast for natural hazards (such as tornados and earthquakes) and environmental hazards (such as chemical releases or oil spills).

These broadcasts can be received by any radio capable of receiving the Weather Service frequency. NOAA All Hazard Radios have the additional advantage of being activated by a pre-broadcast signal transmitted by the NWS, coming off standby and sounding an alert tone loud enough to wake sleeping individuals before transmitting the warning message. NOAA Weather Radio receivers can be purchased at many retail stores that sell electronic merchandise. Typical cost of a residential grade NOAA Weather Radio is between $20 and $200.

For more information on NOAA Weather Radios, see www.nws.noaa.gov/nwr/.

B.5.2 Warning

After the threat recognition system tells the CEMA that a flood or other hazard is coming, the next step is to notify the public and staff of other agencies and critical facilities. The earlier and the more specific the warning, the greater the number of people who can implement protection measures. The following are some of the more common warning methods:

Broadcast announcements & EAS	Good tools for delivering an alert to a wide coverage area but not well-suited for delivering "actionable" information to specific population segments. For an EAS to be effective, it is essential for the target audience to be tuned in to a regional station. Actual practice shows this is not always the case, particularly late at night when the general population is asleep.

Door-to-door Notification	Door-to-door notification would be an ideal way to communicate with specific individuals or neighborhoods. However, efficiency is impacted by the number of addresses to be contacted, the number of personnel available to "walk the streets", and the amount of time available prior to the event (i.e., evacuation). It is highly unlikely that sufficient public safety personnel would be available to effectively provide such door-to-door notification services. Door-to-door also has the potential of putting first responders in harm's way.
Other Communications Devices	There are many communication devices available that may be able to receive emergency notifications – faxes, pagers, PDAs and cell phones. However, as with Weather Alert Radio, their level of penetration throughout the population is too low to ensure effective delivery. Selecting distinct population segments based on geography with such devices is also a problem.
Outdoor warning sirens	Sirens can be effective in their ability to alert people within hearing distance that a crisis or emergency situation may exist. Outdoor warning sirens and public address systems are commonly located in densely populated urban settings, but are not as useful in rural areas. Sirens are intended to alert the public to implement some pre-determined action (i.e., tune to radio and television for specific information on a hazard). However the public generally has no awareness of the need to do so and often will ignore sirens thinking they are a "test" unless they see the hazard approaching, which is often then too late to take appropriate action. In addition, in many areas, sirens are used only for specific emergencies, such as floods or tornadoes, and are of little use in helping public safety personnel alert residents to other events/crises.
NOAA Weather Radio	Weather Alert Radio, while an invaluable tool, has limited applicability. Lacking proper feedback, public safety and emergency management officials have no way of being sure that everyone in their jurisdiction can be reached with such announcements because, similar to broadcast announcements, the audience must have a NOAA radio, and be tuned in.
Sirens on public safety vehicles	These have many of the same drawbacks as both door-to-door notification and outdoor warning sirens. Emergency vehicle sirens do not provide "actionable" information on how to respond. In addition, crucial emergency service personnel may be tied up when their services are more urgently needed for response.

Adapted from *NENA Minimum Standards for Emergency Telephone Notification Systems, NENA 56-003, June 12, 2004*

Multiple or redundant systems are the most effective, since people do not hear one warning, they may still get the message from another part of the system. Each has advantages and disadvantages. Outdoor warning sirens can reach the most people quickly (except those around loud noise, such as at a factory or during a thunderstorm), but they do not explain what hazard is coming and cannot be sounded unless a timely means of threat recognition exists. Radio and TV provide a lot of information, but people have to know to turn them on. Telephone trees are fast, but can be expensive and do not work when phones lines are down.

Just as important as issuing a warning is telling people what to do. A warning program should have a public information aspect. People need to know the difference between a tornado warning (when they should seek shelter in a basement) and a flood warning (when they should stay out of basements).

B.5.3 9-1-1 and 2-1-1

Some communities have expanded their basic 9-1-1 location identification telephone service to include features such as "enhanced 9-1-1" registering name, address, and a description of the building/site. Additionally, non-emergency 2-1-1 service can be used to have people call to get information, such as locations of cooling shelters during a heat wave. For information on coverage areas and contact information for area 2-1-1 systems, see www.211oklahoma.org. For Tulsa, *HelpLine 2-1-1*, in Tulsa, at 918-836-4357, operates 2-1-1.

B.5.4 Emergency Telephone Notification Systems (ETNS)

It has become more common to use a "Emergency Telephone Notification System" (frequently referred to as reverse 9-1-1) with which a community can send out a mass telephone announcement to targeted numbers in the 9-1-1 system, effectively supplementing a community's other warning systems. An effective ETNS can offer certain advantages over other systems:

- ETNS systems provide the ability to precisely target populations in specific geographic locations better than existing alternatives, particularly when ETNS systems were integrated with geographic information systems (GIS) maps commonly used by 9-1-1 systems;
- The telephone, more than any other communications medium, allows officials to deliver specific actionable information that lets those in harm's way know exactly what to do, what to expect, or what to look for;
- The telephone is always on, providing the opportunity to reach nearly everyone in a target area either live or through voicemail.
- Many systems also offer the option of allowing people to call in and retrieve the same message or an updated one. This can reduce the subsequent number of calls to 9-1-1 from people who did not fully understand the message the first time. (*Source: NENA Minimum Standards for Emergency Telephone Notification Systems, NENA 56-003, June 12, 2004*)

Tahlequah is currently exploring the implementation of a Community Emergency Notification System.

B.5.5 Response

The protection of life and property is the foremost important task of emergency responders. Concurrent with threat recognition and issuing warnings, a community should respond with actions that can prevent or reduce damage and injuries. Typical actions and responding parties include the following:

- Activating the emergency operations room (emergency management)
- Closing streets or bridges (police or public works)

- Shutting off power to threatened areas (utility company)
- Holding children at school/releasing children from school (school district)
- Passing out sand and sandbags (public works)
- Ordering an evacuation (mayor)
- Opening evacuation shelters (Red Cross)
- Monitoring water levels (engineering)
- Security and other protection measures (police)

In the event of an emergency, responders must make an organized effort to minimize the impacts of the incident.

An emergency action plan ensures that all bases are covered and that the response activities are appropriate for the expected threat. These plans are developed in coordination with the agencies or offices that are given various responsibilities.

Emergency response plans should be updated annually to keep contact names and telephone numbers current and to make sure that supplies and equipment that will be needed are still available. They should be critiqued and revised after disasters and exercises to take advantage of the lessons learned and changing conditions. The end result is a coordinated effort implemented by people who have experience working together so that available resources will be used in the most efficient manner.

B.5.6 Emergency Operations Plan (EOP)

An EOP develops a comprehensive (multi-use) emergency management program which seeks to mitigate the effects of a hazard, to prepare for measures to be taken which will preserve life and minimize damage, to respond during emergencies and provide necessary assistance and to establish a recovery system in order to return communities to their normal state of affairs. The plan defines who does what, when, where and how in order to mitigate, prepare for, respond to and recover from the effects of war, natural disasters, technological accidents and other major incidents / hazards.

The *State and Local Guide (SLG) 101: Guide for All-Hazard Emergency Operations Planning* is available from FEMA. The guide provides ideas and advice to state and local emergency managers in their efforts to develop and maintain an EOP. The guide can be ordered directly from FEMA or downloaded from http://www.fema.gov/rrr/gaheop.shtm.

Funding for creating or updating an EOP is available from FEMA. For information on how to obtain funding contact the Oklahoma Office of Homeland Security or go to http://www.youroklahoma.com/homelandsecurity/.

The State of Oklahoma's Emergency Operations Plan is published on www.ok.gov/OEM/Programs_&_Services/Planning/State_Emergency_Operations_Plan_(EOP)/.

B.5.7 Incident Command System (ICS)

The Incident Command System is the model tool for the command, control and coordination of resources at the scene of an emergency. It is a management tool of procedures for organizing personnel, facilities, equipment and communications. ICS is based upon basic management skills managers and leaders already know: planning, directing, organizing, coordinating, communicating, delegating and evaluating.

Continuity of Operations (COOP) planning should be addressed in the EOP. COOP ensures the essential functions of an organization, including government, can continue to operate during and after an emergency incident. An incident may prevent access to normally operating systems, such as physical plant, data or communication networks, or transportation. Government, business, other organizations, and families should be encouraged to prepare by regularly backing up computer drives, copying essential files, and storing these items in a separate location.

ICS is not a means to wrestle control or authority away from agencies or departments, a way to subvert the normal chain of command within a department or agency, nor is it always managed by the fire department, too big for small everyday events or restricted to use by government agencies and departments. ICS is an adaptable methodology suitable for emergency management as well as many other categories. If leadership is essential for the success of an event or a response, ICS is the supporting foundation for successfully managing that event.

The Incident Command System is built around five major management activities. These activities are:

- Command – sets objects and priorities and has overall responsibility at the incident or event.
- Operations – conducts tactical operations to carry out the plan and directs resources.
- Planning – develops the action plan to accomplish objectives and collects and evaluates information.
- Logistics – provides resources and services to support incident needs.
- Finance / Administration – monitors costs, provides accounting, reports time and cost analysis.

The system can grow or shrink to meet changing needs. This makes it very cost-effective and efficient. The system can be applied to a wide variety of situations such as fires, multi-jurisdiction and multi-agency disasters, hazardous material spills and recovery incidents, pest eradication programs and state or local natural hazards management.

For a detailed description of ICS, a diagram of ICS organization, or checklists of duties for each management activity and links to other resources see http://www.911dispatch.com/ics/ics_main.html.

B.5.8 Mutual Aid / Interagency Agreements

Local governments should establish mutual aid agreements for utility and communications systems, including 9-1-1. Mutual aid or interagency agreements have value for preventing or responding to other hazard or emergency situations, as fire and police departments often do.

B.5.9 CERT (Community Emergency Response Team)

After a major disaster, local emergency teams quickly become overwhelmed. CERT is designed to have trained groups of citizens in every neighborhood and business ready to assist first responders (police, firefighters and EMSA) during an emergency.

CERT programs train and equip citizens in neighborhoods and businesses enabling them to "self-activate" immediately after a disaster. CERT teams are trained in:

- Disaster preparedness.
- Light fire and suppression.
- Light search and rescue.
- Basic medical care.

FEMA grants have been given to states for funding CERT programs or expanding existing teams. For information about the Oklahoma grant see www.fema.gov/news/newsrelease.fema?id=3155.

For more information on the CERT program talk to your local emergency management official or visit training.fema.gov/emiweb/CERT/.

B.5.10 Debris Management

The tornados of May 3, 1999 left an estimated 500,000 cubic yards of debris. Debris in the aftermath of a disaster poses significant health and safety risks. Debris can include fuel containers, chemicals, appliances and explosives.

Two key considerations regarding debris management are the need for rapid removal and protection of the public health and environment. Before a disaster strikes communities should set up staging area(s) where citizens and cleanup crews can take debris prior to final disposal.

Community members can participate in debris control by securing debris, yard items, or stored objects that my otherwise be swept away, damaged, or pose a hazard if floodwaters would pick them up and carry them away. Additionally, a community can pass and enforce an ordinance regulating dumping.

For the Oklahoma Department of Environmental Quality's *Guidelines for Debris Management* see document www.deq.state.ok.us/mainlinks/storms/Options%20for%20Disposal%20Guidelines.doc.

B.5.11 Critical Facilities Protection

"Critical facilities" are previously discussed in Section 2.3.5. Generally, they fall into three categories:

- Buildings or locations vital to the response and recovery effort, such as police and fire stations and telephone exchanges;
- Buildings or locations that, if damaged, would create secondary disasters, such as hazardous materials or utility facilities, or water treatment plants; and
- Locations that would require extraordinary response or preparedness measures, such as hospitals, retirement homes, or childcare facilities.

In addition, since September 11th, FEMA has also included financial institutions as critical facilities, because of the potential devastating effect on the community infrastructure upon their loss.

Protecting critical facilities during a disaster is the responsibility of the facility owner or operator. However, if they are not prepared for an emergency, the rest of the community could be impacted. If a critical facility is damaged, workers and resources may be unnecessarily drawn away from other disaster response efforts. If the owner or operator adequately prepares such a facility, it will be better able to support the community's emergency response efforts.

Most critical facilities have full-time professional managers or staff who are responsible for the facility during a disaster. These people often have their own emergency response plans. Many facilities would benefit from early disaster warning, disaster response planning, and coordination with community disaster response efforts.

Schools are critical facilities not only because of the special population they accommodate, but because they are often identified as shelter sites for a community. Processes and procedures can be developed to determine mitigation priorities incorporated into capital improvement plans that will ensure these buildings function after an event.

Tahlequah has taken the steps to ensure that there are adequate backup facilities for the Emergency Operations Center the 9-1-1 Center, both of which are critical facilities. In addition, fire extinguishers have been strategically placed and properly maintained in all community facilities.

B.5.12 Site Emergency Plans

Communities can encourage development and testing of internal emergency plans and procedures, including continuity planning, by businesses and other organizations.

Communities should develop and test site emergency plans for schools, factories, office buildings, shopping malls, hospitals, correctional facilities, stadiums, recreation areas, and other similar facilities.

B.5.13 Post-Disaster Recovery and Mitigation

After a disaster, communities should undertake activities to protect public health and safety, facilitate recovery, and help people and property for the next disaster. Throughout the recovery phase, everyone wants to get “back to normal.” The problem is, “normal” means the way they were before the disaster. Measures needed include the following:

Recovery Actions

- Patrolling evacuated areas to prevent looting
- Providing safe drinking water
- Monitoring for diseases
- Vaccinating residents for tetanus
- Clearing streets
- Cleaning up debris and garbage
- Regulating reconstruction to ensure that it meets all code requirements, including the NFIP's substantial damage regulations

A firefighter searches through the remains of a hotel in Midwest City.
Oklahoman Staff Photo by Paul Hellstern

Mitigation Actions

- Conducting a public information effort to advise residents about mitigation measures they can incorporate into their reconstruction work
- Evaluating damaged public facilities to identify mitigation measures that can be included during repairs
- Acquiring substantially or repeatedly damaged properties from willing sellers
- Planning for long term mitigation activities
- Applying for post-disaster mitigation funds

Requiring permits, conducting inspections, and enforcing the NFIP substantial improvement/substantial damage regulations can be very difficult for local, understaffed overworked offices after a disaster. If these activities are not carried out properly, not only does the municipality miss a tremendous opportunity to redevelop or clear out a hazardous area, it may be violating its obligations under the NFIP.

B.5.14 StormReady Communities

StormReady, a program started in Oklahoma in 1999, helps arm America's communities with the communication and safety skills needed to save lives and property before and during an event. *StormReady* communities are better prepared to save lives from the onslaught of severe weather through better planning, education, and awareness.

StormReady has different guidelines for different sized communities. To be StormReady a community must:

- Establish a 24-hour warning point and emergency operations center.
- Have more than one way to receive severe weather warnings and forecasts and to alert the public.
- Create a system that monitors weather conditions locally.
- Promote the importance of public readiness through community seminars.

- Develop a formal hazardous weather plan, which includes training severe weather spotters and holding emergency exercises.

The economic investment in *StormReady* will depend on current assets. There is currently no grant funding for becoming *StormReady*. However, the Insurance Services Organization (ISO) may provide community rating points to *StormReady* communities. Those points may be applied toward lowering flood insurance rates.

For details on how to become *StormReady* and the requirements based on community size see http://www.stormready.noaa.gov/. Tahlequah is a StormReady Community.

B.5.15 Conclusions

1. Using solid, dependable threat recognition systems is first and foremost in emergency services.
2. Following a threat recognition, multiple or redundant warning systems and instructions for action are most effective in protecting citizens.
3. Good emergency response plans that are updated yearly ensure that well-trained and experienced people can quickly take the appropriate measures to protect citizens and property.
4. To ensure effective emergency response, critical facilities protection must be part of the plan.
5. Post-disaster recovery activities include providing neighborhood security, safe drinking water, appropriate vaccinations, and cleanup and regulated reconstruction.

B.5.16 Recommendations

Refer to *Chapter 6: Action Plan and Mitigation Measures,* Table 6–1, for a complete listing of all recommended mitigation measures by hazard and priority.

B.6 Natural Resource Protection

Natural resource protection activities are generally aimed at preserving and restoring the natural and beneficial uses of natural areas. In doing so, these activities enable the beneficial functions of floodplains and drainageways to be better realized. These natural functions include:

Wetlands are a valued resource to ecosystems and should be protected.

- Storage of floodwaters
- Absorption of flood energy
- Reduction of flood scour
- Infiltration and aquifer/groundwater recharge
- Removal/filtration of excess nutrients, pollutants, and sediments from floodwaters
- Habitat for flora and fauna
- Recreation and aesthetic opportunities, and
- Opportunities for off-street hiking and biking trails

This Section reviews natural resource protection activities that protect natural areas and mitigate damage from other hazards. Integrating these activities into the hazards mitigation program will not only reduce the City's susceptibility to flood damage, but will also improve the overall environment.

B.6.1 Wetland Protection

Wetlands are often found in floodplains and depressional areas of a watershed. Many wetlands receive and store floodwaters, thus slowing and reducing downstream flows. They also serve as a natural filter, which helps to improve water quality, and provide habitat for many species of fish, wildlife, and plants.

Wetlands

- Store large amounts of floodwaters
- Reduce flood velocities and erosion
- Filter water, making it cleaner for those downstream
- Provide habitat for species that cannot live or breed anywhere else

Wetlands are regulated by the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency under Section 404 of the Clean Water Act. Before a "404" permit is issued, the plans are reviewed by several agencies, including the Corps and the U.S. Fish and Wildlife Service. Each of these agencies must sign off on individual permits. There are also nationwide permits that allow small projects that meet certain criteria to proceed without individual permits.

B.6.2 Erosion and Sedimentation Control

Farmlands and construction sites typically contain large areas of bare exposed soil. Surface water runoff can erode soil from these sites, sending sediment into downstream waterways. Sediment tends to settle where the river slows down and loses power, such as when it enters a lake or a wetland.

Construction projects, which can expose large areas to erosion, should be closely monitored.

Sedimentation will gradually fill in channels and lakes, reducing their ability to carry or store floodwaters. When channels are constricted and flooding cannot deposit sediment in the bottomlands, even more is left in the channels. The result is either clogged streams or increased dredging costs.

Not only are the drainage channels less able to do their job, but also the sediment in the water reduces light, oxygen, and water quality and often brings chemicals, heavy metals and other pollutants. Sediment has been identified as the nation's number one nonpoint source pollutant for aquatic life.

Practices to reduce erosion and sedimentation have two principal components:

1. Minimize erosion with vegetation and
2. Capture sediment before it leaves the site.

Lack of vegetation along drainage channels promotes erosion

Slowing surface water runoff on the way to a drainage channel increases infiltration into the soil and reduces the volume of topsoil eroded from the site. Runoff can be slowed down by measures such as terraces, contour strip farming, no-till farm practices, sediment fences, hay or straw bales (as illustrated), constructed wetlands, and impoundments (e.g., sediment basins and farm ponds).

Erosion and sedimentation control regulations mandate that these types of practices be incorporated into construction plans. They are usually oriented toward construction sites rather than farms. The most common approach is to require applicants for permits to submit an erosion and sediment control plan for the construction project. This allows the applicant to determine the best practices for the site.

One tried and true approach is to have the contractor design the detention basins with extra capacity. They are built first, so they detain runoff during construction and act as sediment catch basins. The extra capacity collects the sediment that comes with the runoff until the site is planted and erosion is reduced.

B.6.3 River Restoration

There is a growing movement that has several names, such as “stream conservation,” “bioengineering” or “riparian corridor restoration.” The objective of these approaches is to return streams, stream banks and adjacent land to a more natural condition, including the natural meanders. Another term is “ecological restoration” which restores native indigenous plants and animals to an area.

A key component of these efforts is using appropriate native plantings along the banks that resist erosion. This may involve “retrofitting” the shoreline with willow cuttings, wetland plants, and/or rolls of landscape material covered with a natural fabric that decomposes after the banks are stabilized with plant roots.

Retrofitting streambanks with willow cuttings and geotextiles can be more cost effective than riprap or concrete-lined floodways.

Studies have shown that after establishing the right vegetation, long-term maintenance costs are lower than if the banks were concrete. The Natural Resources Conservation Service estimates that over a ten-year period, the combined costs of installation and maintenance of a natural landscape may be one-fifth of the cost for conventional landscape maintenance, e.g., mowing turf grass.

B.6.4 Best Management Practices

Point source pollutants come from pipes such as the outfall of a municipal wastewater treatment plant. State and federal water quality laws have reduced the pollutants that come from these facilities.

Non-point source pollutants come from non-specific locations and are harder to regulate. Examples are lawn fertilizers, pesticides, and other farm chemicals, animal wastes, oils from street surfaces and industrial areas, and sediment from agriculture, construction, mining and forestry. These pollutants are washed off the ground’s surface by stormwater and flushed into receiving storm sewers, ditches and streams.

Best management practices (BMPs) are measures that reduce nonpoint source pollutants that enter the waterways. BMPs can be implemented during construction and as part of a project’s design to permanently address nonpoint source pollutants.

There are three general categories of BMPs:

1. **Avoidance**—Setting construction projects back from the stream.
2. **Reduction**—Preventing runoff that conveys sediment and other water-borne pollutants, such as planting proper vegetation and conservation tillage.
3. **Cleansing**—Stopping pollutants after they are en route to a stream, such as using grass drainageways that filter the water and retention and detention basins that let pollutants settle to the bottom before they are drained.

In addition to improving water quality, BMPs can have flood related benefits. By managing runoff, they can attenuate flows and reduce the peaks after a storm. Combining water quality and water quantity measures can result in more efficient multi-purpose stormwater facilities.

Because of the need to clean up our rivers and lakes, there are several laws mandating the use of best management practices for new developments and various land uses. The furthest reaching one is the U.S. Environmental Protection Agency's National Pollutant Discharge Elimination System (NPDES) requirements.

B.6.5 Dumping Regulations

NPDES addresses liquid pollutants. Dumping regulations address solid matter, such as shopping carts, appliances and landscape waste that can be accidentally or intentionally thrown into channels or wetlands. Such materials may not pollute the water, but they can obstruct even low flows and reduce the channels' and wetlands' ability to convey or clean stormwater.

Many cities have nuisance ordinances that prohibit dumping garbage or other "objectionable waste" on public or private property. Waterway dumping regulations need to also apply to "non-objectionable" materials, such as grass clippings or tree branches which can kill ground cover or cause obstructions in channels.

