October
2017

The City of Oklahoma City

Hazard Mitigation Plan Update

RESOLUTION

RESOLUTION ADOPTING THE CITY OF OKLAHOMA CITY UPDATED HAZARD MITIGATION PLAN 2017.

WHEREAS, The Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988, P.L. 93-288 (Stafford Act) as amended by the Disaster Mitigation Act of 2000, P.L. 106-390 (DMA 2000) requires local governments to develop and formally adopt a Hazard Mitigation Plan to be eligible to receive federal hazard mitigation grant funds; and

WHEREAS, The Hazard Mitigation Plan is used by City Staff to evaluate the potential impact of natural hazards within the City and to identify actions that will help reduce the effects of such hazards.

WHEREAS, The original Hazard Mitigation Plan (Plan) was adopted and approved in 2006. The Plan was updated in FY2011-2012 and formally adopted by the City Council on June 12, 2012 and approved by the Federal Emergency Management Agency (FEMA) on July 11, 2012.

WHEREAS, Federal regulations require Hazard Mitigation Plans be updated every five (5) years; and

WHEREAS, The City Office of Emergency Management and Planning Department partnered to review, revise, and update the plan from 2016-2017; and

WHEREAS, A Hazard Mitigation Planning Team was formed to oversee and coordinate the planning process, gather information, and prepare the Updated Hazard Mitigation Plan 2017; and

WHEREAS, The Updated Hazard Mitigation Plan 2017 has been prepared in accordance with the Disaster Mitigation Action of 2000 and revised using the new hazard mitigation plan template provided by Oklahoma Department of Emergency Management (ODEM). The Planning Team revised and updated all natural hazard profiles, removed technological and manmade hazards, reduced the size of the document so it is more manageable and easier to share electronically, reduced

the number of mitigation actions, removed unnecessary tables/photographs, made greater use of maps to replace text, and reduced the number of chapters from 22 chapters to 19 chapters; and

WHEREAS, Public outreach included on-line and in-person surveys to solicit resident input on natural hazards and which ones concerned them most. City staff also solicited resident comments on the draft Updated Hazard Mitigation Plan both on-line and in-person at the City Clerk's Office. No public comments were received on the draft plan; and

WHEREAS, The City's Local Planning and Preparedness Committee, which includes representatives from various City departments, the private sector and community based organizations served as the City's Hazard Mitigation Planning Committee (HMPC) providing input during the planning process and reviewed the draft plan approving it for submission to City Council, ODEM, and FEMA; and

WHEREAS, On March 28, 2017 the City Council accepted the draft Updated Hazard Mitigation Plan 2017 and authorized its submission to ODEM and FEMA for their review and approval;

WHEREAS, ODEM and FEMA reviewed the draft Updated Hazard Mitigation Plan 2017 and requested minor revisions be made to the draft plan. The ODEM and FEMA requested revisions were to meet new FEMA standards and/or to clarify the hazard profiles, severity and vulnerability analysis as it pertains to Oklahoma City these revisions did not make substantial changes to the plan as originally accepted by Council in March 28, 2017. These revisions have been incorporated into the plan, which is now being submitted to City Council for final approval.

WHEREAS, after requested minor revisions were made to the plan FEMA approved it pending adoption by City Council;

WHEREAS, FEMA requires the Updated Hazard Mitigation Plan 2017 be formally adopted by the City Council prior to formal official approval by FEMA; and

WHEREAS, the Updated Hazard Mitigation Plan 2017 is being submitted to the City Council for their adoption.

NOW, THERE, BE IT RESOLVED by the Mayor and Council of The City of Oklahoma City that the Updated Hazard Mitigation Plan 2017 be adopted.

ADOPTED by the Council and **SIGNED** by the Mayor of The City of Oklahoma City this 24th day of October, 2017.

ATTEST: (Seal)

THE CITY OF OKLAHOMA CITY

City Clerk

Mick Cornett, Mayor

APPROVED as to form and legality

Assistant Municipal Counselor

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Chapter 1 - Introduction

Overview

This Hazard Mitigation Plan (Plan) is a hazard mitigation plan update for the City of Oklahoma City (