Many people do not realize the consequences of their actions. They may, for example, fill in the ditch in their front yard not realizing that it is needed to drain street runoff. They may not understand how regrading their yard, filling a wetland, or discarding leaves or branches in a watercourse can cause a problem to themselves and others. Therefore, a dumping enforcement program should include public information materials that explain the reasons for the rules as well as the penalties.

Regular inspections to catch violations also should be scheduled. Finding dumped materials is easy; locating the source of the refuse is hard. Usually the owner of property adjacent to a stream is responsible for keeping the stream clean. This may not be fair for sites near bridges and other public access points.

B.6.6 Conclusions

1. Wetlands play an important role in natural course of flood control, preservation of water quality, and wildlife habitation, making a strong case for their protection.
2. Erosion can be reduced by use of vegetation. Sedimentation should be captured before it leaves its original location with oversized detention basins.
3. Vegetation used along riverbanks works more effectively in river maintenance than using banks made of concrete.
4. Nonpoint source pollutants are best managed by keeping construction projects away from streams, reducing sediment runoff, and using grass drainageways and detention basins for filtration.
5. Dumping regulations need to be communicated to the public and enforced.
6. The establishment and maintenance of wildlife habitat and natural ecosystems should be an important aspect of any drainage system program the City may implement in

regards to floodplain management. This can be developed in cooperation with the Oklahoma Department of Wildlife Conservation, allowing aquatic plants and wildlife to be established in stormwater detention ponds and floodways.

B.6.7 Recommendations

Refer to *Chapter 6: Action Plan*, for a complete listing of all recommended mitigation measures by hazard and priority.

City of Tulsa Hazard Mitigation
Staff Meeting
September 12, 2007, 3:00 P.M.
City Hall, Room 403

AGENDA

Report, discuss, and take action, if any, on the following:

Reports

A. Non-Structural Inventory List Status Update – Ron Flanagan

B. Hazard Mitigation Plan (Phase 2) Update – Brent Stout

C. SDHMAB Responsibilities and Hazards – Brent Stout

1. Status of Mitigation Measures (Monitor and Update) – Ron Flanagan
2. Multi-Hazard Mitigation Plan Update & Historic Preservation Annex – Ron Flanagan
3. HMGP Current and Future Disaster Funding – Ron Flanagan
4. Status of MDP and RL applications for HMGP – Ron Flanagan
5. Future projects for HMGP NOIs – Ron Flanagan
6. Reverse 911 Status Report – Brent Stout
7. Emergency Management Performance Grant Program – Brent Stout
8. New Business
9. Next Meeting, Wednesday, October 10th, 3:00 - 5:00, Room 403 City Hall
10. Adjourn

AGENDA

Stormwater Drainage Advisory Board

3:00 P.M., Tuesday, September 18, 2007

Emergency Operations Center, 600 Civic Center, Tulsa, OK 74103

Gary Cheatham, Chair
Judith Finn, Vice-Chair
Sandy Cox, Secretary
Kyle Brierly, Member
Raymond "Bud" Frye, Member

--

Corri Cousins, Asst. Secretary & Records Custodian
Jack Page, OWRB Accredited Floodplain Administrator
Mark Swiney, Board Counsel

Call to Order & Roll Call .... Chair

I. ADMINISTRATIVE MATTERS

- **A. Approval/Correction of Minutes: 08/21/07 .... Chair**
- **B. Changes to Ordinance .... Chair**

II. REPORTS

- **A. Fee-in-Lieu-of On-Site Detention Fee Review .... Ken Hill**
- **B. Director's Report .... Charles Hardt**
  - **1) Monthly Financial Report .... Alan Rowland**
  - **2) Proposed Fund Transfers .... Alan Rowland**
  - **3) Capital Projects Status Report .... Deborah Stowers**
- **C. Floodplain Administrator's Report .... Jack Page**
  - **1) Permit Center Report .... Harold Tohlen**
- **D. Stormwater Criteria Manual Update .... Brent Stout**
- **E. CRS Recertification .... Ron Flanagan**
- **F. Hazard Mitigation Report .... Brent Stout**
  - **1) Natural Hazards Review .... Ron Flanagan**
  - **2) Hazard Mitigation Action Plan Review .... Ron Flanagan**

III. APPEALS & VARIANCES .... Chair
None Anticipated

IV. NEW BUSINESS
Please Note: The OMA limits "new business" to only those matters not known about, or which could not have been reasonably foreseen, prior to the posting of the Agenda.

V. FUTURE AGENDA ITEMS

- **A. Proposed Use of 1986 Flood Elevations .... Jack Page**

VI. PUBLIC COMMENTS
Although the OMA limits Board action to those matters specifically listed on this Agenda, the Board solicits and encourages public comments and ideas.

VII. MEETING CLOSURE .... Chair

VIII. NEXT MEETING .... September 18, 2007

Should you wish to attend and participate in the Board's meeting but require SPECIAL ACCOMMODATIONS pursuant to the AMERICANS WITH DISABILITIES ACT, please contact the City's Stormwater Design Staff by calling 918/596-9498 as soon as possible but at least 24 hours prior to the meeting so that we can meet your needs.

City of Tulsa Hazard Mitigation
Staff Meeting
October 10 2007, 2:30 P.M.
City Hall, Room 532

AGENDA

Report, discuss, and take action, if any, on the following:

Reports

A. HMGP Acquisition Candidates Update – Ron Flanagan

B. Non-Structural Inventory List Status Update – Ron Flanagan

C. SDHMAB Hazard Mitigation Briefing – Brent Stout

D. Hazards and Mitigation Measures for SDHMB – Ron Flanagan

1. Multi-Hazard Mitigation Plan Update & Historic Preservation Annex – Ron Flanagan
2. Hazard Mitigation Funding Availability – Ron Flanagan
3. Status of HMGP Applications for MDP Updates and RL – Ron Flanagan
4. Future projects for HMGP NOIs – Ron Flanagan
5. Tulsa County Hazard Mitigation Plan Status – Ron Flanagan
6. New Business
7. Future Agenda Items
    - Reverse 911
    - TAEMA Participation in Hazard Mitigation
8. Next Meeting, Wednesday, November 14th, 3:00 - 5:00, Room 532 City Hall
9. Adjourn

AGENDA

Stormwater Drainage Advisory Board

3:00 P.M., Tuesday, October 16, 2007

200 Civic Center, Room 1102, Tulsa, OK 74103

Gary Cheatham, Chair
Judith Finn, Vice-Chair
Sandy Cox, Secretary
Kyle Brierly, Member
Raymond "Bud" Frye, Member

--

Corri Cousins, Asst. Secretary & Records Custodian
Jack Page, OWRB Accredited Floodplain Administrator
Mark Swiney, Board Counsel

Call to Order & Roll Call .... Chair

I. ADMINISTRATIVE MATTERS

- **A. Approval/Correction of Minutes: 09/18/07 .... Chair**
- **B. Changes to Ordinance .... Chair**

II. REPORTS

- **A. Fee-in-Lieu of On-Site Detention Fee Review .... Alan Rowland**
- **B. Director's Report .... Charles Hardt**
  - **1) Monthly Financial Report .... Alan Rowland**
  - **2) Proposed Fund Transfers .... Alan Rowland**
  - **3) Capital Projects Status Report .... Deborah Stowers**
- **C. Floodplain Administrator's Report .... Jack Page**
  - **1) Permit Center Report .... Harold Tohlen**
- **D. Stormwater Criteria Manual Update .... Mark Swift**
- **E. Hazard Mitigation Report .... Brent Stout**
  - **1) Natural Hazards Review .... Ron Flanagan**
  - **2) Hazard Mitigation Action Plan Review .... Ron Flanagan**
  - **3) Tulsa County Hazard Mitigation .... Ron Flanagan**

III. APPEALS & VARIANCES .... Chair

None Anticipated

IV. NEW BUSINESS

Please Note: The OMA limits "new business" to only those matters not known about, or which could not have been reasonably foreseen, prior to the posting of the Agenda.

V. BOARD ACTION ITEMS

- **A. West Tulsa Maintenance Report .... Deborah Stowers**

VI. FUTURE AGENDA ITEMS

- **A. Proposed Use of 1986 Flood Elevations .... Jack Page**

VII. PUBLIC COMMENTS

Although the OMA limits Board action to those matters specifically listed on this Agenda, the Board solicits and encourages public comments and ideas.

VIII. MEETING CLOSURE .... Chair

IX. NEXT MEETING .... November 19, 2007

Should you wish to attend and participate in the Board's meeting but require SPECIAL ACCOMMODATIONS pursuant to the AMERICANS WITH DISABILITIES ACT, please contact the City's Stormwater Design Staff by calling 918/596-9498 as soon as possible but at least 24 hours prior to the meeting so that we can meet your needs.

City of Tulsa Hazard Mitigation
Staff Meeting
November 14 2007, 3:00 P.M.
City Hall, Room 532

AGENDA

Report, discuss, and take action, if any, on the following:

Reports

A. HMGP Acquisition Candidates Update – Ron Flanagan

B. Non-Structural Inventory List Status Update – Ron Flanagan

C. SDHMAB Hazard Mitigation Briefing – Brent Stout

D. Hazards and Mitigation Measures for SDHMB – Ron Flanagan

1. Multi-Hazard Mitigation Plan Update & Historic Preservation Annex – Ron Flanagan
2. Hazard Mitigation Funding Availability – Ron Flanagan
3. Status of HMGP Applications for MDP Updates and RL – Ron Flanagan
4. Future projects for HMGP NOIs – Ron Flanagan
5. Tulsa County Hazard Mitigation Plan Status – Ron Flanagan
6. New Business
7. Future Agenda Items
    - Reverse 911
    - TAEMA Participation in Hazard Mitigation
8. Next Meeting, Wednesday, December 12th, 3:00 - 5:00, Room 532 City Hall
9. Adjourn

AGENDA

Stormwater Drainage Advisory Board

3:00 P.M., Tuesday, November 20, 2007

200 Civic Center, Room 1102, Tulsa, OK 74103

Gary Cheatham, Chair
Judith Finn, Vice-Chair
Sandy Cox, Secretary
Kyle Brierly, Member
Raymond "Bud" Frye, Member

--

Corri Cousins, Asst. Secretary & Records Custodian
Jack Page, OWRB Accredited Floodplain Administrator
Mark Swiney, Board Counsel

Call to Order & Roll Call .... Chair

I. ADMINISTRATIVE MATTERS
- **A. Approval/Correction of Minutes: 10/16/07 .... Chair**
- **B. 2008 Meeting Schedule .... Chair**

II. REPORTS
- **A. Fee-in-Lieu of On-Site Detention Fee Review .... Deborah Stowers**
- **B. Director's Report .... Charles Hardt**
  - **1) Monthly Financial Report .... Alan Rowland**
  - **2) Proposed Fund Transfers .... Alan Rowland**
  - **3) Capital Projects Status Report .... Deborah Stowers**
- **C. Floodplain Administrator's Report .... Jack Page**
  - **1) Permit Center Report .... Harold Tohlen**
- **D. Stormwater Criteria Manual Update .... Mark Swift**
- **E. Hazard Mitigation Report .... Bill Robison**
  - **1) Natural Hazards Review .... Ron Flanagan**
  - **2) Hazard Mitigation Action Plan Review .... Ron Flanagan**

III. APPEALS & VARIANCES .... Chair
None Anticipated

IV. NEW BUSINESS
Please Note: The OMA limits "new business" to only those matters not known about, or which could not have been reasonably foreseen, prior to the posting of the Agenda.

V. BOARD ACTION ITEMS
- **A. West Tulsa Maintenance Report .... Deborah Stowers**

VI. FUTURE AGENDA ITEMS
- **A. Proposed Use of 1986 Flood Elevations .... Jack Page**

VII. PUBLIC COMMENTS
Although the OMA limits Board action to those matters specifically listed on this Agenda, the Board solicits and encourages public comments and ideas.

VIII. MEETING CLOSURE .... Chair

IX. NEXT MEETING .... December 18, 2007

Should you wish to attend and participate in the Board's meeting but require SPECIAL ACCOMMODATIONS pursuant to the AMERICANS WITH DISABILITIES ACT, please contact the City's Stormwater Design Staff by calling 918/596-9498 as soon as possible but at least 24 hours prior to the meeting so that we can meet your needs.

City of Tulsa Hazard Mitigation
Staff Meeting
December 17, 2007, 3:00 P.M.
City Hall, Room 532

AGENDA

Report, discuss, and take action, if any, on the following:

Reports

A. HMGP Acquisition Candidates Update – Ron Flanagan

B. Non-Structural Inventory List Status Update – Ron Flanagan

C. SDHMAB Hazard Mitigation Briefing – Brent Stout

D. Hazards and Mitigation Measures for SDHMB – Ron Flanagan

1. Multi-Hazard Mitigation Plan Update & Historic Preservation Annex – Ron Flanagan
2. Hazard Mitigation Funding Availability – Ron Flanagan
3. Status of HMGP Applications for MDP Updates and RL – Ron Flanagan
4. Future projects for HMGP NOIs – Ron Flanagan
5. Tulsa County Hazard Mitigation Plan Status – Ron Flanagan
6. New Business
7. Future Agenda Items
    - Reverse 911
    - TAEMA Participation in Hazard Mitigation
8. Next Meeting, Wednesday, December 12th, 3:00 - 5:00, Room 532 City Hall
9. Adjourn

AGENDA

Stormwater Drainage Advisory Board

3:00 P.M., Tuesday December 18, 2007

200 Civic Center, Room 1102, Tulsa, OK 74103

Gary Cheatham, Chair
Judith Finn, Vice-Chair
Sandy Cox, Secretary
Kyle Brierly, Member
Raymond "Bud" Frye, Member

--

Corri Cousins, Asst. Secretary & Records Custodian
Jack Page, OWRB Accredited Floodplain Administrator
Mark Swiney, Board Counsel

Call to Order & Roll Call Chair

I. ADMINISTRATIVE MATTERS

- **A. Approval/Correction of Minutes: 11/20/07.. Chair**
- **B. 2008 Meeting Schedule .... Chair**
- **C. Tulsa United Soccer Club Requests .... Mark Swiney**
  - **1) Alsuma & Bishop Lease Extensions .... Mark Swiney**
  - **2) Lighting Installation at Alsuma Detention Pond .... Mark Swiney**
  - **3) Public Works to be Managing Department at Alsuma Detention Pond .... Mark Swiney**

II. REPORTS

- **A. Fee-in-Lieu of On-Site Detention Fee Review ....Deborah Stowers**
- **B. Director's Report ....Charles Hardt**
  - **1) Monthly Financial Report..Alan Rowland**
  - **2) Proposed Fund Transfers...Alan Rowland**
  - **3) Capital Projects Status Report ....Deborah Stowers**
- **C. Floodplain Administrator's Report .... Jack Page**
  - **1) Permit Center Report .... Harold Tohlen**
- **D. Stormwater Criteria Manual Update ....Mark Swift**
- **E. Hazard Mitigation Report.. Bill Robison**
  - **1) Natural Hazards Review .... Ron Flanagan**

III. APPEALS & VARIANCES .... Chair

None Anticipated

IV. NEW BUSINESS

Please Note: The OMA limits "new business" to only those matters not known about, or which could not have been reasonably foreseen, prior to the posting of the Agenda.

V. BOARD ACTION ITEMS

- **A. West Tulsa Maintenance Report ....Deborah Stowers**

VI. FUTURE AGENDA ITEMS

- **A. Proposed Use of 1986 Flood Elevations .... Jack Page**

VII. PUBLIC COMMENTS

Although the OMA limits Board action to those matters specifically listed on this Agenda, the Board solicits and encourages public comments and ideas.

VIII. MEETING CLOSURE.. Chair

IX. NEXT MEETING .... January 22, 2008

Should you wish to attend and participate in the Board's meeting but require SPECIAL ACCOMMODATIONS pursuant to the AMERICANS WITH DISABILITIES ACT, please contact the City's Stormwater Design Staff by calling 918/596-9498 as soon as possible but at least 24 hours prior to the meeting so that we can meet your needs.

AGENDA

Stormwater Drainage and Hazard Mitigation Advisory Board

3:00 P.M., Tuesday, January 15, 2008

200 Civic Center, Room 1102, Tulsa, OK 74103

Call to Order & Roll Call .... Chair

I. ADMINISTRATIVE MATTERS

A. Approval/Correction of Minutes: 12/18/07 .... Chair

II. REPORTS

A. Fee-in-Lieu of On-Site Detention Fee Review .... Janet Meshek

1) Low-Impact Development .... Bill Robison

B. Director's Report .... Charles Hardt

1) Monthly Financial Report .... Alan Rowland

2) Proposed Fund Transfers .... Alan Rowland

3) Capital Projects Status Report .... Deborah Stowers

C. Floodplain Administrator's Report .... Jack Page

1) Permit Center Report .... Harold Tohlen

D. Stormwater Criteria Manual Update .... Mark Swift

E. Hazard Mitigation Report .... Bill Robison

1) Natural Hazards Review .... Ron Flanagan

2) Hazard Mitigation Action Plan Review .... Ron Flanagan

3) Hazard Mitigation Grant Availability .... Bill Robison

III. APPEALS & VARIANCES .... Chair

None Anticipated

IV. NEW BUSINESS

Please Note: The OMA limits "new business" to only those matters not known about, or which could not have been reasonably foreseen, prior to the posting of the Agenda.

V. BOARD ACTION ITEMS

A. West Tulsa Maintenance Report .... Deborah Stowers

VI. FUTURE AGENDA ITEMS

A. Proposed Use of 1986 Flood Elevations .... Jack Page

VII. PUBLIC COMMENTS

Although the OMA limits Board action to those matters specifically listed on this Agenda, the Board solicits and encourages public comments and ideas.

VIII. MEETING CLOSURE .... Chair

IX. NEXT MEETING .... February 19, 2008

Should you wish to attend and participate in the Board's meeting but require SPECIAL ACCOMMODATIONS pursuant to the AMERICANS WITH DISABILITIES ACT, please contact the City's Stormwater Design Staff by calling 918/596-9498 as soon as possible but at least 24 hours prior to the meeting so that we can meet your needs.

AGENDA

City of Tulsa
Hazard Mitigation Staff Meeting
February 13, 2008
PW Engineering Services
Room N-209

Report, discuss, and take action, if any, on the following:

Reports

A. HMGP Acquisition Candidates Update – Ron Flanagan

B. Non-Structural Inventory List Status Update – Ron Flanagan

C. SDHMAB Hazard Mitigation Briefing – Bill Robison

D. Hazards and Mitigation Measures for SDHMB – Ron Flanagan

1. Multi-Hazard Mitigation Plan Update & Historic Preservation Annex – Ron Flanagan

2. Hazard Mitigation Funding Availability – Ron Flanagan

3. Status of HMGP Applications for MDP Updates and RL – Ron Flanagan

4. Future projects for HMGP NOIs – Ron Flanagan

5. Tulsa County Hazard Mitigation Plan Status – Ron Flanagan

6. New Business

7. Future Agenda Items
    - Reverse 911
    - TAEMA Participation in Hazard Mitigation

8. Next Meeting, Wednesday, March 12, 2008, 2:30-5:00 p.m.
   PW Engineering Services, Conference Room 328

9. Adjourn

AGENDA

Stormwater Drainage and Hazard Mitigation Advisory Board

3:00 P.M., Tuesday, February 19, 2008

200 Civic Center, Room 1102, Tulsa, OK 74103

Gary Cheatham, Chair
Judith Finn, Vice-Chair
Vacant, Secretary
Kyle Brierly, Member
Raymond "Bud" Frye, Member
Ann Patton, Member

--

Corri Cousins, Asst. Secretary & Records Custodian
Jack Page, OWRB Accredited Floodplain Administrator
Mark Swiney, Board Counsel

Call to Order & Roll Call .... Chair

I. ADMINISTRATIVE MATTERS

- **A. Approval/Correction of Minutes: 1/22/2008 .... Chair**
- **B. Approval of 2008 Regulatory Floodplain Atlas .... Bill Robison**
- **C. Approval of Mayoral and City Staff Commendation .... Chair**

II. REPORTS

- **A. Historical Preservation Commission .... Amanda DeCort**
- **B. Fee-in-Lieu of On-Site Detention Fee Review .... Janet Meshek**
- **C. Director's Report .... Charles Hardt**
  - **1) Monthly Financial Report .... Alan Rowland**
  - **2) Proposed Fund Transfers .... Alan Rowland**
  - **3) Capital Projects Status Report .... Deborah Stowers**
- **D. Floodplain Administrator's Report .... Jack Page**
  - **1) Permit Center Report .... Harold Tohlen**
- **E. Stormwater Criteria Manual Update .... Mark Swift**
- **F. Hazard Mitigation Report .... Bill Robison**
  - **1) Natural Hazards Review .... Ron Flanagan**
  - **2) Hazard Mitigation Action Plan Review .... Ron Flanagan**
  - **3) Hazard Mitigation Grant Availability .... Bill Robison**

III. APPEALS & VARIANCES .... Chair
None Anticipated

IV. NEW BUSINESS
Please Note: The OMA limits "new business" to only those matters not known about, or which could not have been reasonably foreseen, prior to the posting of the Agenda.

V. FUTURE AGENDA ITEMS

- **A. Proposed Use of 1986 Flood Elevations .... Jack Page**

VI. PUBLIC COMMENTS
Although the OMA limits Board action to those matters specifically listed on this Agenda, the Board solicits and encourages public comments and ideas.

VII. MEETING CLOSURE .... Chair

VIII. NEXT MEETING .... March 18, 2008

Should you wish to attend and participate in the Board's meeting but require SPECIAL ACCOMMODATIONS pursuant to the AMERICANS WITH DISABILITIES ACT, please contact the City's Stormwater Design Staff by calling 918/596-9498 as soon as possible but at least 24 hours prior to the meeting so that we can meet your needs.

AGENDA

Stormwater Drainage and Hazard Mitigation Advisory Board

3:00 P.M., Tuesday, March 18, 2008

200 Civic Center, Room 1102, Tulsa, OK 74103

Gary Cheatham, Chair
Judith Finn, Vice-Chair
Vacant, Secretary
Kyle Brierly, Member
Raymond "Bud" Frye, Member
Ann Patton, Member

--

Corri Cousins, Asst. Secretary & Records Custodian
Jack Page, OWRB Accredited Floodplain Administrator
Mark Swiney, Board Counsel

Call to Order & Roll Call .... Chair

I. ADMINISTRATIVE MATTERS

- **A. Approval/Correction of Minutes: 2/19/2008....... Chair**
- **B. Approval of 2008 Osage County Flood Insurance Rate Map. Bill Robison**

II. REPORTS

- **A. Corps of Engineers Function Briefing .... Richard Bilinski**
- **B. Director's Report .... Charles Hardt**
  - **1) Monthly Financial Report .... Alan Rowland**
  - **2) Proposed Fund Transfers .... Alan Rowland**
  - **3) Capital Projects Status Report .... Deborah Stowers**
- **C. Floodplain Administrator's Report .... Jack Page**
  - **1) Permit Center Report .... Harold Tohlen**
- **D. Stormwater Criteria Manual Update .... Mark Swift**
- **E. Hazard Mitigation Report....... Bill Robison**
  - **1) Natural Hazards Review .... Ron Flanagan**
  - **2) Hazard Mitigation Action Plan Review .... Ron Flanagan**
  - **3) Hazard Mitigation Grant Availability .... Bill Robison**
  - **4) Proposed Use of 1986 Flood Elevations .... Bill Robison**

III. APPEALS & VARIANCES .... Chair
None Anticipated

IV. NEW BUSINESS
Please Note: The OMA limits "new business" to only those matters not known about, or which could not have been reasonably foreseen, prior to the posting of the Agenda.

V. FUTURE AGENDA ITEMS

VI. PUBLIC COMMENTS
Although the OMA limits Board action to those matters specifically listed on this Agenda, the Board solicits and encourages public comments and ideas.

VII. MEETING CLOSURE....... Chair

VIII. NEXT MEETING .... April 15, 2008

Should you wish to attend and participate in the Board's meeting but require SPECIAL ACCOMMODATIONS pursuant to the AMERICANS WITH DISABILITIES ACT, please contact the City's Stormwater Design Staff by calling 918/596-9498 as soon as possible but at least 24 hours prior to the meeting so that we can meet your needs.

AGENDA

Stormwater Drainage and Hazard Mitigation Advisory Board

3:00 P.M., Tuesday, April 15, 2008

200 Civic Center, Room 1102, Tulsa, OK 74103

Call to Order & Roll Call .... Chair

I. ADMINISTRATIVE MATTERS

A. Approval/Correction of Minutes: 3/18/2008 .... Chair

II. REPORTS

A. Director's Report .... Charles Hardt

1) Monthly Financial Report .... Alan Rowland

2) Proposed Fund Transfers .... Alan Rowland

3) Capital Projects Status Report .... Deborah Stowers

B. Floodplain Administrator's Report .... Jack Page

1) Permit Center Report .... Harold Tohlen

C. Stormwater Criteria Manual Update .... Mark Swift

D. Hazard Mitigation Report .... Bill Robison

1) Natural Hazards Review .... Ron Flanagan

2) Hazard Mitigation Action Plan Review .... Ron Flanagan

3) Hazard Mitigation Grant Availability .... Bill Robison

III. APPEALS & VARIANCES .... Chair

None Anticipated

IV. NEW BUSINESS

Please Note: The OMA limits "new business" to only those matters not known about, or which could not have been reasonably foreseen, prior to the posting of the Agenda.

V. FUTURE AGENDA ITEMS

VI. BOARD ACTION ITEMS

A. Funding for EOC Improvements .... Mike McCool

VII. PUBLIC COMMENTS

Although the OMA limits Board action to those matters specifically listed on this Agenda, the Board solicits and encourages public comments and ideas.

VIII. MEETING CLOSURE .... Chair

IX. NEXT MEETING .... May 20, 2008

Should you wish to attend and participate in the Board's meeting but require SPECIAL ACCOMMODATIONS pursuant to the AMERICANS WITH DISABILITIES ACT, please contact the City's Stormwater Design Staff by calling 918/596-9498 as soon as possible but at least 24 hours prior to the meeting so that we can meet your needs.

AGENDA

City of Tulsa
Hazard Mitigation Staff Meeting
April 16, 2008
PW Engineering Services
Conference Room 328

Report, discuss, and take action, if any, on the following:

Reports

A. HMGP Acquisition Candidates Update – Ron Flanagan

B. Non-Structural Inventory List Status Update – Ron Flanagan

C. SDHMAB Hazard Mitigation Briefing – Bill Robison

D. Hazards and Mitigation Measures for SDHMB – Ron Flanagan

1. Multi-Hazard Mitigation Plan Update & Historic Preservation Annex – Ron Flanagan
2. Hazard Mitigation Funding Availability – Ron Flanagan
3. Status of HMGP Applications for MDP Updates and RL – Ron Flanagan
4. Future projects for HMGP NOIs – Ron Flanagan
5. Tulsa County Hazard Mitigation Plan Status – Ron Flanagan
6. New Business
7. Future Agenda Items
    - Reverse 911
    - TAEMA Participation in Hazard Mitigation
8. Next Meeting, Wednesday, May 14, 2008, 2:30-5:00 p.m.
   PW Engineering Services, Conference Room 328
9. Adjourn

AGENDA

CITY OF TULSA
MULTI-HAZARD MITIGATION PLAN UPDATE
HAZARD MITIGATION TECHNICAL ADIVSORY COMMITTEE

May 7, 2008
PW Engineering Services
Conference Room S-328

1. Call to Order
2. May 12 Public Meeting
3. Mitigation Plan Update Status
4. Copy Distribution
5. FEMA Crosswalk of Required Items
6. Timeline for Plan Update
7. Activities and Work Assignments
8. New Business
9. Next Meeting May 14, 2008, 1:00-3:00 p.m.,
   PW Engineering Services, Conference Room S-328
10. Adjourn

Future Items for Discussion:

AGENDA

CITY OF TULSA
MULTI-HAZARD MITIGATION PLAN UPDATE
HAZARD MITIGATION TECHNICAL ADIVSORY COMMITTEE

May 14, 2008
PW Engineering Services
Conference Room S-328

1. Call to Order
2. May 12 Public Meeting and Editing of Video
3. West Tulsa Meeting
4. Mitigation Plan Update Status
5. FEMA Crosswalk of Required Items
6. Timeline for Plan Update
7. Activities and Work Assignments
8. New Business
9. Next Meeting May 21, 2008, 1:00-3:00 p.m.,
   PW Engineering Services, Conference Room S-328
10. Adjourn

Future Items for Discussion:

AGENDA

City of Tulsa
Hazard Mitigation Staff Meeting
May 14, 2008 – 3:00 p.m.
PW Engineering Services
Conference Room 328

Report, discuss, and take action, if any, on the following:

Reports

A. HMGP Acquisition Candidates Update – Ron Flanagan

B. Non-Structural Inventory List Status Update – Ron Flanagan

C. SDHMAB Hazard Mitigation Briefing – Bill Robison

D. Hazards and Mitigation Measures for SDHMB – Ron Flanagan

1. Multi-Hazard Mitigation Plan Update & Historic Preservation Annex – Ron Flanagan

2. Hazard Mitigation Funding Availability – Ron Flanagan

3. Status of HMGP Applications for MDP Updates and RL – Ron Flanagan

4. Future projects for HMGP NOIs – Ron Flanagan
5. Tulsa County Hazard Mitigation Plan Status – Ron Flanagan
6. New Business
7. Future Agenda Items
    - Reverse 911
    - TAEMA Participation in Hazard Mitigation
8. Next Meeting, Wednesday, June 11, 2008, 2:30-5:00 p.m.
   PW Engineering Services, Conference Room 328

9. Adjourn

AGENDA

Stormwater Drainage and Hazard Mitigation Advisory Board

3:00 P.M., Tuesday, May 20, 2008

200 Civic Center, Room 1102, Tulsa, OK 74103

Gary Cheatham, Chair
Judith Finn, Vice-Chair
Vacant, Secretary
Kyle Brierly, Member
Raymond "Bud" Frye, Member
Ann Patton, Member

--

Corri Cousins, Asst. Secretary & Records Custodian
Jack Page, OWRB Accredited Floodplain Administrator
Mark Swiney, Board Counsel

Call to Order & Roll Call .... Chair

I. ADMINISTRATIVE MATTERS

A. Approval/Correction of Minutes: 3/18/2008 .... Chair

II. REPORTS

A. Director's Report .... Charles Hardt

1) Monthly Financial Report .... Alan Rowland

2) Proposed Fund Transfers .... Alan Rowland

3) Stormwater Fund 7010 Budget & Capital Program .... Ken Hill

4) Capital Projects Status Report .... Deborah Stowers

B. Floodplain Administrator's Report .... Jack Page

1) Permit Center Report .... Harold Tohlen

C. Stormwater Criteria Manual Update .... Mark Swift

D. Hazard Mitigation Report .... Ron Flanagan

1) Natural Hazards Review .... Ron Flanagan

2) Hazard Mitigation Action Plan Review .... Ron Flanagan

III. APPEALS & VARIANCES .... Chair

A. Building Permit Waiver: Jerry Prescott .... Jack Page

IV. NEW BUSINESS

Please Note: The OMA limits "new business" to only those matters not known about, or which could not have been reasonably foreseen, prior to the posting of the Agenda.

V. FUTURE AGENDA ITEMS

VI. BOARD ACTION ITEMS

A. Funding for EOC Improvements .... Mike McCool

VII. PUBLIC COMMENTS

Although the OMA limits Board action to those matters specifically listed on this Agenda, the Board solicits and encourages public comments and ideas.

VIII. MEETING CLOSURE .... Chair

IX. NEXT MEETING .... June 17, 2008

Should you wish to attend and participate in the Board's meeting but require SPECIAL ACCOMMODATIONS pursuant to the AMERICANS WITH DISABILITIES ACT, please contact the City's Stormwater Design Staff by calling 918/596-9498 as soon as possible but at least 24 hours prior to the meeting so that we can meet your needs.

MINUTES

CITY OF TULSA
MULTI-HAZARD MITIGATION PLAN UPDATE
HAZARD MITIGATION TECHNICAL ADIVSORY COMMITTEE

May 21, 2008
PW Engineering Services
Conference Room S-328

City Attendees
Roy Foster
Brent Stout
Crystal Kline
Richard Green
Mike McCool

Other Attendees
Tim Lovell
Ron Flanagan

1. Activities and Work Assignments
Ron Flanagan, R.D. Flanagan and Associates, assigned 12 hazards to Tulsa Partners to research and update:
    Tim Lovell – tornadoes, wind, and expansive soils
    Ann Patton – dams/levees, floods, and winter storms
    Jessica Hill – is assisting Ann with winter storms. She is also assigned extreme heat, draught, and earthquakes.
    Jo Ann Woody – wild fires, hail, and lightening
    Bob Roberts – is helping with the lightening.
Ron Flanagan is focusing on what has occurred since the 2002 plan in relation to updating the plan and what FEMA is requiring now. Chapter one is about the community and what is common to all the hazards (population, number of buildings, values of structures, critical facilities, etc.). Chapter two is existing mitigation programs. Things the city is already doing to mitigate hazards. We want to identify all of those.

(Brent) Is that a follow up to mitigation that we did in the first plan?

(Ron) It's also things we're doing like:
A. Public information and education programs – anything we're doing citywide that mitigates any kind of damage.
B. Looking at building permit requirements:
    1. What level are we at?
    2. How adequate is that?
    3. What are the issues that you respond to?
C. Ann is doing research on expansive soils. This is a Jack Page question. We know we have expansive soils. What does the city do about that? Is there any difference in the way permits are issued? Are there any requirements for building on expansive soils as opposed to building on regular soil? Are building requirements the same for everyone and it isn't taken into account? I (Ron) work all over the state and haven't found one community that takes soils into account. For example, in Stillwater where this is a major problem and Oklahoma's State University's buildings are severely challenged and they recognize that. In our meetings, when

we were adamant with them, they said it was an interesting idea that we should actually identify these soils maybe do soil samples (since we have an agricultural department here), we do those kinds of things, and it wouldn't cost us anything. Maybe we should do that, and maybe we should design the foundations to be appropriate to those types of soils. Oklahoma State University that's a good idea. There's not a single community in the state that does that; that requires soil samples and testing prior to issuing a building permit to make sure the foundation is appropriate for the soils. Are we doing anything along that line or not? Those are questions that we need to know. I think we're not, but we need to know for sure.

(Brent) What I want to know is if we identified in the first plan that there were some measures along that line and there's nothing that happened since that time. Why not? And is there implications for not doing it? I suppose not, but you would want . . . would probably want to document why it's not there.

(Ron) Right, and that's one of the things that what we are doing is taking a look at all the mitigation measures that were identified in the first plan, and we're looking at them and evaluating them. What has been done on these and what not? If nothing had been done on those measures, why not and is it because what is the repugnance to it? And if it's not something that anybody is going to do anything about, do we need to eliminate it? Or what? Now, the problem with all the things that we would like to do is strictly a question of time. In order to get together with all the agencies, and the departments, and the people who are responsible for these and get together with them to do an interview and find out why are we doing this or whatever and is this reasonable or do we need to alter? That takes time, and time is something we don't have. So we've got to take that into account. What our approach is right now is that all we're interested in doing is meeting FEMA's minimum requirements. Because that's what our goal is here to have this plan in place so that we don't lose our qualifications as being able to get hazard mitigation funds from the federal government. And then Bill is going to put in a budget item from now on for $50,000 a year to constantly update the plan. That way we don't wait for five years to go through all this stuff. We could be working on it through out. At any rate, just because we don't get to it this time, what we need to do in our mitigation measures is identify lack of data, or whatever it is, as an issue and that needs to be a mitigation measure to collect that information for our next update, etc. That's where we're headed with that.

(Brent) That's chapter two you're saying.

(Ron) That's chapter two. Chapter three is the planning process, and that's where we identify who the people are who participated, our meetings, etc. All that housekeeping sort of stuff to make sure; to let the government know that staff was involved, the Citizens Advisory Committee, the public was involved. We had scheduled, talked about scheduling five meetings throughout the city to give citizens an opportunity maybe to come to these meetings and participate. The complication has been that at the same time the city is going forward with a street bond issue, which takes precedence over everything else. There's no question about that. And, so, they are scheduling their meetings during the same period of time that we were thinking about scheduling meetings, and we can't do them both. Because that way the public gets too confused if we go out there and start talking about combining the citywide stormwater meetings with this and kill two birds with one stone throughout the city.

(Brent) And CRS?

(Ron) And CRS. Right. But if we get out there and start talking about stormwater needs and all that kind of stuff and then the city is probably got out talking at the same time to the same people about street needs, they'll just get all confused, so we need to put that off. The problem is putting it off is not necessarily helpful because we're going to be doing meetings after we already pretty much finished the work on the plan, so all we'll be doing then is just telling them here's what we've come up with and we're not really seeking their input legitimately even though they won't know that.

(Brent) There's no way that we can get their input? We can't give them a couple of alternatives or something?

(Ron) We could present the plan. We could get their input. Whether they like it or not, or what they think we should do about changing it or adding to it, or whatever. But, that's not really what we ought to be doing. We ought to be going to them up front and getting their thoughts and stuff before we're doing all this, but that's just not going to work. Hopefully we can take care of that during the next year. Maybe we can schedule meetings and come back and get their thoughts on the plan and get the input. We're working at less than a perfect world, and that assumes anybody bothered to show up to begin with. So what we are doing, we're very unhappy with the way the first meeting was advertised. (Turn the recorder off for a second). That's the challenge we have here because getting . . . The way we're going to play it now is that the new press release is going to emphasize Councilor Westcott cause he did appear at the meeting. And he's very good. He even got up and talked. So he wants this meeting on the west side.

(Brent) On the 3rd?

(Ron) On June 3rd on the west side at the Zarrow Public Library. In the newspaper article, etc. we are going to be quoting him and, since Bill Robison is not going to be there he is scheduled for another meeting, we are asking Councilor Westcott if he would host the meeting, if he would open it up. Which I think is very cool. That way it gets the Council's involvement, it puts him up there. It makes him look good. Plus it gets the folks an idea of who is in charge. So, I think that approach will be . . . If we can do that in the future when we have these other meetings, if we can get the Councilor in charge of that particular district to appear, I think it would be very helpful. (Crystal) Kevin Brierly from the Mayor's office, can send someone also. (Someone asked) When is the public meeting again?

(Ron) June 3rd, 6:30, on Tuesday.

(Respondent) Are we going to have the five meetings still there?

(Ron) No, well, sometime, but it may be in July.

(Brent) I think we're still meeting on the street issue in June and July. It's been scheduled; Bond Issue scheduling.

(Ron) I thought the Bond Issue was scheduled for voting in early July.

(Brent) Maybe, but the e-mail I got from the Mayor was saying June and July. That's a citywide e-mail.

Ron) Well, at any rate, if we do it's going to be after that. Hopefully, before the plan approval, or whatever, before August. But maybe if we could get it during July it would be good. After the elections at any rate. Whenever they are. Chapter four is where we actually look into doing this stuff on the hazards. And, we are revising the chapter four approach and the outline and the way we're doing it. The thing I handed out to you is our approach. The crosswalk is the federal government document they go by and evaluate our plans by. It specifically spells out things they have to make sure we jump through those particular hoops. It's organized in a very logical way. Our organization was different than the crosswalk. We took our 2002 plan and the crosswalk and James Lee Witt & Associates analysis of what they would recommend as far as the format's concerned and then the format we've been using in all other plans throughout the state and lined them all up and worked through them and saw what it was that was in common and tried to come up with a completely logical way to address the problem. This is what we've come up with. We've sent this out to the state and FEMA as well as our consultants and asked their comment on it. They all liked it, and they think this works good. We do, too. The chapter instead of being called natural hazards is now called hazards risk assessment. We take, for example, winter storms (which would be chapter 4.1 since winter storms is the first one we'll be dealing with) and we'll give a basic description of the event. What is a winter storm? What constitutes a winter storm? And a table, if possible. A lot of these hazards have ways to measure the impacts of those particular events (such as those tornados is called the fugea scale or high winds, the sacrisimpson scale, or the rictor scale for earthquakes). Then 4.1.1 would be the profile of the hazard itself. The location if site specific (floodplains, expansive soils, etc.). The extent, magnitude, how often it happens, history of previous occurances, probability of that happening in the future. Then existing vulnerability. Who are the vulnerable populations? What are the vulnerable structures and buildings? Critical facilities and infrastructure? Infrastructure is not something we've dealt with in the past. It is something FEMA is beginning to ask for now. How does it impact your infrastructure? When the city puts a new street in how do they deal with expansive soils? Do they even take that into account or not? If so, how? Do our streets break up and no one knows why? I'm sure when the engineers design the streets they take that into account. Is that right?

(Brent) They do bores and . . .

(Ron) We need to know about that. We need to put in here under expansive soils when it comes to infrastructure this is what the city does (mitigate that). What about our infrastructure? Our water lines? Our sewer lines? Do they do the same thing . . . water and sewer lines. . . when they do them?

(Brent) Yes, sometimes.

(Ron) And do we have a lot of problems with that? I mean when a water line breaks; do we know why that happens? (Response) Sometimes we do.

(Ron) Well, that's the thing we need to document, you know, is how many water lines and sewer lines breaks do we have, and how much money do we spend on it, and what are the causes of those problems, and what can we do to mitigate that? (Response) Most causes why a water line or sewer line breaks; you're talking about natural hazards to be more specific.

Ron) Excuse me, what did you say it was?

(Respondent) Multi causes. There are many reasons why it could happen. It could be change direction of water to cause a water line to break. Water hammer's going to cause it to break. (Respondent 2) Inflow and infiltration.

(Respondent) And that would be a sanitary sewer site. But Ron, you're talking about tornados and earthquakes and ice storms . . .

(Ron) And expanding soils. Right, all of those things.

(Respondent) Right. Now expansive soils shouldn't be as big of an issue because you do bedding material. You actually come in and bed the line according to industry standards, so the line isn't actually in contact with the major soils. It's in contact with the bedding material.

(Ron) We didn't spell that out, you know, when it comes to things in the infrastructure, I mean in the mitigation measures discussion chapter.

(Respondent) It's an industry wide practice that would be a nationwide/industry wide practice.

(Ron) So they should know about that, but we just need to mention that you know.

(Brent) That's a brief interview with the lead engineers in different sections, or something like that just to get their input on how they deal with that, or maybe construction instruction issues or construction people. Albert maybe.

(Respondent) I think you're right to begin with. Like Matt's group could talk about the bedding materials and standards for laying lines (sewer lines). Anthony's group could give you the standards they use for laying water lines, etc. and make sure you note the freeze lines and things like that. Even temperatures on a truck when it gets really cold can make them brittle.

(Respondent) Is there a document, like maybe ASCE or some group like that, that would tie in the industry standard?

(Ron) So back to your point that we should have a simple point, we ought to get all of our questions together as to what kind of issues or what kind of questions we have and then give them to somebody at the city so that you have a complete list and so you don't have 15 consultants contacting people and then wondering about . . .

(Respondent) Get all of the questions together, and we'll send them out to whomever we need to, and they respond to them. (Tim) I'm sending out an e-mail to people under me to get me their preliminary questions by tomorrow morning. We'll get them to Ron.

(Ron) We'll get them in some kind of a format and get them to you, so we can get that in process so we don't have a bunch of different people working/contacting all kinds of people. People not knowing what's going on saying, "Well, what priority is this? I've got my own work priorities and here such and such is asking me this. Who are they? They don't work for the city any more. Why are they . . . " (Tim) Roy, what are the names you just mentioned? (Roy) Matt Vaughan is the Lead Wastewater Design Engineer.   Anthony Wilkins is the Lead Water Design Engineer. (Tim) What I was going to do when I gave them to Ron was to reference those names. (Roy) Matt Leichti is the Lead in Transportation. Deborah Stowers is Stormwater Design.

(Ron) I was looking at, for example, the Atlanta . . . a tornado hit the city of Atlanta and one of the things (I think it was Atlanta or Fort Worth, I'm not sure which one) sewage treatment plant was hit or water treatment plant and it caused some major havoc. You get one of those major facilities out of commission it affects the entire city, you know, and I'm just wondering how we're going to go about on something like this. Such a critical piece of infrastructure where is one facility and if something happens to that rascal we're SOL. And how do we go about getting in contact with that kind of a person and finding out how these various hazards affect your operation there and which one could put you out of business or have an impact on your business and what are we doing about it? What even could we do about it let along what are we doing about it? That happens in a short period of time.

(Respondent) By talking to the manager of the facility. You could talk to the individual section managers. We've got plans to look into. The biggest thing that always affects water and wastewater is power – energy. That's going to affect us more than the tornados.

(Respondent) Power outages.

(Respondent) Exactly. We lose electricity just like everybody else. When we lose electricity, everything stops. That's why I came back to these meetings because Tim and Ann put the bug in my ear that we're included in the plan and probably have the opportunity for grant money through FEMA. We've looked at the cost effectiveness of putting in generators or going to alternative energy sources. Having gas drive for each one of our pumps so we have natural gas drive and electric drive so maybe we wouldn't lose them both at the same time. Or have generators. When you talk about the size of generators you need to run these plants, it's not possible. You can't . It doesn't pay for itself in 40 years.

(Respondent) Can I add something to that? Ron, I just learned the day before yesterday morning that Robert Brownwood and Clayton Edwards are looking at being able to either put a generator to one of the pumps at each end of the two fresh water treatment plants or put a direct drive into one of the pumps at both of the fresh water treatment plants and have the engine run off of either diesel or natural gas (they're not sure which). If they go the direct run pump way, rather than the generator way, they can not only have one of those seven pumps (at the Mohawk plant for instance) that drive not matter whether we have power or not. It can push 30-36 million gallons per day emergency but also in the summer time when you have peak demand, they can run that pump off that direct drive engine, not have to pay the $5 for every kilowatt, and save about 50-60 thousand dollars a year in money to PSO. These are mitigation measures.

(Ron) We need to write that up. Right now the state has $30,000,000 and that's not including the last three disasters that have been declared. They are looking for projects.

(Respondent) That is the perfect mitigation project, and I would argue to my dying breath, if necessary, to the state or the feds on this one. It's a mitigation measures not a preparation measures.

(Ron) It's a critical facility, and it serves the population, and that meets all of their criteria.

(Respondent) It's exciting to me because each of those electric motors is 4800 hp. That is major electricity. I mean big time electricity. If those go down, you're done.

(Respondent) We need this at the wastewater plants, too.

(Tim) This brings up an interesting point to me. We're working on trying to write up the hazards and descriptions. When we actually get back to the mitigation measures, we may have to go back, just as we are talking about now about getting information in details to put into this document. We're going to have to go back and get mitigation measures as well.

(Ron) Or maybe we can, in our discussions with people, we can kill two birds with one stone, just like this talking about the problem, We're also identifying what potential solutions are, and we're identifying mitigation measures as we speak.

(Tim) So what that means to me, in addition to asking my folks to get me their questions, we're also going to have to request mitigation measures that people might have/any ideas.

(Ron) Assuming they even know what a mitigation measure means you know.

(Tim) I know that.

(Brent) Well, once they get to see the problem, once it's identified. There's probably solutions to a lot of those. They talk, and we just need money.

(Tim) I guess in my mind I'm thinking, if we get these written up and they're written up by next week/next Wednesday, you can bring it back to the TAC meeting with draft documents and they could be distributed out to the folks for them to actually read the situation and then maybe come up with measures.

(Ron) But I'm wondering, just like we're chatting here, and all this sort of stuff sort of comes out with Mr. McCool, actually chatting with him, these kinds of issues comes out. I'm wondering if we did just send them something in writing whether or not it would be . . .

(Tim) It might not be as effective. You're right.

(Respondent) It might not click in their mind.

(Respondent) Mike doesn't speak for water and wastewater. I met with Bob and Tom both, which is Bob's counterpart for the wastewater side, and both had the same basic things. We need a separate drive whether it be diesel or gas. We also need generators. Now for wastewater plants, you're going to have to find a way to the sewage there because everyone one of our plants it has to be lifted to get it to the plant.

(Ron) You need smaller lift stations then.

(Respondent) You need to get the power back up.

(Ron) Do we know how many lift stations we have and what size of generators they would need?

(Respondent) We already know all this . . .

(Ron) And is it cost effective or not?

(Respondent) It isn't necessarily cost effective. Of course, if I can't get water to them we don't have to worry about wastewater.

(Ron) But are all those lift stations going to go down simultaneously or . . .

(Respondent) Probably not that's why a couple of skid mounted generators that could be moved around would probably/usually take care of the problem.

(Respondent) I never thought in the middle of the night when they crashed; I never understood, and I admit it; right after life and limb those lift stations are number one. You've got sewage backing up and needs to get going.

(Ron) So what we can do is, sort of like Chester Kajole has done to the Quik Trips, and that is you go in put your pad in and have the transfer ,f and you know what the size of the generator is, and you're ready to go. You have those backup generators warehoused, so when it does the ---- does hit the fan you just hook them all up and then you're done right? That would be a great mitigation measure. Does that make sense? Does it work?

(Respondent) It does. Yes, that's what we talked about before I came to this meeting; having a few skid mounted ones we could actually deploy where we need them. Of course, that ice storm kind of shoots my odds because we probably lose power all over town. We were moving small generators around to keep things going.

(Respondent) We replaced the 17 that were a problem during that storm. A couple in the private sector, but most in the public sector, of course. It's really exciting to me to think about direct drive engines to keep those pumps flying.

(Respondent) When you get 62-64 million gallons per day, you're almost to the point when the demand was during the ice storm.

(Respondent) It was 76,000,000.

(Respondent) When you push 66-67 million gallons a day, you've got enough water for sanitation for fire fighting, and that's all you need. You are going to buy yourself some time with 102,000,000 gallons that are in distribution systems already.

(Ron) What we need to do then, and I don't know how quickly we're going to be able to do that, but if we can identify how many lift stations we have. I guess it's unreasonable to expect that we would be able to evaluate in a short period of time what their voltage requirements would be or what size of generators they would need.

(Respondent) I think we already have that information.

(Respondent) Yes, we already have that information. Plus, we had to do the vulnerability assessment studies as part of the homeland security issue.

(Ron) For all of those lift stations?

(Respondent) For all of our facilities. Correct. For all of our water and wastewater facilities. Including lift stations and pump stations. I bet you copies of them are sitting in these two offices right here. Bob has a copy, and I bet Joan has a copy. We're required to do them on the water side. It's federal law. We went ahead and took monies and did it on the wastewater side. It made sense.

(Ron) So we have then the studies that identify what out needs are, right? And how many of these things we're going to need and . . .

(Respondent) On the minimum, what we're going to need to keep the system running is correct.

(Ron) How are we going to get . . . How are you guys going to get that information to us, so we can get it summarized and put into the report. And then identify them as mitigation measures, so we can cost them out and get them in chapter six.

(Brent) Everything needs to go through Bill.

(Respondent) There were cost analyses done on each one. We were prioritizing which ones we needed to get in place first. That's how we knew the payout for generators was greater than 40 years. You don't know when you're going to need it, and, if you spend the resource, it's just going to sit and rust. I don't know that they looked at the drives – natural gas or diesel, but they should have.

(Ron) You raised a good point though about saying that it's not cost effective to have enough of these generators , or whatever our system is, to do every one of them because chances of it affecting the entire city. I wonder how we're going to come up with some kind of . . .

(Respondent) What the minimum level is?

(Ron) Or the cost effective one, so it does get a 1:1 benefit cost ratio. That's what FEMA requires. Whatever that level is. Whether it's 50%, or 25% of them, or 75% of whatever, at some point we gotta be able to say this is cost effective at this point. Maybe it's only having, if we have 100 pump stations, maybe 33 generators is what . . .

(Brent) You would have to kind of determine what an average event would be where you have situations like this.

(Ron) Yes, and maybe we can get James Lee Witt's people to help us. They've got all kinds of formulas for all these disasters and stuff that FEMA accepts. Loss of infrastructure is some of the things they have formulas for calculating all that. We were looking at it. Like so many kilowatt hours lost to the public equals $12.50 in losses. You can calculate up then. If it's out for 5 days, and this is what has happened, and it affects x amount of people then that's x amount of kilowatt hours and the cost is this. Then what is it that we can do than that the cost doesn't exceed the benefit. If we just have the base information. This is a wonderful opportunity to talk with you about this because you have given us ideas we have never even thought about. Last time when Mike and I were talking this and we were talking about water treatment plants and stuff. He was saying to run those pumps you're going to need a generator as big as a diesel engine; a bunch of those. How are we going to do that?

(Respondent) It would be like a movie production company brings out a scene where they're going to shoot they bring an 18-wheeler out. That's the kind of electricity we have to have.

(Brent) I thought we applied for a couple of those a few years ago and got shot down.

(Respondent) Through homeland security.

(Brent) That's what I thought.

(Respondent) Any time we apply through homeland security we get shot down because we don't have police and fire in front of us. I spent a lot of time putting together a proposal.

(Respondent) They have no concept of how important Public Works is.

(Ron) FEMA does though. They deal with infrastructure all the time.

(Respondent) They're buried so far down in DHS that you don't even know where they are.

(Ron) Hopefully, it's time to get them out of DHS, separate them back out again. Here is the Atlanta tornado. A shot of the tornado as it impacted the city of Atlanta. The interesting thing there is it almost mirrors the scenarios we're looking at for the city of Tulsa. What we've decided to do here is, last time we did this we had one tornado scenario, but this time we're talking about doing four of them. One that hits downtown Tulsa, and then the Northside, one that hits midtown, one that goes south, and one that is way south. The initial damage figures are all, strangely enough, around the same general damages (700 and some million dollars) regardless. This one is less. It's about half. I'm going to look at our methodology on that.

(Brent) Do they want to see F5 level damage?

(Ron) They want to see a maximum probable event.

(Respondent) Is F5 a maximum event?

(Respondent) No. If you add F5 and F4 together, it's causes less than 5% of all tornado damage.

(Ron) A probable maximum event.

(Respondent) Then you want it to be about an F2.

(Ron) What we're using is the Moore tornado, and that's what that is.

(Respondent) That's not a likely tornado.

(Ron) No, but . . .

(Respondent) If you're talking about you want maximum then you do an F4 or 5. If you're talking about maximum probability then you do an F1 or 2.

2. Next Meeting May 28, 2008, 1:00-3:00 p.m., PW Engineering Services, Conference Room S-328

AGENDA

CITY OF TULSA
MULTI-HAZARD MITIGATION PLAN UPDATE
HAZARD MITIGATION TECHNICAL ADIVSORY COMMITTEE

May 28, 2008
PW Engineering Services
Conference Room S-328

1. Call to Order
2. Activities and Work Assignments
3. West Tulsa Meeting/ Press Release
4. Mitigation Plan Update Status
5. FEMA Crosswalk of Required Items
6. Timeline for Plan Update
7. Expansive Soils and other Hazard Specific Topics
8. New Business
9. Next Meeting June 4, 2008, 1:00-3:00 p.m.,
   PW Engineering Services, Conference Room S-328
10. Adjourn

Future Items for Discussion:

AGENDA

CITY OF TULSA
MULTI-HAZARD MITIGATION PLAN UPDATE
HAZARD MITIGATION TECHNICAL ADIVSORY COMMITTEE

June 4, 2008
PW Engineering Services
Conference Room S-328

1. Call to Order
2. Review of Rough Draft & Additional Work Needed
3. West Tulsa Meeting and Possible Improvements
4. Additional Public Meetings
5. Press Release
6. FEMA Crosswalk of Required Items
7. Timeline for Plan Update
8. In-House Questioner
9. Hazard Specific Topics
10. New Business
11. Next Meeting June 11, 2008, 1:00-3:00 p.m.,
    PW Engineering Services, Conference Room S-328
12. Adjourn

Future Items for Discussion:

AGENDA

Stormwater Drainage and Hazard Mitigation Advisory Board

3:00 P.M., Tuesday, June 17, 2008

200 Civic Center, Room 1102, Tulsa, OK 74103

Gary Cheatham, Chair
Judith Finn, Vice-Chair
Vacant, Secretary
Kyle Brierly, Member
Raymond "Bud" Frye, Member
Ann Patton, Member

--

Corri Cousins, Asst. Secretary & Records Custodian
Jack Page, OWRB Accredited Floodplain Administrator
Mark Swiney, Board Counsel

Call to Order & Roll Call .... Chair

I. ADMINISTRATIVE MATTERS

- **A. Approval/Correction of Minutes: 5/20/2008 .... Chair**
- **B. License Agreement: Triad Bank-S. Lewis Ave (Joe Creek) . Mark Swiney**
- **C. Detention Facility Surplus: 71st & S. Columbia Ave. .... Mark Swiney**

II. REPORTS

- **A. Director's Report .... Charles Hardt**
  - **1) Monthly Financial Report .... Alan Rowland**
  - **2) Proposed Fund Transfers .... Alan Rowland**
  - **3) Capital Projects Status Report .... Deborah Stowers**
- **B. Floodplain Administrator's Report .... Jack Page**
  - **1) Permit Center Report .... Harold Tohlen**
- **C. Stormwater Criteria Manual Update .... Bill Robison**
- **D. Hazard Mitigation Report .... Ron Flanagan**
  - **1) Multi-Hazard Mitigation Plan Update .... Bill Robison**
  - **2) 1986 Arkansas River Flood Map .... Bill Robison**

III. APPEALS & VARIANCES .... None

IV. NEW BUSINESS

Please Note: The OMA limits "new business" to only those matters not known about, or which could not have been reasonably foreseen, prior to the posting of the Agenda.

V. FUTURE AGENDA ITEMS

VI. BOARD ACTION ITEMS

- **A. Corps of Engineers Levee Assessment .... Frank Keith**

VII. PUBLIC COMMENTS

Although the OMA limits Board action to those matters specifically listed on this Agenda, the Board solicits and encourages public comments and ideas.

VIII. MEETING CLOSURE .... Chair

IX. NEXT MEETING .... July 15, 2008

Should you wish to attend and participate in the Board's meeting but require SPECIAL ACCOMMODATIONS pursuant to the AMERICANS WITH DISABILITIES ACT, please contact the City's Stormwater Design Staff by calling 918/596-9498 as soon as possible but at least 24 hours prior to the meeting so that we can meet your needs.

AGENDA

CITY OF TULSA
MULTI-HAZARD MITIGATION PLAN UPDATE
HAZARD MITIGATION TECHNICAL ADIVSORY COMMITTEE

June 25, 2008
PW Engineering Services
Conference Room S-328

1. Call to Order
2. Review of Rough Draft & Additional Work Needed
3. Public Meeting Schedule
4. Press Release
5. FEMA Crosswalk of Required Items
6. Timeline for Plan Update
7. In-House Questioner
8. Hazard Specific Topics
9. New Business
10. Next Meeting July 9, 2008, 1:00-3:00 p.m.,
    PW Engineering Services, Conference Room S-328
11. Adjourn

Future Items for Discussion:

AGENDA

CITY OF TULSA
MULTI-HAZARD MITIGATION PLAN UPDATE
HAZARD MITIGATION TECHNICAL ADIVSORY COMMITTEE

July 9, 2008
PW Engineering Services
Conference Room S-328

1. Call to Order
2. Review of Rough Draft & Additional Work Needed
3. Public Meeting Schedule
4. Press Release and Advertising Budget
5. FEMA Crosswalk of Required Items
6. Timeline for Plan Update
7. In-House Questioner
8. Hazard Specific Topics
9. New Business
10. Next Meeting July 23, 2008, 1:00-3:00 p.m.,
    PW Engineering Services, Conference Room S-328
11. Adjourn

Future Items for Discussion:

AGENDA

Stormwater Drainage and Hazard Mitigation Advisory Board

3:00 P.M., Tuesday, July 15, 2008

200 Civic Center, Room 1102, Tulsa, OK 74103

Gary Cheatham, Chair
Judith Finn, Vice-Chair
Vacant, Secretary
Kyle Brierly, Member
Raymond "Bud" Frye, Member
Ann Patton, Member

--

Corri Cousins, Asst. Secretary & Records Custodian
Jack Page, OWRB Accredited Floodplain Administrator
Mark Swiney, Board Counsel

Call to Order & Roll Call .... Chair

I. ADMINISTRATIVE MATTERS

- **A. Approval/Correction of Minutes: 6/17/2008 .... Chair**
- **B. License Agreement: Russ Roach/71st & Columbia Ave .... Mark Swiney**

II. REPORTS

- **A. Director's Report .... Charles Hardt**
  - **1) Monthly Financial Report .... Alan Rowland**
  - **2) Proposed Fund Transfers .... Alan Rowland**
  - **3) Capital Projects Status Report .... Deborah Stowers**
- **B. Floodplain Administrator's Report .... Jack Page**
  - **1) Permit Center Report .... Harold Tohlen**
- **C. Stormwater Criteria Manual Update .... Bill Robison**
- **D. Hazard Mitigation Report .... Ron Flanagan**
  - **1) Multi-Hazard Mitigation Plan Update .... Bill Robison**
  - **2) 1986 Arkansas River Regulatory Flood .... Bill Robison**

III. APPEALS & VARIANCES .... None

IV. NEW BUSINESS

Please Note: The OMA limits "new business" to only those matters not known about, or which could not have been reasonably foreseen, prior to the posting of the Agenda.

V. FUTURE AGENDA ITEMS

VI. BOARD ACTION ITEMS

VII. PUBLIC COMMENTS

Although the OMA limits Board action to those matters specifically listed on this Agenda, the Board solicits and encourages public comments and ideas.

VIII. MEETING CLOSURE .... Chair

IX. NEXT MEETING .... August 19, 2008

Should you wish to attend and participate in the Board's meeting but require SPECIAL ACCOMMODATIONS pursuant to the AMERICANS WITH DISABILITIES ACT, please contact the City's Stormwater Design Staff by calling 918/596-9498 as soon as possible but at least 24 hours prior to the meeting so that we can meet your needs.

AGENDA

CITY OF TULSA
MULTI-HAZARD MITIGATION PLAN UPDATE
HAZARD MITIGATION TECHNICAL ADIVSORY COMMITTEE

July 23, 2008
PW Engineering Services
Conference Room S-328

1. Call to Order
2. Review of Rough Draft & Additional Work Needed
3. Public Meeting Schedule
4. Press Release and Advertising Budget
5. Definition of Critical Facilities
6. Timeline for Plan Update, Missing Pieces.
7. In-House Questioner
8. Hazard Specific Topics
9. New Business
10. Next Meeting August 13, 2008, 1:00-3:00 p.m.,
    PW Engineering Services, Conference Room S-328
11. Adjourn

Future Items for Discussion:

AGENDA

CITY OF TULSA
MULTI-HAZARD MITIGATION PLAN UPDATE
HAZARD MITIGATION TECHNICAL ADIVSORY COMMITTEE

August 13, 2008
PW Engineering Services
Conference Room S-328

1. Call to Order
2. Review of Rough Draft & Additional Work Needed
3. Public Meeting Schedule
4. New FEMA Requirements
5. Definition of Critical Facilities
6. Timeline for Plan Update, Missing Pieces.
7. In-House Questioner
8. Hazard Specific Topics
9. New Business
10. Next Meeting September 10, 2008, 1:00-3:00 p.m.,
    PW Engineering Services, Conference Room S-328
11. Adjourn

Future Items for Discussion:

AGENDA

City of Tulsa
Hazard Mitigation Staff Meeting
August 13, 2008 – 3:00 p.m.
PW Engineering Services
Conference Room 328

Report, discuss, and take action, if any, on the following:

Reports

A. HMGP Acquisition Candidates Update – Ron Flanagan

B. Non-Structural Inventory List Status Update – Ron Flanagan

C. SDHMAB Hazard Mitigation Briefing – Bill Robison

D. Hazards and Mitigation Measures for SDHMB – Ron Flanagan

1. Multi-Hazard Mitigation Plan Update & Historic Preservation Annex – Ron Flanagan

2. Hazard Mitigation Funding Availability – Ron Flanagan

3. Status of HMGP Applications for MDP Updates and RL – Ron Flanagan

4. Future projects for HMGP NOIs – Ron Flanagan
5. Tulsa County Hazard Mitigation Plan Status – Ron Flanagan
6. New Business
7. Future Agenda Items
    - Reverse 911
    - TAEMA Participation in Hazard Mitigation
8. Next Meeting, Wednesday, September 10, 2008, 3:00-5:00 p.m.
   PW Engineering Services, Conference Room 328

9. Adjourn

AGENDA

Stormwater Drainage and Hazard Mitigation Advisory Board

3:00 P.M., Tuesday, August 19, 2008

2317 South Jackson Room S-213, Tulsa, OK 74107

Call to Order & Roll Call .... Chair

I. ADMINISTRATIVE MATTERS

A. Approval/Correction of Minutes: 6/20/2008 .... Chair

II. REPORTS

A. Director's Report .... Charles Hardt

1) **Monthly Financial Report .... Alan Rowland**
2) **Proposed Fund Transfers .... Alan Rowland**
3) **Capital Projects Status Report .... Deborah Stowers**

B. Floodplain Administrator's Report .... Jack Page

1) **Permit Center Report .... Harold Tohlen**

C. Hazard Mitigation Report .... Ron Flanagan

1) **Multi-Hazard Mitigation Plan Update .... Bill Robison**
2) **Elm Creek Master Drainage Plan Update .... Mark Swift**
3) **Elm Creek Acquisition .... Bill Robison**

III. APPEALS & VARIANCES .... None

IV. NEW BUSINESS

Please Note: The OMA limits "new business" to only those matters not known about, or which could not have been reasonably foreseen, prior to the posting of the Agenda.

V. FUTURE AGENDA ITEMS

VI. BOARD ACTION ITEMS

A. Corps of Engineers Levee Assessment Feedback .... Jim Martell

VII. PUBLIC COMMENTS

Although the OMA limits Board action to those matters specifically listed on this Agenda, the Board solicits and encourages public comments and ideas.

VIII. MEETING CLOSURE .... Chair

IX. NEXT MEETING .... September 16, 2008

Should you wish to attend and participate in the Board's meeting but require SPECIAL ACCOMMODATIONS pursuant to the AMERICANS WITH DISABILITIES ACT, please contact the City's Stormwater Design Staff by calling 918/596-9498 as soon as possible but at least 24 hours prior to the meeting so that we can meet your needs.

AGENDA

CITY OF TULSA
MULTI-HAZARD MITIGATION PLAN UPDATE
HAZARD MITIGATION TECHNICAL ADIVSORY COMMITTEE

August 27, 2008
PW Engineering Services
Conference Room S-328

1. Call to Order
2. Review of Rough Draft & Additional Work Needed
3. New FEMA Requirements
4. Definition of Critical Facilities
5. Timeline for Plan Update, Missing Pieces.
6. Hazard Specific Topics
7. New Business
8. Next Meeting September 10, 2008, 1:00-3:00 p.m.,
   PW Engineering Services, Conference Room S-328
9. Adjourn

Future Items for Discussion:

Appendix D: Progress to date on 2003 Mitigation Plan

The following items are a list of all Mitigation Measures included in the 2003 City of Tulsa Multi-Hazard Mitigation Plan, followed by a summary of progress and current activities pertaining to each of those measures.

Hazard	Mitigation Measure	Progress and/or Activity
Dam/Levee Failure	1. Develop a computer-mapping program for results of Arkansas River's Keystone Dam release rates of 250, 350, and 450,000 cubic fps.	Completed. GIS Mapping of 250, 350, & 450 thousand CFS release rates have been created. COE is presently revising the HEC-RAS model for the Arkansas River. Expected to be completed in Fall 2008.
	2. Re-evaluate and update MDP for areas protected by the levees.	Ongoing. Corps of Engineers is currently conducting this reevaluation and update.
	3. Continue checking and replacing levees	Partially complete. A number of Arkansas River levees have been deemed unacceptable in a preliminary study by the Corps of Engineers. We are including a 2009 Mitigation Measure to develop a comprehensive Levee Evaluation and Repair Plan to address these issues.
	4. Update Corps of Engineers H&H for Arkansas River	Ongoing. Corps is currently updating Arkansas River H&H.
	5. Develop pre- and post-flood plans	Partially completed. Pre- and post flood plans are enhanced in the 2007 update of the Tulsa Area Emergency Operations Plan. An updated Levee Education and Evacuation Plan is included in the 2009 plan.
	6. Develop warning and evacuation plans for Arkansas River	Completed through Tulsa Area Emergency Management Agency.
Extreme Heat	7. Review and update Tulsa's heat response plan.	Completed. Review & revision of Extreme Heat Annex to Tulsa's EOP completed 12/07.

	8. Obtain funding for publication and distribution of public information and education materials to vulnerable populations through participating community agencies.	Completed. Extreme Heat Public information brochures have been revised and printed in coordination with Community Service Council, and distributed to vulnerable populations.
Floods	9. Continue to update Master Drainage Plans	Ongoing. Update currently in progress and continues on an ongoing basis. Listed in 2009 Mitigation Measures.
	10. Monitoring/warning system	Completed. We have a system that monitors stream gauges throughout the City and sends both a page and e-mail to desired staff when street flooding is pending. This system is presently being upgraded to provide satellite communication as a backup and so staff can access the system from remote locations via the internet.
	11. Continue instituting Structural and Non-structural mitigation measures in conjunction with updated MDPs.	Ongoing. Non-Structural: Pete Rose, Letts, Shadow Mountain. Structural: The City has completed approximately 150 flood control projects since 2003. See Table C-1 below for complete list. This is maintained as a Mitigation Measure in the 2009 plan.
	12. Continue acquiring Repetitive Loss and frequently flooded properties	Ongoing. Applications have been submitted for acquisition through both HMGP and FMA, and this remains as a Mitigation Measure in the 2009 Plan.
Tornadoes and High Winds	13. Investigate building codes and incentives	Ongoing. The 2009 update will continue to address this issue, and will include the new ICC/NSSA criteria being incorporated into the 2009 ICC.
	14. Provide mobile home community safe rooms.	Not completed. Efforts to complete this have been unsuccessful to this date due to a lack of funding. The 2009 Update will continue to address this issue.
	15. Provide employee safe rooms at critical facilities	Partially completed. The new 911 center central call room is designed to withstand an

	16. Provide SafeRooms at city recreation facilities	F-5 tornado and the remainder of the facility is resistant to F1 or F2 events. A Mitigation Measure in 2009 update addresses the need to develop a plan for all other City facilities.
	17. Provide safe rooms in fire and police stations	
	18. Evaluate Tulsa school facilities for tornado safety	Completed. Tulsa Emergency Management, in conjunction with engineers & architects, physically walked through and evaluated all Tulsa Public School facilities for tornado and high wind resistance and to review appropriate tornado response.
Hazardous Materials Events	19. Continue collections of household hazardous materials	Completed and ongoing. We conduct 2 events/year in cooperation with the Metropolitan Environmental Trust (MET). The MET operates 5 recycling stations within the City of Tulsa that have differing hours of operations, www.metrecycle.com/depots.htm
	20. Combine the M.E.T, TFD Hazmat and Quality Assurance Section in a facility that would act as a year-round pollutant collection facility.	Incomplete. Funding has never been obtained. This still remains as a proposal for the Metropolitan Environmental Trust.
	21. Update the study for routing HM through the City.	Incomplete. This is not considered a priority for the City of Tulsa at this time, and has not be re-included as a Mitigation Measure in the 2009 plan.
Winter Storms	22. Continue the City's aggressive snow and ice removal plan	Completed and ongoing. Removal plan has worked effectively during last two major winter storms.
	23. Develop a Debris Management Plan	Completed. After the 12/07, ice storm contractors were used for the first clean up. After that the City was sectioned up and Surface Drainage, Street Maintenance, and Underground Collections each worked a portion of the City.
	24. Provide for routine tree trimming	Completed and ongoing. PSO has an aggressive tree trimming program. In addition, the need for tree trimming was significantly reduced by the 12/07 ice storm.

	25. Move new and existing power lines underground.	Still in process. AEP/PSO has currently, at the request of the City, increased their reviewing of options for this possibility with Ok Corporation Commission. Since the process has begun, this will not be re-listed as a Mitigation Measure in the 2009 plan.
Urban Fires and Wildfires	26. Replace inadequate sized lines	Completed and ongoing. The City is systematically replacing all 2" water mains with 4"-6" lines. No dead end lines are permitted. All water main lines must be looped for water quality and quantity issues.
	27. Install a fire suppression system in City Hall	No longer necessary. The new City Hall has a fire suppression system. It was required by code when this building was constructed.
	28. Apply for mitigation funding for backflow valves for commercial, industrial, and multi-family buildings.	Incomplete. The Tulsa Fire Department has since concluded that this is not a significant hazard and it is not included as a Measure in the 2009 Plan.
	29. Continue TFD smoke detector program	Completed and ongoing. The Tulsa Fire Department Project Life is now being conducted 4 times a year instead of one.
Lightning	30. Provide surge suppression for critical facilities such as 911, EOC, etc.	Completed. Critical facilities such as telecommunications and water treatment plants, the airport and the Police Academy have lightning protection. All individual city of Tulsa computers have surge protection, but not robust enough to protect against a significant lightning strike, and lightning protection is not typically included in the design of new facilities unless there is considerable or sensitive electronics and computer equipment.
	31. Provide public education on lightning safety.	Partially completed and ongoing. Lightning safety measures successfully used in other communities, such as automated lightning detection and warning systems in outdoor recreation areas, are being included in the 2009 update.
	32. Study other communities with successful lightning safety programs.	

Earthquake	33. Provide for building reinforcement for earthquake protection	Not completed. Earthquakes are an extremely low hazard possibility. Earthquake reinforcement has not been addressed. It is included in the 2009 Update as a potential measure.
Drought	34. Construct a third flowline from Lake Hudson	Partially completed and in process. Right of way has been acquired for third flowline. Construction of this flowline is considered low priority because maximum use per day has only reached about 85% of our capacity.
	35. Tie Oologah & Spavinaw flowlines together	Incomplete. This is no longer considered necessary. We presently have the capability of flowing Oologah or Spavinaw water to Mohawk treatment plant, but only Oologah water will go to A.B. Jewell. There is a project under construction that will allow us to flow 52 MGD from Spavinaw to A.B. Jewell.
Expansive Soils	36. Provide for Engineers' seal on all non-residential construction.	Completed. All non-residential building foundations must have an engineers seal on the design.
General	37. Continue Public Education and Information Program	Ongoing. City of Tulsa actively participates in the McReady and Turn Around, Don't Drown programs. This measure will continue to be addressed in the 2009 update.
	38. Upgrade warning system	Partially completed. The most critical sirens have been upgraded, and regular replacement of sirens is now included as a line-item budget item for the City.
	39. Provide new facilities for 911 Communications Center and Emergency Operations Center	Partially completed. New 911 Center will open fall of 2008. New EOC continues to be a need that will be included in the 2009 Update.
	40. Update GIS to include public utilities	Partially completed and in progress. Atlas information already done for water and wastewater. Currently working on stormwater system. Since this is actively in progress, it will not be included as a measure in the 2009 plan.

	41. Install emergency communication network for Fire, Police, 911, etc.	Completed. Tulsa has acquired ECHO-1, a mobile communications trailer that provides for interoperability among multiple radio systems, both internal to the Tulsa area, and for any outside agencies that may be working here.
	42. Contact agencies that distribute information to at-risk communities	Partially completed and Ongoing. Several agencies that work with people with disabilities, the elderly, low-income and people who speak a language other than English were heavily engaged in the updating of the Tulsa Emergency Operations Plan. Several Mitigation Measures in the 2009 Mitigation Plan address specific needs in this area.

Table D-1: Stormwater Projects Status Report
As of August, 2008

Project Description	Status	Date	Compl.
Garden City Drainage Improvements	**Complete.** Designed with 872003 funds.	Sep-01	100%
Cedar Ridge Park Second	**Complete.**	Jul-02	100%
Valley View Creek	Constructed with 994178. Awaiting Final.	Oct-01	100%
Smittal Pond	**Complete.**		100%
7th and Houston	**Complete.** To remove the puddle.	Aug-02	100%
84th and Garnett Ditch Rehab	**Complete.** Rehab existing concrete ditch liner	Dec-02	100%
Little Haikey Creek - 7904 E 87th Ct	**Complete.** Designed with B3, B13, and D1.	Sep-02	100%
Union Ave. Bridge over Mooser Creek	**Complete.** 5300 Block of S. Union	Nov-01	100%
6322 S. Richmond	**Complete.** Constructing flume to channel water to inlet.	Jan-03	100%
7400 S. Harvard	**Complete.**	Jan-03	100%
Coal Creek Rehab	**Complete.** Constructed with 993300-6.	Feb-02	100%
Langenheim Park	**Complete.** Constructed with 993300-2.	Feb-02	100%
3303 S. 140 E. Avenue	**Complete.** Replaced street to improve drainage.	Mar-03	100%
3027 E. 82nd Street S.	**Complete.** Repair headwall and build dissipater.	Jun-03	100%
Perryman Ditch Plan C, Phase 1	**Complete.**	Sep-02	100%
5230 S. Marion Avenue	**Complete.**	Nov-01	100%
Phase 3	**Complete.** Cleaning channel in Garnett Ctr.	Aug-02	100%
Cherry Creek - Cherry Creek & S Elwood	**Complete.** Constructed with Cresent Park.	Jul-02	100%
5230 S. Marion Avenue	**Complete.**	Nov-01	100%
5230 S. Marion Avenue	**Complete.**	Nov-01	100%
Cresent Park	**Complete.** Constructed with Cherry Creek.	Jul-02	100%
Vensel Crk Bridge -98th & Oswego	**Complete.**	Aug-02	100%
Garnett Road Detention Facility	**Complete.**	Mar-01	100%
5230 S. Marion Avenue	**Complete.**	Nov-01	100%
Cooley Creek - 1225 S 141st E	**Complete.** By UGC 11/03.	Nov-03	100%
56th and Mingo	**Complete.** Removed ponding behind curb.	Oct-03	100%
Heller Park - 5919 S. Utica	**Complete.**	Aug-03	100%
Main Auto Parts - 16401 E. Admiral Pl	**Complete.** Replaced culvert aliveate flooding to car wash.	Sep-03	100%
Regency Park West	**Complete.**	Dec-02	100%

Jiffy Lube - 1102 S. Garnett	**Complete.**	Aug-03	100%
4246 S Columbia Ave. Inlets	**Complete.**	Nov-03	100%
Regency Park West	**Complete.**	Dec-02	100%
5700 S. Delaware Ave.	**Complete.** Constructed w/ Regency Park.	Dec-02	100%
Coal Creek - 1200 N Columbia	**Complete.**	Oct-02	100%
West Highlands Inlet Repl - 6820 S 32nd W	**Complete.**	Nov-03	100%
7200 E 82nd Street	**Complete.** Removing ponding.	Jan-04	100%
6716 E 83rd Place	**Complete.** Removing ponding at curb.	Jan-04	100%
4171 S. New Haven Place	**Complete.** Placed inlet over storm sewer.	Dec-03	100%
Brookwood Detention Facility - 8300 S Urbana	**Complete.**	Nov-03	100%
7050 E 82nd St	**Complete.** Removing ponding.	Jan-04	100%
7143 E 82nd Pl	**Complete.** Removing ponding.	Jan-04	100%
7200 E 84th St	**Complete.** Removing ponding.	Jan-04	100%
8307 S 71st E	**Complete.** Removing ponding at curb.	Feb-04	100%
Phase 5	**Complete.** Cleaning channel from Garnett Center to 122nd.	Sep-04	100%
87th and Quebec	**Complete.** Removing ponding at curb.	Dec-03	100%
7512 S. Erie.	**Complete.** Extending storm to contain spring.	Jan-04	100%
Vensel - 8300 S. Pittsburg	**Complete.** Inlets added	May-04	100%
64th & Peoria	**Complete.** Crossover pipe and paved ditch.	Apr-04	100%
Burl Watson - 3442 E. 61st Pl	**Complete.**	Aug-03	100%
STLSF RR Ind Park Relief Channel	**Complete.** 900 N. Lewis	Aug-03	100%
STLSF RR Ind Park Relief Channel	**Complete.** 900 N. Lewis	Aug-03	100%
Channel repairs -Shot Crete Contract	**Complete.** For use at various locations through out the City.	May-03	100%
Downtown Storm Sewer Repair	**Complete.** 1830 S Boulder.	Jul-04	100%
Joe Creek E Branch - 4157 E 46th Pl	**Complete.** With Zone 7045 - Project No. 014170, Contract O	Jun-06	100%
7100 E 82nd	**Complete.** Removing ponding.	Aug-04	100%
Mooser Creek Bridge Mountain Manor	**Complete.** Remaining funds to be transferred to 013180.	Jul-03	100%
2900 E. 56th Pl Underdrain	**Complete.** Removing ponding at curb.	Oct-04	100%
15 St/Mingo Creek Drainge Improvement	**Complete.** Constructed with 994526, Phase III	Aug-03	100%
Valley View Channel	**Complete.** Repairing channel failure.	Nov-04	100%
6843 E 83rd St	**Complete.** Removing ponding at curb.	Jan-04	100%
Joe Creek East Branch - 3123 S. Toledo Ave.	**Complete.** Make break in retaining wall to allow drainage to pass.	Dec-04	100%

Brady Lofts - Brady and Detroit	**Complete.** Remove storm sewer from under building.	Dec-04	100%
Hope VI - TCC Drainage	**Complete.**	Aug-04	100%
8218 S 71st E Ave	**Complete.** Removing ponding at curb.	Jan-04	100%
Dirty Butter - 2708 N Denver Ave	**Complete.**	Jun-06	100%
Vienna Woods Drainage Improvements	**Complete.**	Jul-03	100%
Valley View - 4600 N Cincinnati Pl & Detroit	**Complete.** Designed and constructed with Valley View channel.	Jun-03	100%
Phase III	**Complete.** 4630 W. Brady.	Aug-04	100%
Magic Circle Storm Sewer	**Complete.**	Jul-03	100%
Magic Circle Storm Sewer	**Complete.** AEP/PSO Work Pay Agreement not closed.	Jul-03	100%
Inlets at 2625 E 59th St	**Complete.** Constructed Inlets. Record drawings?	Aug-05	99%
Mockingbird Lake Spillway	**Complete.** Remove and replace spillway at 31st and Gary	Aug-05	100%
Fred Creek Guier Wood III & IV Drainage	**Complete.** Final 10/20/05. AEP/PSO Work Pay not closed.	May-04	100%
Fred Creek Guier Wood III & IV Drainage	**Complete.**	May-04	100%
Fred Creek Southridge Drainage	**Complete.** Designed and Constructed with Yale - 71st to 81st.	Apr-04	99%
Channel repairs -Shot Crete Contract	**Complete.** For use at various locations through out the City.	Aug-04	100%
Epworth Church -	Installing a median drain on existing pipe.	Jan-06	90%
Epworth Church -	**Complete.** Installing a median drain on existing pipe.	Jan-06	100%
3121 S Gary Pl.	**Complete.** Correct inlet on Walgreens. Record Drawings?	Mar-04	99%
Signal Hill - 8600 S Braden Ave	**Complete.** Construct inlets along ditch & connect to storm sewer.	Aug-05	100%
Tupelo Creek - 1400 S 121st E	**Complete.** Extend stormsewer system to relive flooding.	Aug-05	100%
Little Joe Creek - 5400 S Lakewood	**Complete.** Contract 4 -	Jan-06	95%
Perryman Ditch	**Complete.** 4001 S. Utica Ave.	Mar-06	100%
Crow Creek	**Complete.** 31st Street & Rockford Avenue	Mar-06	100%
Vienna Woods Landscaping	**Complete.**	Jul-05	99%
Fry Ditch #2 - 10100 S. Memorial	**Complete.** Concrete Flume.	Aug-05	100%
Garden City Drainage Improvements	**Complete.** Add'l work at RR crossing completed w/ Street Cuts.	Sep-01	100%
Jones Creek - 1600-1700 S 68th E	**Complete.** Contract 3 -	Dec-06	96%
Perryman Ditch - 4000 S Madison	**Complete.** Contract 3 -	Dec-06	96%
Vensel Creek - 3839 E 103rd S	**Complete.** Extend culvert. Sent to Street Cuts.	May-07	100%
Audubon Creek - 7310 E 31st Pl	**Complete.** Contract 2 - Street Cuts	Jun-06	97%
Cherry Creek - North of W 41st St	**Complete.** Contract 4. Street cuts.	Jan-06	95%
Cherry Creek - North of W 41st	**Complete.** Contract 4. Street cuts.	Jan-06	95%

Coal Creek - 3535 E Virgin Pl	**Complete.** Contract 2	Jun-06	97%
Dirty Butter - Virgin and Hartford	**Complete.**	Oct-04	100%
Woodland Meadows - 8600 E 81st	**Complete.** Contract 2 - Street Cuts	Jul-06	97%
5219 E 105th Street	**Complete.** Improved ditch drainage.	Jan-06	100%
Audobon Creek - 3157 S. 76th E..	**Complete.** Storm sewer extension and inlets.	Aug-05	100%
Little Haikey Creek - 7000 E 72nd	**Complete.** Contract 4 - Street Cuts	Jul-06	95%
Parkview Ditch - Archer and Vancouver	**Complete.** Contract 2 - Street Cuts	Jun-06	97%
Little Haikey Creek - 69th and 71st E	**Complete.**	Jan-05	100%
Parkview Tributary – 2016 W Cameron	**Complete.** Contract 2 - Street Cuts	Jun-06	97%
Dirty Butter Creek - D/S Peoria & Mohawk	**Complete.** Contract 4. Street cuts.	Jul-06	95%
Joe Creek - 6000 S Lewis	**Complete.** Storm sewer extension to drain bar ditch.	May-07	95%
Dirty Butter Creek - D/S Peoria & Mohawk	**Complete.** Contract 4. Street cuts.	Jul-06	95%
Upper Joe Creek	**Complete.** 3319 S. Darlington - UCS constructed project.	Jan-07	94%
Flat Rock - 4400 N Peoria	**Complete.** Contract 2	Jun-06	97%
Elm Creek 6th St Drainage	**Complete.** Need final bill from engr.	Dec-04	99%
Elm Creek 6th St Drainage	Finaled 9/7/07. Includes 3 year maintenance.	Dec-04	99%
Joe Creek - 6700 S. Zunis	**Complete.** Construction in 2005 Bond. Finaled 11/8/07.	Jun-06	100%
Joe Creek Channel Rehab - Phase 1	**Complete.** Finaled 11/8/07.	Jan-06	97%
Rose Dew Channel & Crossing Improvements	Designed with Fee-In-Lieu Funds. Finaled 2/4/08.	Apr-02	99%
Southern Tribs - 5701 E 121st S	**Complete.** Repairing drive.	Oct-07	100%
Mingo Creek	**Complete.** 9703 E. 3rd St. S.	Jan-07	94%
Mingo Creek	**Complete.** 9703 E. 3rd St. S.	Jan-07	94%
Haikey Creek	**Complete.** 7223 E. 77th St. S.	Jan-07	94%
Oak Creek	**Complete.** 400 S. Nogales Ave. - Finaled 11/29/07.	Jan-07	94%
Oak Creek	**Complete.** 400 S. Nogales Ave.	Jan-07	94%
Fred Creek	**Complete.** 7200 S. Sleepy Hollow Drive	Jan-07	94%
Coal Creek - 2600 N. Sheridan	**Complete.** Ditch relining. Final 12/10/07.	Mar-07	95%
Coal Creek - 2600 N. Sheridan	**Complete.** Ditch relining. Final 12/10/07.	Mar-07	95%
Vensel - Wexford - 103rd and Yale	**Complete.** 10300 S. Yale Ave. - Needs complete rehab.	Dec-04	96%
Vensel - Wexford - 103rd and Yale	**Complete.** 10300 S. Yale Ave. - Needs slope stabilization.	Dec-04	96%
Vensel - Wexford - 103rd and Yale	**Complete.** 10300 S. Yale - Needs complete rehab.	Dec-04	96%
Vensel Crk-Wexford Det Pond	**Complete.** 10300 S. Yale Ave. - Needs complete rehab.	Dec-04	96%

Little Joe Creek	**Complete.** 5624 S. 72nd E. Ave.	Jan-07	94%
Little Joe Creek	5624 S. 72nd E. Ave. - Finaled 1/31/08.	Jan-07	94%
Joe Creek - 4320 E 27th	**Complete.** Contract 2	Jun-06	97%
Joe Creek - 3345 S Harvard, 4320 E 27th	**Complete.** Contract 2 - Amendment	Jun-06	97%
Douglas Creek - 822 N 67th E	**Complete.** Contract 2 - Amendment	Jun-06	97%
Perryman Ditch - 3738 S Xanthus	**Complete.** Contract 2	Jun-06	97%
Bell Creek Tributary - 4500 S 91st E	**Complete.** Contract 3 - License agreement w/ RR.	Jul-06	96%
Fry Ditch #2 - 9247S 71st E Ave	**Complete.** Contract 3 - Licsence agreement w/ OTA.	Jul-06	96%
Fieldstone Detention Facility - 5500 E 115th	Contract 2 - Under construction.	Jul-06	97%
Sweetbriar - 7554 E 77th	**Complete**. Contract 2 - Amendment	Jul-06	97%
Vensel Creek - Grupe Channel	**Complete.** 9800 S. Delaware Ave.	Jan-06	99%
8111 S 72nd E	Removing ponding at curb. Under Construction.	Feb-05	99%
8200 S 69th E	Cul-de-sac S. 69th E. Ave at 82nd Street. Under Construction.	Feb-05	99%
8436-8440 S 69th E	Removing ponding at curb. Under Construction.	Feb-05	99%
Vensel Creek (Grupe Channel)	**Complete.** 9800 S. Delaware Ave.	Jan-06	91%
Vensel Creek (Grupe Channel)	**Complete.** 9800 S. Delaware Ave.	Jan-06	91%
Jones Creek - 6935 and 6936 E 13th	**Complete.** Contract 2 - Amendment	Jun-06	97%
Joe Creek - 4523 E 40th	**Complete.** Enlarging inlets in system. Need record drawings.	Dec-07	90%
Crow Creek - 3509 S Yorktown Pl	**Complete.** Regrading Kennebunkport Pond.	Dec-07	90%
Elm Creek - 053308	1228 S. Trenton Ave. - Opened 1/11/08. Finaled 7/15/08.	Jan-07	94%
Cooley Creek	**Complete.** 13700 E. 11th St. S. - Finaled 11/29/07.	Jan-07	94%
Mooser Creek - 244 W 81st Street	Contract 3 - Under construction.	Jul-06	96%
Elm Creek	1228 S. Trenton Ave. - Opened 1/11/08. Finaled 7/15/08.	Jan-07	94%
Tupelo - 12000 E Skelly	Advertised 8/3/07. Open 9/14/07. Finaled 7/29/08.	Aug-07	97%
Tupelo - 12000 E Skelly	Advertised 8/3/07. Open 9/14/07. Finaled 7/29/08.	Aug-07	97%
Tupelo Creek - 12000 E. Skelly	Advertised 8/3/07. Open 9/14/07. Finaled 7/29/08.	Aug-07	97%
Tupelo Creek - 12000 E. Skelly	Advertised 8/3/07. Open 9/14/07. Finaled 7/29/08.	Jul-07	97%
Charles Page Areawide - Phase IV	Grading behind Waterworks to remove ponding.	Jan-08	95%
Winsor Park Drainage Improvements	Channel Stabilization near 3665 E 67th S. Work to resume 8/11/08.	Mar-07	95%
Winsor Park Drainage Improvements	Channel Stabilization near 3665 E 67th S. Public Meeting 5/5/08.	Mar-07	95%

Appendix E: 2009 Plan Update Changes

The following items are the identified significant changes made from the 2003 City of Tulsa Multi-Hazard Mitigation Plan. Changes are based on criteria outlined for Plan Updates in the ***Local Multi-Hazard Mitigation Planning Guidance*** document of July 1, 2008. The changes are indicated on a Chapter-by-Chapter and section-by-section basis, when appropriate.

The FEMA guidance document identified 5 major areas of significance, including:

- Prerequisites
- Planning Process
- Risk Assessment
- Mitigation Strategy
- Plan Maintenance.

In addition, changes in the process for continued public involvement are noted.

Table E-1: Significant Plan Update Changes

Section	Significant Changes
Introduction and general overview	
1.1.5	2009 update reflects the most recent Oklahoma and FEMA goals, as stated in the most recent Oklahoma Enhanced State Mitigation Plan.
1.2	The 2009 update reflects updated land area and land usage maps
All Chapters	While still based primarily on the 2000 U.S. Census, the 2009 update incorporates the most recent 2006 estimates of population numbers, ethnicity, income, etc. when available.
1.2.5 & All Chapter	Additional consideration is given here, and throughout the plan, to identified Special Needs populations, based on the increasing federal and state priorities in that area. Maps identifying such categories as the U.S. Census "People with Disabilities" are used to assist in assessing vulnerabilities.
1.2.6	Lifeline information has been reviewed and, if needed, updated, based on the most current information available from utility and transportation companies.
1.2.7	The Major Employers' List has been updated based on the most current City of Tulsa Comprehensive Financial Report.

Section	Significant Changes
1.2.9 & All Chapters	Critical Facilities has been reviewed and modified as needed based on the most current information from local and state government, Emergency Management, the Chamber of Commerce, and other pertinent entities. It takes into account that FEMA now includes financial institutions as potential critical facilities.
1.2.8 & All Chapters	Future Development takes into account recent planning efforts and zoning, the construction of the new Tulsa BOk Center, and the significance of PLANiTULSA, the currently ongoing update of Tulsa's 30-year old Comprehensive Plan.
Prerequisites	
7.3	The City of Tulsa and the Tulsa Planning Commission will adopt the 2009 Plan by resolution as an amendment to the City's Comprehensive Plan. In the 2003 plan, only "Appropriate Action Items" were incorporated into the Comprehensive Plan.
Planning Process	
3.1	Additional consultants, both local and national, were brought in to assure that the most recent protocols and methods were incorporated into the Planning Process.
3.2	A series of geographically specific, smaller public meetings were used in this iteration of the plan, as opposed to fewer, larger meetings in the last one. In addition, the opportunity for public input was provided on the City of Tulsa website.
3.3	The list of Coordinating Agencies and Organizations was updated and enhanced to include representatives from the Business Community (Tulsa Metro Chamber of Commerce, Home Builders Association of Greater Tulsa), and the educational community (Universities, all Public School Systems).
App. D	An Appendix was included documenting the previously identified mitigation measures from the 2003 Plan, identifying what actions have taken place or are continuing to take place. The Technical Advisory Committee reviewed the list of measures and the status of each for accuracy.
Chap. 1 & 2	In the 2003 plan, the Community Description and Existing Mitigation Measures were included in one Chapter. The plan consultant has successfully separated these two sections into two Chapters in previously completed plans in order to enhance readability of the Plan. The Tulsa Technical Advisory Committee agreed it would be appropriate to continue that approach for the 2009 City of Tulsa Mitigation Plan.

Section	Significant Changes
Risk Assessment	
Chap. 4 All hazards	All risk assessments were reviewed for recent events, using interviews with local response agencies, City of Tulsa Public Works representatives, the state Fire Marshall's database, the NCDC database, National Weather Service Tulsa Forecast Office, and other partners.
Chap. 4 All hazards	With all hazards, risk assessment was analyzed from the specific standpoints of population, structures/buildings, infrastructure, and critical facilities. Not all hazards required an analysis in all four categories (Extreme Heat, for example, produces little building and structure damage directly). This four-part breakdown carried over into the analysis of Future Trends.
Chap. 4 All hazards	In the 2003 plan, scenarios were presented for Floods, Tornadoes, and Dam Breaks. In the 2009 plan, additional scenarios were created for High Winds, Lightning, Hailstorms, Winter Storms, and Extreme Heat.
Chap. 4 All hazards	Updated parcel values from the County Assessor's office and other data sources have been incorporated when available.
Chap. 4 All hazards	Analyses for Vulnerability and Future Trends are now subdivided into sections for Population, Structures, Infrastructure, and Critical Facilities when appropriate.
Chap. 4 All hazards	When estimating losses for Future Development areas, a more robust method for estimating property values has been used. Breaking down zoning based on residential, commercial, and office allows the plan to better estimate the type of development. Averaging property costs based on the most recent development in the Tulsa area based on that type of zoning gives a more specific average parcel value.
4.2	Description and appropriate tables for the Enhanced Fujita Scale, adopted in 2006 by the National Weather Service, were included.
4.6.2	Two recent highly documented major winter storms allowed for a much more detailed estimate of potential damages from future storms and the development of a much more rigorous process for creating a Winter Storm Scenario which could illustrate a "worst-case scenario."
4.10.1.5	The increased spread of Eastern Red Cedar and its contribution to Oklahoma wildfire risk was studied in conjunction with the University of Oklahoma Department of Agriculture. These concerns were incorporated into the plan.
4.10.2 Fig. 4-18 Tbl. 4-30	Wildfire risk assessment was conducted using the recently released Southern Wildfire Risk Assessment Survey tools. With this, the plan was able to identify a significantly more detailed map of the areas of the community with a substantial level of concern.

Section	Significant Changes
4.11.1	An updated version of HAZUS allows for a much more effective hazard assessment of potential earthquake damage.
4.12	Dam Failures and Levee Failures, included in separate sections in the 2003 Plan, were combined into one section in the 2009 Plan. It was agreed by the TAC and CAC that the hazards are so closely interconnected that they could be dealt with more effectively as a combined hazard assessment.
4.1.2.2 App. G	Repetitive loss structures are addressed more strongly in the new plan, mapped in Chapter 4, and fully listed in Appendix G.
Mitigation Strategy	
2003 Chapter 4	Goals and Objectives from the 2003 plan were individually reviewed and evaluated based on both progress made in mitigation strategies, and in other plan development for the City.
5.1 5.2	In the 2003 plans, general goals, and appropriate disaster-specific goals were enumerated in the Mitigation Strategy Chapter. In the 2009 update, a separate Chapter was developed for Goals and Objectives. An overall Mission Statement was developed along with an overall Mitigation Goal. This was followed by a series of Goals for all hazards to refine the overall goal. A Goal was then developed for each of the 12 addressed hazards, and a specific Objective was developed for each of the 6 mitigation categories: Public Information & Education, Preventive Measures, Structural Projects, Property Protection, Emergency Services, and Natural Resource Protection. This produced a total of 72 overall Objectives to more effectively define the City of Tulsa Mitigation Strategies.
5.1 5.2	Goals and Objectives were evaluated in view of the changes in the development of current City Planning Documents, to include the updated Capital Improvement Plans, and the current ongoing process of updating the Tulsa Comprehensive Plan through the PLANiTULSA program (www.planitulsa.org).
5.1 5.2	Goals and Objectives were reviewed and evaluated in light of progress made in previous Mitigation Measures during the last 5 years. Also in light of issues that have arisen due to After Action Evaluations from recent disaster incidents, i.e. – recognizing that generator power for fueling stations is a critical issue occurred following adverse impacts during the 2007 Winter Ice Storm.
App. D	An Appendix was included documenting the previously identified mitigation measures from the 2003 Plan, identifying what actions have taken place or are continuing to take place. The Technical Advisory Committee reviewed the list of measures and the status of each for accuracy.

Section	Significant Changes
Plan Maintenance	
7.1	The ongoing Monitoring and Evaluation of the Mitigation Plan has been made more robust by requiring more frequent meetings of the Technical Advisory Committee, more frequent update reports to critical personnel in City Government, and by requiring semi-annual, as opposed to annual, reports to the Hazard Mitigation Planning Committee. This will simplify the update process by helping to ensure that ongoing revisions and updates are developed on an interim basis.
7.2	The City of Tulsa is committed to involving the public directly in updating and maintaining the Multi-Hazard Mitigation Plan. Copies of the Plan will be maintained at the public library, and the plan will be placed on the website of the City of Tulsa. In addition, the Plan Coordinator will be conducting small, area-specific meetings on no less than a semi-annual basis at Public Libraries or other public venues, similar to the public meetings used in the development of the 2009 plan.
7.3	The 2009 Plan Update will be incorporated into the PLANiTULSA program that is currently updating the City of Tulsa Comprehensive Plan. Representatives of the Mitigation Plan Technical Advisory Committee also sit on the PLANiTULSA Committees, and are committed to ensuring that appropriate elements of the plan are carried through into the Comprehensive Plan.
Continued Public Involvement	
3.1 – 3.2	The Stormwater Drainage and Hazard Mitigation Advisory Board has met regularly over the previous 5 years to ensure that continued public involvement in the 2003 Hazard Mitigation Plan has been maintained.
7.2	As mentioned above in Plan Maintenance, the Plan Coordinator is committed to conducting small, geographic-specific meetings throughout the 5-year period before the next update. This will ensure that public involvement is continual and robust.

Appendix F: City of Tulsa Capital Improvements Plan

CITY OF TULSA
FISCAL YEARS 2009-2013 CAPITAL IMPROVEMENTS FUNDING SCHEDULE
Prepared by the Department of Finance in Collaboration with the Operating Departments
All Dollars In Thousands. Projects Shown in Boldface Type are New Requests
Priority Indicated Represents Department's Rating
BLUE indicates revised, RED indicates projects added by Stormwater Planning

CITY OF TULSA
FISCAL YEARS 2009-2013 CAPITAL IMPROVEMENTS FUNDING SCHEDULE
Prepared by the Department of Finance in Collaboration with the Operating Departments
All Dollars In Thousands. Projects Shown in Boldface Type are New Requests
Priority Indicated Represents Department's Rating
BLUE indicates revised, RED indicates projects added by Stormwater Planning

										Priority			
Ref.	**Project**	**Est. Cost**	**FY09**	**FY10**	**FY11**	**FY12**	**FY13**	**Total**	**Funding Source**	**FY08**	**FY07**	**Comments**	**Ref.**
	Flood Control Projects												**Flood Control Projects**
1	Brookhollow Creek - Bridges and Channel Improvements (MUM6B)	$1,000		$1,000				$1,000	Future Bond Program	High	New	Replace two bridges at 136th and 137th East Avenue over Brookhollow Creek, and improvements to the channel including widening. Improvements will alleviate potential flooding to residences in Eastland Acres Addition.	1
2	Citywide - Bridge and Culvert Replacements	$8,000	$400	$600	$600	$600	$600	$2,800	Storm Sewer Enterprise	High	High	Coordinate with street capital programs. Includes Mingo Road Bridges, Mountain Manor, Tupleo Creek, and other bridges constricting flows.	2
3	Citywide - Concrete Channel Rehabilitation	$10,000	$100	$500	$500	$500	$500	$2,100	Storm Sewer Enterprise	High	High	Perform joint and panel repair at various sites in the City. Surface Drainage/Vegetative Management has identified various locations as needing immediate repairs beyond their normal activities. Priorities to be established by channel inventory.	3
4	Citywide - Stormwater Facility Repair and Construction	$5,000		$900	$900	$900	$900	$3,600	Future Bond Program	High	High	Continuous funding needed. Partially funded by 99 GO Bonds.	4
5	Citywide - Urban Lake Maintenance	$2,500		$250	$250	$250	$250	$1,000	Future Bond Program	High	High	Perform emergency and scheduled repair at various sites throughout the City. These are in response to urgent citizen and Surface Drainage/Vegetative Maintenance requests.	5
6	Citywide - Urgent Small Drainage Projects	$7,000	$685	$1,000	$1,000	$1,000	$1,000	$4,685	Storm Sewer Enterprise	High	High	Backlog needs to be addressed. 2005 GO funded $2.5 million for Swan/Travis, Vensel, Fred Trib. #3, Little Joe, Oak, Mingo, Perryman, Elm, Haikey, Upper Joe, Fred, Crow, and Cooley small projects in exiting inventory.	6
7	**Coal Creek - Rose Hill Cemetery**	**$5,170**		**$850**	**$460**	**$3,860**		**$5,170**	**Future Bond Program**	**High**	**High**	**Project is to address erosion in Rose Hill Cemetery the is unearthing graves.**	**7**
8	Coal Creek - Pine St. and Fulton Ave. Drainage Improvements	$350		$350				$350	Future Bond Program	High	High	Alleviate street flooding in this intersection. Project includes inlets and approx. 400 LF of reinforced concrete pipe.	8
9	Elm Creek - North Branch Detention Facility (EL4)	$4,420			$400	$4,020		$4,420	Future Bond Program	High	High	Construction of a flow through detention facility to contain the regulatory flood event. Part of a proposed Urban Renewal Project.	9
10	Fred Creek - Richmond Tributary Drainage Channel Improvements (FR14)	$250		$250				$250	Future Bond Program	High	Low	Correct erosion problem behind houses at 71st & Richmond Ave. by improving approximately 900 LF of drainage channel.	10
11	**Fry Ditch #2 - Forest Meadows Detention Pond Pump Station**	**$890**		**$100**	**$790**			**$890**	**Future Bond Program**	**High**	**High**	**Homeowners Association has requested that Public Works take over maintenance of this facility. Project is to bring facility up to City standards.**	**11**
12	Fulton Creek - Lazy Circle Acres Channel Improvements (MUM3)	$1,400		$400	$1,000			$1,400	Future Bond Program	High	New	Construct channel improvements for Fulton Creek. Severe erosion is causing flooding problems in the area. Reaches upstream and downstream are improved. Purpose of project is to improve flow characteristics of the channel while controlling erosion.	12
13	Mingo Creek (Lower) - Carriage Village Mobile Home Park Drainage Improvements (LM4)	$5,130			$450	$1,050		$1,500	Future Bond Program	High	New	Project would upsize storm sewers, provide additional inlets, and improved ditches. This is a top priority project for both Surface Drainage and Underground Collections. Project could be constructed in two phases.	13
14	Parkview Creek - Central High School Channel (PV10)	$300		$300				$300	Future Bond Program	High	High	Existing creek (RB-4) runs through campus of Central High School. Proposed improvements will lessen the risk of adjacent classrooms flooding.	14
15	Tupelo Creek - Cherokee Village Relief Drainage System (MLM8A) (Phase 1)	$5,130			$600			$600	Future Bond Program	High	High	Relief storm sewer to reduce flooding to residences along existing system. Two residences adjacent to Tupelo Creek will be acquired. This is phase one of four to be constructed in the area to improve drainage. Funding for design and right-of-way.	15
	Total Flood Control Projects	**$56,540**	**$1,185**	**$6,500**	**$6,950**	**$12,180**	**$3,250**	**$30,065**					

Appendix G: City of Tulsa Critical Facilities

Cat	ID	NAME	ADDRESS	CITY	ZIP	PHONE #
City of Tulsa Facilities						
CoTF	CA1	City Garage	1720 W Newblock Park Dr	Tulsa	74127	
CoTF	CA2	City Of Tulsa (City Hall)	200 Civic Center Plaza	Tulsa	74103	
CoTF	CA3	River Parks Authority	717 S Houston Ave, S 510	Tulsa	74127	596-2001
CoTF	CA4	Tulsa Convention Center	100 Civic Center	Tulsa	74103	596-7177
CoTF	CA5	Tulsa Performing Arts Center	110 E 2nd St	Tulsa	74103	596-7122
CoTF	PD1	Fuel Island - UDN	3411 N Columbia Ave	Tulsa	74110	
CoTF	PD2	Fuel Island - UDSW	7515 S Riverside Dr	Tulsa	74136	
CoTF	PD3	Tulsa Police Department (Courts Bldg)	600 Civic Center	Tulsa	74103	
CoTF	PD4	Tulsa Police Department Support Division	5963 E 13th St	Tulsa	74112	669-6861
CoTF	PD5	Tulsa Police Department Training Facility	6066 E 66th St N	Tulsa	74117	591-4500
CoTF	PD6	Tulsa Police Dept (North Div)	3411 N Columbia	Tulsa	74110	591-4100
CoTF	PD7	Tulsa Police Dept (East Div)	10122 E 11th St	Tulsa	74128	669-6000
CoTF	PD8	Tulsa Police Dept (Southwest Div)	7515 Riverside Dr	Tulsa	74136	596-1100
CoTF	PD9	Tulsa Police Dept Seized Vehicle Facility	1326 E Mohawk Blvd	Tulsa	74106	
CoTF	PD10	Tulsa Police Offices Street Level	600 Civic Center	Tulsa	74103	
CoTF	FD1	Communication Area For Fire Dept	1712 S Phoenix Ave	Tulsa	74107	
CoTF	FD2	Fire Dept Dog Kennel	1760 Newblock Park Dr	Tulsa	74127	
CoTF	FD3	Fire Station #9	1420 Charles Page Blvd	Tulsa	74127	
CoTF	FD4	Garage & Fuel Facility	1720 Newblock Park Dr	Tulsa	74127	
CoTF	FD5	Tulsa Fire Department #10	508 E Pine St	Tulsa	74106	
CoTF	FD6	Tulsa Fire Department #11	5009 E 15th St	Tulsa	74112	
CoTF	FD7	Tulsa Fire Department #12	3123 W 40th St	Tulsa	74107	
CoTF	FD8	Tulsa Fire Department #13	345 S 41st W Ave	Tulsa	74127	
CoTF	FD9	Tulsa Fire Department #14	3602 S Lewis Ave	Tulsa	74105	
CoTF	FD10	Tulsa Fire Department #15	4168 E Admiral Pl	Tulsa	74115	
CoTF	FD11	Tulsa Fire Department #16	1401 N Lewis Ave	Tulsa	74110	
CoTF	FD12	Tulsa Fire Department #17	1351 N Sheridan Rd	Tulsa	74115	
CoTF	FD13	Tulsa Fire Department #18	4802 S Peoria Ave	Tulsa	74105	
CoTF	FD14	Tulsa Fire Department #19	509 E 56th St N	Tulsa	74126	

Cat	ID	NAME	ADDRESS	CITY	ZIP	PHONE #
CoTF	FD15	Tulsa Fire Department #2	524 W Edison St	Tulsa	74103	
CoTF	FD16	Tulsa Fire Department #21	4606 E 31st St	Tulsa	74135	
CoTF	FD17	Tulsa Fire Department #22	616 S 73rd E Ave	Tulsa	74112	
CoTF	FD18	Tulsa Fire Department #23	4348 E 51st St	Tulsa	74135	
CoTF	FD19	Tulsa Fire Department #24	3520 N Peoria Ave	Tulsa	74106	
CoTF	FD20	Tulsa Fire Department #25	7419 E 42nd Pl	Tulsa	74145	
CoTF	FD21	Tulsa Fire Department #26	2404 W 51st St	Tulsa	74107	
CoTF	FD22	Tulsa Fire Department #27	11707 E 31st St	Tulsa	74146	
CoTF	FD23	Tulsa Fire Department #28	7310 E 71st Street	Tulsa	74133	
CoTF	FD24	Tulsa Fire Department #29	7429 S Lewis Ave	Tulsa	74136	
CoTF	FD25	Tulsa Fire Department #3	62 N Utica Ave	Tulsa	74110	
CoTF	FD26	Tulsa Fire Department #30	14333 E 11th St	Tulsa	74108	
CoTF	FD27	Tulsa Fire Department #31	3002 N Mingo Rd	Tulsa	74116	
CoTF	FD28	Tulsa Fire Department #32	6010 E 91st St	Tulsa	74137	
CoTF	FD29	Tulsa Fire Department #4	524 W 12th St	Tulsa	74119	
CoTF	FD30	Tulsa Fire Department #5	102 E 18th St	Tulsa	74119	
CoTF	FD31	Tulsa Fire Department #51 (Airport)	Taxiway Echo & Bravo	Tulsa	74116	
CoTF	FD32	Tulsa Fire Department #6	7212 S Union Ave	Tulsa	74132	
CoTF	FD33	Tulsa Fire Department #7	601 S Lewis Ave	Tulsa	74104	
CoTF	FD34	Tulsa Fire Department Hazardous Mtls	1420 W Charles Page Blvd	Tulsa	74127	
CoTF	FD35	Tulsa Fire Department Hdqtrs	411 S Frankfort Ave	Tulsa	74120	596-9444
CoTF	FD36	Tulsa Fire Department Supply	1790 Newblock Park Dr	Tulsa	74127	
CoTF	FD37	Tulsa Fire Department Training	1760 Newblock Park Dr	Tulsa	74127	596-9420
CoTF	FD38	Tulsa Fire Dept (Alarm Office/tower)	1010 E 8th St	Tulsa	74120	
CoTF	PW1	Chemical Storage Building	2317 S Jackson Ave	Tulsa	74107	
CoTF	PW2	Equipment Maintenance	5625 S Garnett Rd	Tulsa	74146	
CoTF	PW3	Equipment Management	1720 Newblock Park Dr	Tulsa	74127	
CoTF	PW4	Field Customer Services	2445 S Jackson Ave	Tulsa	74107	
CoTF	PW5	Fuel Facility	2317 S Jackson Ave	Tulsa	74107	
CoTF	PW6	Portable Building	2317 S Jackson Ave	Tulsa	74107	
CoTF	PW7	Satellite Fuel Station	1747 S 101st E Ave	Tulsa	74128	
CoTF	PW8	Storage Shed	2317 S Jackson Ave	Tulsa	74107	
CoTF	PW9	Street Dept Garage/Offices	5675 S Garnett Rd	Tulsa	74146	

Cat	ID	NAME	ADDRESS	CITY	ZIP	PHONE #
CoTF	PW10	Structural Maintenance	1712 Charles Page Blvd	Tulsa	74127	
CoTF	PW11	Surplus Facility	2317 S Jackson Ave	Tulsa	74107	
CoTF	PW12	Tire Shop	2317 S Jackson Ave	Tulsa	74107	
CoTF	PW13	W&M South Yard Storage Building	2317 S Jackson Ave	Tulsa	74107	
CoTF	PW14	W&M South Yard Office/stock Building	2317 S Jackson Ave	Tulsa	74107	
CoTF	PW15	Warehouse/Materials Stockroom	2317 S Jackson Ave	Tulsa	74107	
CoTF	PW16	Water District Office/Warehouse	5605 S Garnett Rd	Tulsa	74146	
Federal - State - County Government						
FSCG	FG1	USPS - Downtown Post Office	333 W 4th St	Tulsa	74103	
FSCG	FG2	USPS - Whittier Post Office	111 S Lewis Ave	Tulsa	74104	584-3204
FSCG	FG3	USPS - Northside Post Office	626 E Apache	Tulsa	74106	584-0745
FSCG	FG4	USPS - Gilcrease Post Office	4001 W Edison	Tulsa	74127	585-6026
FSCG	FG5	USPS - Tulsa AMF Retail	2161 Cargo Rd	Tulsa	74115	
FSCG	FG6	USPS - Northeast Post Office	5313 E Independence	Tulsa	74115	
FSCG	FG7	USPS - Univ. of Tulsa Post Office	800 S Tucker Dr	Tulsa	74104	631-2110
FSCG	FG8	USPS - Westside Post Office	3408 W 42nd Pl	Tulsa	74107	
FSCG	FG9	USPS - Donaldson Post Office	1423 Terrace Dr	Tulsa	74104	744-4158
FSCG	FG10	Post Office - CPU American Heritage Bank	7042 S Union	Tulsa	74132	
FSCG	FG11	USPS - Robert Jenkins Post Office	6910 S Yorktown	Tulsa	74136	
FSCG	FG12	USPS - Sheridan Tulsa Post Office	6110 E 51st Pl	Tulsa	74133	
FSCG	FG13	USPS - Southeast Tulsa Post Office	9023 E 46st St	Tulsa	74145	
FSCG	FG14	USPS - Eastside Tulsa	2920 S 129th E Ave	Tulsa	74134	664-8618
FSCG	FG15	FBI - Tulsa	8023 E 63rd Pl	Tulsa	74133	664-3300
FSCG	FG16	NOAA - NWS	10159 E 11th St	Tulsa	74128	838-7838
FSCG	FG17	USACE	1645 S 101st E Ave	Tulsa	74128	669-7201
FSCG	FG18	Internal Revenue Service	1645 S 101st E Ave	Tulsa	74128	622-8482
FSCG	FG19	USPS - Postage Handling Facility	2114 S 91st E Ave	Tulsa	74141	270-7533
FSCG	FG20	ATF	125 W 15th St	Tulsa	74119	581-7731
FSCG	FG21	Secret Service	125 W 15th St	Tulsa	74119	581-7272
FSCG	FG22	US Attorney	110 W 7th St	Tulsa	74119	382-2700
FSCG	SG1	Oklahoma Air National Guard - 138th Fighter Wing	9100 E 46th St	Tulsa	74115	833-7000
FSCG	SG2	Oklahoma Highway Patrol - Troop B HQ	9191 E Skelly Dr	Tulsa	74129	627-3881
FSCG	SG3	Medical Examiner	1115 W 17th St	Tulsa	74107	582-0985

Cat	ID	NAME	ADDRESS	CITY	ZIP	PHONE #
FSCG	SG4	Dept. of Human Services	444 S Houston	Tulsa	74127	581-2401
FSCG	SG5	OK State Office Building	440 S Houston	Tulsa	74127	581-2885
FSCG	CG1	TAEMA Emergency Operations Center	600 Civic Center	Tulsa	74103	596-9899
FSCG	CG2	Tulsa City-County Health Dept, Main	5051 S. 129th East Ave.	Tulsa	74134	582-9355
FSCG	CG3	Tulsa City-County Health Department	4616 E. 15th St.	Tulsa	74112	594-4780
FSCG	CG4	Tulsa City-County Health Department	315 S. Utica	Tulsa	74104	
FSCG	CG5	Tulsa County Correctional Facility	300 N. Denver	Tulsa	74103	596-8900
FSCG	CG6	Tulsa County Deputy Sheriff	3240 Charles Page Blvd	Tulsa	74127	
FSCG	CG7	Tulsa County Offices	500 S. Denver Ave	Tulsa	74103	596-5000
FSCG	CG8	Tulsa County Sheriff	500 S. Denver Ave	Tulsa	74103	596-5601
FSCG	CG9	Tulsa County Sheriff Office	303 W. 1st St.	Tulsa	74103	596-5701
FSCG	CG10	Tulsa County Offices	500 S. Denver Ave.	Tulsa	74103	
FSCG	CG11	Tulsa County Sheriff Office	303 W. 1st St.	Tulsa	74103	596-5701
FSCG	CG12	OK Highway Dept Construction Division	4002 N. Mingo Expressway	Tulsa	74116	
FSCG	CG13	Tulsa Co Fairgrounds	4145 E 21st St	Tulsa	74114	744--1113
FSCG	CG14	Tulsa County Juvenile Detention Center	315 S Gilcrease	Tulsa	74127	596-5971
		Major Medical				
MMED	BH1	Brookhaven Hospital	201 S Garnett Rd	Tulsa	74128	438-4257
MMED	HO2	Hillcrest Medical Center	1120 S Utica Ave	Tulsa	74104	579-1000
MMED	HO3	Hillcrest Speciality Hospital	1125 S Trenton Ave	Tulsa	74120	579-7300
MMED	BH4	Laureate Psychiatric Clinic & Hospital	6655 S Yale Ave	Tulsa	74136	481-5600
MMED	HO5	Saint Francis Hospital	6161 S Yale Ave	Tulsa	74136	494-2497
MMED	HO6	Select Speciality Hospital - Tulsa	6161 S Yale Ave, 5 South	Tulsa	74136	502-1400
MMED	HO7	Oklahoma Surgical Hospital	2408 E 81st St Ste 300	Tulsa	74137	477-0578
MMED	HO8	Tulsa Spine & Speciality Hospital	6901 S Olympia	Tulsa	74132	388-5701
MMED	BH9	Shadow Mountain Behavioral Health System	6262 S Sheridan Rd	Tulsa	74133	492-8200
MMED	HO10	SouthCrest Hospital	8801 S 101st East Ave	Tulsa	74133	294-4000
MMED	HO11	Saint Francis Heart Hospital	10501 E 91st St	Tulsa	74012	307-6000
MMED	HO12	Southwestern Regional Medical Center	10109 E 79th St	Tulsa	74133	286-5000
MMED	BH13	Parkside Community Psychiatric Services & Hospital	1620 E 12th St	Tulsa	74120	582-2131
MMED	HO14	Saint John Medical Center	1923 S Utica Ave	Tulsa	74104	744-3157
MMED	HO15	Oklahoma State University Medical Center	744 W 9th St	Tulsa	74127	587-2561
MMED	HO16	Meadowbrook Specialty Hospital of Tulsa	3219 S 79th East Ave	Tulsa	74145	663-8183

Cat	ID	NAME	ADDRESS	CITY	ZIP	PHONE #
Local Financial Headquarters						
FNCL	LF1	American Bank & Trust Corp	6100 S Yale Ave	Tulsa	74136	481-3000
FNCL	LF2	American TrustCorp	5727 S Lewis Ave	Tulsa	74105	744-0053
FNCL	LF3	Bank of Oklahoma Tech. Center	6424 E 41st St	Tulsa	74135	619-0509
FNCL	LF4	Bank South of Tulsa	6130 E 81st St	Tulsa	74137	492-2882
FNCL	LF5	Oklahoma Central Credit Union	11335 E 41st St	Tulsa	74146	664-6000
FNCL	LF6	ONB Bank & Trust Co.	8908 S Yale Ave	Tulsa	74137	744-7400
FNCL	LF7	Triad Bank NA	7666 E 61st St	Tulsa	74133	254-1444
FNCL	LF8	Tulsa Valley Bancshares	8080 S Yale Ave	Tulsa	74137	495-1700
FNCL	LF9	Tulsa National Bancshares	7120 S Lewis Ave	Tulsa	74136	494-4884
FNCL	LF10	Trust Co of Oklahoma	6120 S Yale Ave	Tulsa	74136	744-0553
FNCL	LF11	National Bank of Commerce	7127 Riverside	Tulsa	74136	499-5990
FNCL	LF12	Sooner Southwest Bankshares	1751 E 71st St	Tulsa	74136	496-4242
FNCL	LF13	Tulsa Teachers Credit Union	3720 E 31st St	Tulsa	74135	749-8828
FNCL	LF14	F & M Bank Trust Co	1330 S Harvard Ave	Tulsa	74112	748-4000
FNCL	LF15	Bank of Oklahoma	1 Wiliams Ctr	Tulsa	74172	588-6000
FNCL	LF16	BOK Financial Corp	Bank of Oklahoma Tower	Tulsa	74172	588-6000
FNCL	LF17	Energy One Federal Credit Union	220 W 7th	Tulsa	74119	699-7100
FNCL	LF18	Peoples State Bank Inc	445 S Lewis Ave	Tulsa	74104	583-9800
FNCL	LF19	Red Crown Federal Credit Union	509 S Boston	Tulsa	74103	477-3200
FNCL	LF20	Tulsa Federal Employees Credit Union	401 E 4th	Tulsa	74120	583-5076
Education Facilities - Public Schools						
PBLSC	JES1	Jenks East Elementary School	8925 S. Harvard Ave.	Tulsa	74137	299-4411
PBLSC	JES2	Jenks Southeast Elementary School	10222 S. Yale Ave.	Tulsa	74137	299-4415
PBLSC	JMS1	Jenks Middle School	3019 E. 101st St.	Tulsa	74137	299-4411
PBLSC	JMS2	Jenks East Intermediate School	3933 E. 91st St.	Tulsa	74137	299-4411
PBLSC	TES1	Addams Elementary School	5323 S 65th West Ave	Tulsa	74107	746-8780
PBLSC	TES2	Alcott Elementary School	525 E 46th St North	Tulsa	74126	746-9660
PBLSC	TES3	Anderson Elementary School	1921 E 29th St North	Tulsa	74110	925-1300
PBLSC	TES4	Zarrow International School	2714 S 90th East Ave	Tulsa	74129	925-1560
PBLSC	TES5	Barnard Elementary School	2324 E 17th St	Tulsa	74104	833-9420
PBLSC	TES6	Bell Elementary School	6304 E Admiral	Tulsa	74115	833-8600
PBLSC	TES7	Bryant Elementary School	6201 E Virgin St	Tulsa	74115	746-9300

Cat	ID	NAME	ADDRESS	CITY	ZIP	PHONE #
PBLSC	TES8	ECDC	2703 N Yorktown Pl	Tulsa	74110	925-1400
PBLSC	TES9	Burroughs Elementary School	1924 N Cincinnati Ave	Tulsa	74106	833-8780
PBLSC	TES10	Carnegie Elementary School	4309 E 56th St	Tulsa	74135	833-9440
PBLSC	TES11	Cherokee Elementary School	6001 N Peoria Ave	Tulsa	74126	833-8840
PBLSC	TES12	Chouteau Elementary School	575 N 39th West Ave	Tulsa	74127	833-8800
PBLSC	TES13	Celia Clinton Elementary School	1740 N Harvard Ave	Tulsa	74115	746-9320
PBLSC	TES14	Columbus Elementary School	10620 E 27th St	Tulsa	74129	925-1460
PBLSC	TES15	Cooper Elementary School	1808 S 123rd East Ave	Tulsa	74128	746-9480
PBLSC	TES16	Disney Elementary School	11702 E 25th St	Tulsa	74129	925-1480
PBLSC	TES17	Eisenhower International School	2819 S New Haven Ave	Tulsa	74114	746-9100
PBLSC	TES18	Eliot Elementary School	1442 E 36th St	Tulsa	74105	746-8700
PBLSC	TES19	Emerson Elementary School	909 N Boston Ave	Tulsa	74106	925-1320
PBLSC	TES20	Eugene Field Elementary School	2249 S Phoenix Ave	Tulsa	74107	746-8840
PBLSC	TES21	Greeley Elementary School	105 E 63rd St North	Tulsa	74126	746-9680
PBLSC	TES22	Grimes Elementary School	3213 E 56th St	Tulsa	74105	746-8720
PBLSC	TES23	Hawthorne Elementary School	1105 E 33rd St North	Tulsa	74106	925-1340
PBLSC	TES24	Hoover Elementary School	2327 S Darlington Ave	Tulsa	74114	746-9120
PBLSC	TES25	Houston Elementary School	5402 N Cincinnati Ave	Tulsa	74126	746-9020
PBLSC	TES26	Jackson Elementary School	2137 N Pittsburg Ave	Tulsa	74115	746-9340
PBLSC	TES27	Jones Elementary School	1515 S. 71st E. Ave.	Tulsa	74112	746-9040
PBLSC	TES28	Kendall-Whittier Elementary School	2601 E 5th Pl	Tulsa	74104	833-9900
PBLSC	TES29	Kerr Elementary School	202 S 117th East Ave	Tulsa	74128	746-9580
PBLSC	TES30	Key Elementary School	5702 S Irvington Ave	Tulsa	74135	833-9480
PBLSC	TES31	Lanier Elementary School	1727 S Harvard Ave	Tulsa	74112	833-9380
PBLSC	TES32	Lee Elementary School	1920 S Cincinnati Ave	Tulsa	74119	833-9400
PBLSC	TES33	Lindbergh Elementary School	931 S 89th East Ave	Tulsa	74112	833-8700
PBLSC	TES34	Mark Twain Elementary School	541 S 43rd West Ave	Tulsa	74127	833-8820
PBLSC	TES35	Marshall Elementary School	1142 E 56th St	Tulsa	74105	746-8740
PBLSC	TES36	MacArthur Elementary School	2182 S 73rd East Ave	Tulsa	74129	746-9140
PBLSC	TES37	McClure Elementary School	1770 E 61st St	Tulsa	74136	746-8760
PBLSC	TES38	McKinley Elementary School	6703 E King Ave	Tulsa	74115	833-8720
PBLSC	TES39	Mitchell Elementary School	733 N 73rd East Ave	Tulsa	74115	833-8740
PBLSC	TES40	Owen Elementary School	1132 N Vandalia Ave	Tulsa	74115	746-9230

Cat	ID	NAME	ADDRESS	CITY	ZIP	PHONE #
PBLSC	TES41	Park Elementary School	3205 W 39th St	Tulsa	74107	746-8860
PBLSC	TES42	Patrick Henry Elementary School	3820 E 41st St	Tulsa	74135	746-9160
PBLSC	TES43	Peary Elementary School	10818 E 17th St	Tulsa	74128	925-1520
PBLSC	TES44	Penn Elementary School	2138 E 48th St North	Tulsa	74130	833-8940
PBLSC	TES45	Phillips Elementary School	3613 S Hudson Ave	Tulsa	74135	746-9180
PBLSC	TES46	Newcomer International School	10908 E 5th St	Tulsa	74128	746-6930
PBLSC	TES47	Remington Elementary School	2524 W 53rd St	Tulsa	74107	746-8880
PBLSC	TES48	Robertson Elementary School	2721 W 50th St	Tulsa	74107	746-8900
PBLSC	TES49	Roosevelt Elementary School	1202 W Easton St	Tulsa	74127	833-8960
PBLSC	TES50	Salk Elementary School	7625 E 58th Ave	Tulsa	74145	833-9500
PBLSC	TES51	Sandburg Elementary School	18580 E 3rd St	Tulsa	74108	746-9640
PBLSC	TES52	Sequoyah Elementary School	3441 E Archer	Tulsa	74115	746-9360
PBLSC	TES53	Skelly Elementary School	2940 S 90th East Ave	Tulsa	74129	925-1540
PBLSC	TES54	Springdale Elementary School	2510 E Pine St	Tulsa	74110	746-9380
PBLSC	TES55	Whitman Elementary School	3924 N Lansing Ave	Tulsa	74106	925-1380
PBLSC	TES56	Wright Elementary School	1110 E 45th Pl	Tulsa	74105	746-8920
PBLSC	TES57	Academy Central Elementary School	1789 W Seminole St	Tulsa	74127	833-8760
PBLSC	TES58	Grissom Elementary School	6646 S 73rd East Ave	Tulsa	74133	833-9460
PBLSC	TES59	Mayo Demonstration Academy	2525 S 101st East Ave	Tulsa	74129	925-1500
PBLSC	TMS1	Byrd Middle School	7502 E 57th St	Tulsa	74145	833-9520
PBLSC	TMS2	Carver Middle School	624 E Oklahoma Pl	Tulsa	74106	925-1420
PBLSC	TMS3	Cleveland Middle School	724 N Birmingham Ave	Tulsa	74110	946-9400
PBLSC	TMS4	Clinton Middle School	2224 W 41st St	Tulsa	74107	746-8640
PBLSC	TMS5	Edison Middle School	2800 E 41st St	Tulsa	74105	746-8500
PBLSC	TMS6	Foster Middle School	12121 E 21st St	Tulsa	74129	746-9500
PBLSC	TMS7	Franklin Youth Academy	1136 S. Allegheny Ave	Tulsa	74112	833-9860
PBLSC	TMS8	Fulton Teaching & Learning Academy	8906 E 34th St	Tulsa	74145	925-1100
PBLSC	TMS9	Gilcrease Middle School	5550 N Cincinnati Ave	Tulsa	74126	746-9600
PBLSC	TMS10	Hamilton Middle School	2316 N Norwood Pl	Tulsa	74115	746-9440
PBLSC	TMS11	Lewis and Clark Middle School	737 S Garnett Rd	Tulsa	74128	746-9540
PBLSC	TMS12	Madison Middle School	4132 W Cameron St	Tulsa	74127	833-8860
PBLSC	TMS13	Nimitz Middle School	3111 E 56th St	Tulsa	74105	746-8800
PBLSC	TMS14	Whitney Middle School	2177 S 67th East Ave	Tulsa	74129	746-9260

Cat	ID	NAME	ADDRESS	CITY	ZIP	PHONE #
PBLSC	TMS15	Wilson Middle School	1127 S Columbia Ave	Tulsa	74104	833-9340
PBLSC	TMS16	KIPP Tulsa Academy	1661 E Virgin St	Tulsa	74106	925-1580
PBLSC	TMS17	Thoreau Demonstration Academy	7370 E 71st St	Tulsa	74133	833-9700
PBLSC	THS1	Booker T Washington High School	1514 N Zion St	Tulsa	74106	925-1000
PBLSC	THS2	Central High School	3101 W Edison St	Tulsa	74127	833-8400
PBLSC	THS3	East Central High School	12150 E 11th St	Tulsa	74128	746-9700
PBLSC	THS4	Edison High School	2906 E 41st St	Tulsa	74105	746-8500
PBLSC	THS5	Hale High School	6960 E 21st St	Tulsa	74129	925-1200
PBLSC	THS6	McLain High School	4929 N Peoria Ave	Tulsa	74126	833-8500
PBLSC	THS7	Memorial High School	5840 S Hudson	Tulsa	74135	833-9600
PBLSC	THS8	Rogers High School	3909 E 5th Pl	Tulsa	74112	833-9000
PBLSC	THS9	Webster High School	1919 W 40th St	Tulsa	74107	746-8000
PBLSC	THS10	Project "12"	1205 W. Newton	Tulsa	74127	833-8650
PBLSC	UES1	Union George F Boevers Elementary	3433 S 133rd E. Ave	Tulsa	74134	633-3646
PBLSC	UES2	Union Briarglen Elementary	3303S 121st E Ave	Tulsa	74146	622-8321
PBLSC	UES3	Union Cedar Ridge Elementary	9817 S Memorial Dr	Tulsa	74133	252-9495
PBLSC	UES4	Union Roy Clark Elementary	3656 S 103rd E Ave	Tulsa	74146	664-9464
PBLSC	UES5	Union James Darnaby Elementary	7625 E 87th St	Tulsa	74133	252-5759
PBLSC	UES6	Union Robert Grove Elementary	10202 E 62nd St	Tulsa	74133	252-5511
PBLSC	UES7	Union Wesley Jarman Elementary	9015 E 79th E Ave	Tulsa	74133	250-3855
PBLSC	UES8	Union Rosa Parks Elementary	13702 E 46th Pl S	Tulsa	74134	357-2757
PBLSC	UES9	Union Thomas Jefferson Elementary	8418 S 107th E Ave	Tulsa	74133	357-4339
PBLSC	UMS1	Union 6th - 7th Grade Center	1011 E 61st St	Tulsa	74133	459-2730
PBLSC	UMS2	Union 8th Grade Center	6501 S Garnett	Tulsa	74012	250-9541
PBLSC	UHS1	Tulsa Union High School	6636 S Mingo Rd	Tulsa	74133	459-2638
PBLSC	UHS2	Union Intermediate High School	7616 S. Garnett	Broken Arrow	74012	357-4324
PBLSC	UHS3	Union Alternative School	5656 S 129th E Ave	Tulsa	74134	459-6555
PBLSC	UV1	Oklahoma State Univeristy - Tulsa	700 N Greenwood	Tulsa	74106	594-8000
PBLSC	JC2	Tulsa Community College - Metro Campus	909 S Boston Ave	Tulsa	74119	595-7226
PBLSC	UV3	OSU College of Osteopathic Medicine	1111 W 17th St	Tulsa	74107	582-1972
PBLSC	UV4	University of Tulsa	800 S Tucker Dr	Tulsa	74104	631-2000
PBLSC	JC5	Tulsa Community College - Northeast Campus	3727 E Apache St	Tulsa	74115	595-7526
PBLSC	VT6	Tulsa Technology Center - Peoria	3850 N Peoria Ave	Tulsa	74106	828-1619

Cat	ID	NAME	ADDRESS	CITY	ZIP	PHONE #
PBLSC	VT7	Tulsa Technology Center - Lemlely Campus	3420 S Memorial Dr	Tulsa	74045	828-1000
PBLSC	UV8	Oral Roberts University	7777 S Lewis Ave	Tulsa	74171	495-6161
PBLSC	JC9	Tulsa Community College - Southeastern Campus	10300 E 81st St	Tulsa	74133	595-7726
PBLSC	JC10	Tulsa Community College - Conference Center	6111 E Skelly Dr	Tulsa	74135	595-7868
PBLSC	VT11	Tulsa Technology Center - Skyline	6111 E Skelly Dr	Tulsa	74147	828-5059
PBLSC	JC12	Tulsa Technology Center - Riverside	801 E 91st St	Tulsa	74132	828-4000
Education Facilities - Private Schools						
PVTSC	PS1	Bishop Kelly High School	3905 S. Hudson	Tulsa	74135	627-3390
PVTSC	PS2	Cascia Hall Prepatory School	2520 S. Yorktown Ave.	Tulsa	74114	742-7373
PVTSC	PS3	Evangelistic Temple School	1339 E 55th St	Tulsa	74105	743-5597
PVTSC	PS4	Happy Hands Educational Center	5717 E 32nd St	Tulsa	74135	665-1200
PVTSC	PS5	Holland Hall	5666 E 81st St	Tulsa	74137	481-1111
PVTSC	PS6	Holy Family Cathedral School	820 S. Boulder	Tulsa	74119	582-0422
PVTSC	PS7	Lincoln Christian School	1003 N 129th East Ave	Tulsa	74116	234-8863
PVTSC	PS8	Little Light House	5120 E. 36th	Tulsa	74135	664-6746
PVTSC	PS9	Marquette Catholic School	1519 S. Quincy	Tulsa	74120	584-4631
PVTSC	PS10	Metro Christian Academy	6363 S. Trenton	Tulsa	74136	745-9868
PVTSC	PS11	Mingo Valley Christian School	8720 E. 61st	Tulsa	74112	836-9504
PVTSC	PS12	Monte Cassino School	2206 S. Lewis	Tulsa	74114	743-4471
PVTSC	PS13	ORU eAcademy	7777 S. Lewis	Tulsa	74171	800-678-5899
PVTSC	PS14	Oklahoma Job Corps Academy	1133 N Lewis	Tulsa	74110	591-5672
PVTSC	PS15	Peace Academy	4620 S Irvington	Tulsa	74135	627-1040
PVTSC	PS16	Riverfield Country Day School	2433 W 61st	Tulsa	74132	446-3553
PVTSC	PS17	School of Saint Mary	1365 E 49th Pl	Tulsa	74105	749-9361
PVTSC	PS18	Southpark Christian School	10811 E 41st	Tulsa	74146	663-4141
PVTSC	PS19	Saint Catherine Catholic School	2615 W 46th	Tulsa	74107	446-9756
PVTSC	PS20	St. Pius X Catholic School	1717 S 75th East Ave	Tulsa	74134	627-5367
PVTSC	PS21	Sts. Peter & Paul School	1428 N 67th East Ave	Tulsa	74115	836-2165
PVTSC	PS22	Town & Country School	5150 E 101st St	Tulsa	74137	296-3113
PVTSC	PS23	Tulsa Adventist Jr. Academy	900 S New Haven	Tulsa	74112	834-1107
PVTSC	PS24	Victory Christian School	7700 S Lewis	Tulsa	74136	491-7720
PVTSC	PS25	Wright Christian Academy	11391 E Admiral Pl	Tulsa	74116	438-0922
PVTSC	PS26	Aldersgate Learning Center	3702 S 90th E Ave	Tulsa	74145	628-6524

Cat	ID	NAME	ADDRESS	CITY	ZIP	PHONE #
PVTSC	PS27	Asbury United Methodist Weekday Preschool	6767 S Mingo Road	Tulsa	74133	492-1771
PVTSC	PS28	Bethany Christian School	6730 S Sheridan Rd	Tulsa	74133	492-5865
PVTSC	PS29	Boston Avenue Weekday School	1301 S Boston Ave	Tulsa	74133	583-5181
PVTSC	PS30	Christ the Redeemer Lutheran Church	2550 E 71st St	Tulsa	74119	492-1416
PVTSC	PS31	Christview Christian Church	2525 S Garnett Rd	Tulsa	74136	622-7802
PVTSC	PS32	Early Learning Center - Christ UMC	3515 S Harvard	Tulsa	74129	743-7673
Childcare Facilities						
CHLCR	CC1	ABC Child Development Ctr	7915 E. 17th St.	Tulsa	74112	622-0446
CHLCR	CC2	ABC Preschool - Fellowship Bible Church	5434 E. 91st Street	Tulsa	74137	481-0430
CHLCR	CC3	Ave Maria House	6161 S. Yale	Tulsa	74136	494-1501
CHLCR	CC4	Bethany Community School	6730 S. Sheridan Rd.	Tulsa	74133	492-5865
CHLCR	CC5	Boston Avenue UM Weekday School	1301 S. Boston Ave	Tulsa	74119	699-0112
CHLCR	CC6	Bundles of Joy Child Care Ctr	2131 E. 31 Pl. N.	Tulsa	74110	428-4936
CHLCR	CC7	Christ Methodist ELC	3515 S. Harvard Ave.	Tulsa	74135	743-7673
CHLCR	CC8	Cornerstone Child Development Ctr	3434 S. Garnett Road	Tulsa	74146	665-0957
CHLCR	CC9	Crosstown áLearning Ctr	2501 East Archer	Tulsa	74110	582-1457
CHLCR	CC10	Day Schools #1	5085 S. 76th East Ave.	Tulsa	74145	627-8541
CHLCR	CC11	Day Schools #11	2437 S. Sheridan	Tulsa	74129	832-0278
CHLCR	CC12	Day Schools #9	2327 S. Darlington	Tulsa	74114	747-7780
CHLCR	CC13	Disney Family Ctr CAP	11610 East 25th St.	Tulsa	74129	439-9608
CHLCR	CC14	Early Learning Academy	1115 S. Boulder	Tulsa	74119	587-9481
CHLCR	CC15	Eastgate Early Education Ctr	14002 E. 21st St., Ste. 300	Tulsa	74134	938-6600
CHLCR	CC16	First Christian Child Development Ctr	913 S. Boulder	Tulsa	74119	582-8237
CHLCR	CC17	Frost Head Start Early Start	203 West 28th Street North	Tulsa	74106	556-0319
CHLCR	CC18	Garnett Learning Ctr	12000 E. 31st St.	Tulsa	74146	664-9590
CHLCR	CC19	Hillcrest CDC	1121 S. Victor	Tulsa	74104	579-7858
CHLCR	CC20	Hope Worship Ctr	8304 S. 107th East Ave.	Tulsa	74133	252-1893
CHLCR	CC21	Instituto Bilingne Guadalupano	2510 E Admiral Blvd	Tulsa	74104	592-9179
CHLCR	CC23	Jenks PS East Before & After Program	8925 S. Harvard	Tulsa	74137	299-4415
CHLCR	CC24	John Knox Child Development Ctr	2929 E. 31st St.	Tulsa	74105	742-7656
CHLCR	CC25	Kid's Connection Child Development Ctr	3515 S. Harvard	Tulsa	74135	747-5802
CHLCR	CC26	KinderCare Learning Ctr	5110 East 71st St. S.	Tulsa	74136	492-1795
CHLCR	CC27	KinderCare Learning Ctr	11633 E. 31st St. South	Tulsa	74146	663-1937

Cat	ID	NAME	ADDRESS	CITY	ZIP	PHONE #
CHLCR	CC28	KinderCare Learning Ctr	12928 E. 43 Pl. S.	Tulsa	74134	252-1335
CHLCR	CC29	KinderCare Learning Ctr	9625 S. Mingo Rd.	Tulsa	74133	461-7000
CHLCR	CC30	Kirk Of The Hills Preschool	4102 E. 61st St.	Tulsa	74136	494-8859
CHLCR	CC31	Tulsa University Child Development Ctr	2906 E. Third	Tulsa	74104	583-5400
CHLCR	CC32	La Petite #7	1950 S. 131st East Ave.	Tulsa	74108	437-4251
CHLCR	CC33	Mabee Red Shield Boys and Girls	1231 N. Harvard	Tulsa	74115	834-2464
CHLCR	CC34	McClure Head Start	6150 S. Yorktown	Tulsa	74136	747-7123
CHLCR	CC35	Memorial Village Early Learning Ctr	8119 East 12th Street	Tulsa	74112	836-5800
CHLCR	CC36	Miss Helen's Private School	4849 S. Mingo	Tulsa	74146	622-2327
CHLCR	CC37	NACT Headstart & Day Care	1470 W. 41st St.	Tulsa	74107	446-7939
CHLCR	CC38	Reed Family Ctr	10940 E. 5th Ave.	Tulsa	74128	437-1495
CHLCR	CC39	Riverfield Country Day School	2433 W. 61st St.	Tulsa	74132	446-3553
CHLCR	CC40	Shining Through Learning Ctr	6605 E. 93rd Street	Tulsa	74133	392-7852
CHLCR	CC41	South Tulsa Baptist ELP	10310 S. Sheridan	Tulsa	74133	299-0900
CHLCR	CC42	St. John Medical Ctr Chapman Learning Ctr	1710 E. 17th St.	Tulsa	74104	744-2968
CHLCR	CC43	Temple Israel/ Day Schools Inc.	2004 E. 22nd Pl.	Tulsa	74114	747-3122
CHLCR	CC44	Trinity Episcopal Day School	501 S. Cincinnati Ave.	Tulsa	74103	582-2556
CHLCR	CC45	Tulsa Educare Inc.	2511 E. 5th Pl. S	Tulsa	74104	779-6233
CHLCR	CC46	Victory Christian School	7700 S. Lewis	Tulsa	74136	491-7753
CHLCR	CC47	Victory Kids Care	7700 S. Lewis Ave.	Tulsa	74136	499-4655
CHLCR	CC48	Victory Mother's Day Out	7700 S Lewis	Tulsa	74136	491-7754
CHLCR	CC49	WABC Learning Ctr Inc.	5511 S. Harvard	Tulsa	74135	742-1140
CHLCR	CC50	World Won Early Learning Ctr	PO BOX 481018	Tulsa	74148	425-5030
CHLCR	CC51	Happiness is One	455 S. Memorial	Tulsa	74115	838-7555
CHLCR	CC52	YWCA of Tulsa - North Ctr	5424 N. Madison Ave.	Tulsa	74126	425-7511
CHLCR	CC53	YWCA Patti Johnson Wilson ELC	1910 S. Lewis	Tulsa	74104	749-0203
Senior Housing						
SRHSG	IL54	4100 Apartments	3933 S Norfolk Ave	Tulsa	74105	743-4969
SRHSG	IL55	5400 South Apartments	4700 E 54th St	Tulsa	74135	496-9270
SRHSG	AL1	Aberdeen Heights	7220 S Yale	Tulsa	74136	469-0123
SRHSG	NH38	Ambassador Manor Nursing & Rehab Center	1340 E 61st St	Tulsa	74136	743-8978
SRHSG	ML39	Ambassador Manor Nursing & Rehab Center	1340 E 61st St	Tulsa	74136	743-8978
SRHSG	AL2	Ambassador's Courtyards	1380 E 61st St	Tulsa	74136	743-8978

Cat	ID	NAME	ADDRESS	CITY	ZIP	PHONE #
SRHSG	IL56	Boulder Plaza	1840 S Boulder	Tulsa	74119	583-3354
SRHSG	AL4	Brighton Gardens	5211 S Lewis Ave	Tulsa	74105	743-2700
SRHSG	ML50	Burgundy Place	8887 S Lewis Ave	Tulsa	74137	299-0953
SRHSG	IL95	Burgundy Place	8887 S Lewis Ave	Tulsa	74137	299-0953
SRHSG	ML51	Colonial Manor	5015 S Victor Ave	Tulsa	74105	747-4193
SRHSG	IL83	Colonial Manor	5015 S Victor Ave	Tulsa	74105	747-4193
SRHSG	NH19	Colonial Manor Nursing & Rehab Center	1815 E Skelly Dr	Tulsa	74105	743-7838
SRHSG	IL57	Cornerstone Village	1045 N Yale Ave	Tulsa	74115	835-1300
SRHSG	IL58	Country Club Gardens	959 Country Club Dr	Tulsa	74127	599-7427
SRHSG	ML52	Country Club of Woodland Hills	6333 S 91st East Ave	Tulsa	74133	252-5451
SRHSG	IL90	Country Club of Woodland Hills	6333 S 91st East Ave	Tulsa	74133	252-5451
SRHSG	RC18	Country Club of Woodland Hills Residential Care	6333 S 91st East Ave	Tulsa	74133	252-5451
SRHSG	IL100	Country Oaks	5648 S 33rd West Ave	Tulsa	74107	446-3400
SRHSG	IL59	Crestview Senior Duplexes	3535 N Cincinnati Ave	Tulsa	74106	430-0030
SRHSG	IL66	Disciples Village	9014 E 31st St	Tulsa	74145	622-9318
SRHSG	IL99	Edgewood at Gable Hills	7702 W Parkway Blvd	Tulsa	74127	245-1233
SRHSG	IL82	French Villa	4752 S Harvard Ave	Tulsa	74135	743-6862
SRHSG	IL67	Garnett Village	3524 S 120th East Pl	Tulsa	74146	622.2888
SRHSG	IL60	Gilcrease Estates	1143 N 24th West Ave	Tulsa	74127	582-0220
SRHSG	IL68	Glenwood Apartments	10221 E 34th St	Tulsa	74146	663-7797
SRHSG	NH21	Green Country Care Center	3601 N Columbia Ave	Tulsa	74110	428-3600
SRHSG	AL6	Heatheridge Assisted Living Community	2130 S 85th East Ave	Tulsa	74129	622-9191
SRHSG	RC17	Heatheridge Residential Care	2130 S 85th East Ave	Tulsa	74129	622-9191
SRHSG	IL84	Heatherwood Apartments	3006 E 51st St	Tulsa	74105	749-2566
SRHSG	IL75	Hewgley Terrace	420 S Lawton Ave	Tulsa	74127	
SRHSG	IL97	Inhofe Plaza	6565 S Newport	Tulsa	74136	743-3337
SRHSG	ML32	Inverness Village	3800 W 71st St	Tulsa	74132	481-9988
SRHSG	IL98	Inverness Village	3800 W 71st St	Tulsa	74132	481-9988
SRHSG	AL7	Inverness Village - Alzheimers & Memory Support	3800 W 71st St	Tulsa	74132	481-9988
SRHSG	NH33	Inverness Village - Heather Hall	3800 W 71st St	Tulsa	74132	481-9988
SRHSG	AL8	Inverness Village - Redbud Court	3800 W 71st St	Tulsa	74132	481-9988
SRHSG	IL63	Jordan Plaza I & II	630 E Oklahoma St	Tulsa	74106	584-8939
SRHSG	IL64	Jordan Plaza III	775 E Pine St	Tulsa	74106	584-8940

Cat	ID	NAME	ADDRESS	CITY	ZIP	PHONE #
SRHSG	IL76	LaFortune Tower	1725 S Southwest Blvd	Tulsa	74107	583-0784
SRHSG	NH34	Lakewood Care Center	6201 E 36th St	Tulsa	74135	622-3430
SRHSG	NH40	Leisure Village	2154 S 85th East Ave	Tulsa	74129	622-4747
SRHSG	IL74	Luther Place on Troost	1304 S Troost	Tulsa		
SRHSG	NH41	ManorCare Health Services	2425 S Memorial Dr	Tulsa	74129	628-0932
SRHSG	IL77	Mansion House	1638 S Carson	Tulsa	74119	582-6167
SRHSG	NH29	Maplewood Care Center	6202 E 61st St	Tulsa	74136	494-8830
SRHSG	IL91	Montereau in Warren Woods	6800 S Granite	Tulsa	74136	491-5200
SRHSG	IL73	Murdock Villa	828 S Wheeling	Tulsa	74104	583-2666
SRHSG	AL9	Oklahoma Methodist Manor	4134 E 31st St	Tulsa	74135	743-2565
SRHSG	ML35	Oklahoma Methodist Manor	4134 E 31st St	Tulsa	74135	743-2565
SRHSG	NH36	Oklahoma Methodist Manor	4134 E 31st St	Tulsa	74135	743-2565
SRHSG	IL79	Oklahoma Methodist Manor	4134 E 31st St	Tulsa	74135	743-2565
SRHSG	IL72	Park Village	650 S Memorial Dr	Tulsa	74112	834-6400
SRHSG	NH37	Parks Edge Nursing & Rehab Center	5115 E 51st St	Tulsa	74135	627-5238
SRHSG	IL61	Pioneer Plaza	901 N Elgin Ave	Tulsa	74106	584-2554
SRHSG	IL96	Prairie Rose	7401 Riverside Parkway	Tulsa	74136	495-3600
SRHSG	IL89	Quail Creek Villa	7334 S Memorial Dr	Tulsa	74113	252-1602
SRHSG	NH22	Rest Haven	1944 N Iroquois Ave	Tulsa	74106	583-1509
SRHSG	AL15	Saint Simeons Episcopal Home	3701 N Cincinnati Ave	Tulsa	74106	425-3583
SRHSG	ML24	Saint Simeons Episcopal Home	3701 Cincinnati Ave	Tulsa	74106	425-3583
SRHSG	NH25	Saint Simeons Health Care Center	3701 N Cincinnati Ave	Tulsa	74106	425-3583
SRHSG	NH23	Saint Simeons Home Memory Center	3701 N Cincinnati Ave	Tulsa	74106	425-3583
SRHSG	IL69	Shadybrook Apartments	4203 S 109th East Ave	Tulsa	74146	663-6013
SRHSG	IL70	Sheridan Terrace	1937 S 68th East Ave	Tulsa	74112	835-7072
SRHSG	NH48	Sherwood Manor	2416 W 51st St	Tulsa	74107	446-4804
SRHSG	IL81	Southern Elms	4519 E 31st St	Tulsa	74135	743-8001
SRHSG	NH42	Southern Hills Rehab Center	5170 S Vandalia	Tulsa	74135	496-3963
SRHSG	ML43	Southern Hills Retirement Community	5170 S Vandalia	Tulsa	74135	496-3963
SRHSG	IL85	Southern Hills Retirement Community - The Villa	4515 E 53rd St	Tulsa	74135	800-262-7961
SRHSG	AL11	Sterling House of Tulsa	6022 E 71st St	Tulsa	74136	494-4011
SRHSG	AL12	Sterling House of Tulsa South	8231 S Mingo	Tulsa	74133	461-1100
SRHSG	AL3	The Arbors	10201 S Yale Ave	Tulsa	74137	298-7799

Cat	ID	NAME	ADDRESS	CITY	ZIP	PHONE #
SRHSG	IL65	The Broadmoor Retirement Community	8205 E 22nd St	Tulsa	74129	622-2151
SRHSG	NH20	The Cottage Extended Care	2552 E 21st St	Tulsa	74114	742-7080
SRHSG	NH27	The Health Care Centers @ Montereau - Memory Support	6800 S Granite	Tulsa	74136	491-5250
SRHSG	NH28	The Health Care Centers @ Montereau - Skilled Nursing	6800 S Granite	Tulsa	74136	491-5250
SRHSG	AL5	The Health Centers @ Montereau - The Villa	6800 S Granite Ave	Tulsa	74136	491-5250
SRHSG	NH30	The Mayfair Nursing Center	7707 S Memorial Dr	Tulsa	74133	250-8571
SRHSG	ML26	The Montereau in Warren Woods	6800 S Granite	Tulsa	74136	491-5200
SRHSG	AL10	The Parke Senior Living	7821 E 76th St	Tulsa	74133	249-1262
SRHSG	IL80	The Scandia	3510 E 32nd St	Tulsa	74135	747-4478
SRHSG	IL92	Town Village	8222 S Yale Ave	Tulsa	74137	493-1200
SRHSG	AL13	Tulsa Jewish Retirement & Health Care Center	2025 E 71st St	Tulsa	74136	496-8300
SRHSG	ML31	Tulsa Jewish Retirement & Health Care Center	2025 E 71st St	Tulsa	74136	496-8300
SRHSG	NH49	Tulsa Jewish Retirement & Health Care Center	2025 E 71st St	Tulsa	74136	496-8300
SRHSG	IL93	Tulsa Jewish Retirement & Health Care Center	2025 E 71st St	Tulsa	74136	496-8300
SRHSG	NH44	Tulsa Nursing Center	10912 E 14th St	Tulsa	74135	622-3430
SRHSG	IL71	Tulsa Pythian Manor	6568 E 21st Pl	Tulsa	74129	836-2710
SRHSG	IL78	Tulsa Pythian Manor West	1700 Riverside Dr	Tulsa	74119	583-4401
SRHSG	AL14	University Village Retirement Community	8555 S Lewis Ave	Tulsa	74137	299-2661
SRHSG	NH46	University Village Retirement Community	8555 S Lewis Ave	Tulsa	74137	299-2661
SRHSG	ML47	University Village Retirement Community	8555 S Lewis Ave	Tulsa	74137	299-2661
SRHSG	IL94	University Village Retirement Community	8555 S Lewis Ave	Tulsa	74137	299-2661
SRHSG	IL86	Versailles Apartments	4816 S Sheridan	Tulsa	74145	627-6116
SRHSG	RC16	Vintage Heights	1 W 36th St North	Tulsa	74106	428-4412
SRHSG	IL62	West Edison Plaza	570 N 39th West Ave	Tulsa	74127	584-4224
SRHSG	NH45	Wildwood Care Center	3333 E 28th St	Tulsa	74114	747-8008
SRHSG	IL87	Woodland Manor	8641 E 61st St	Tulsa	74133	461-1929
SRHSG	ML53	Woodland Terrace	9524 E 71st St	Tulsa	74133	250-3631
SRHSG	IL88	Woodland Terrace	9524 E 71st St	Tulsa	74133	250-3631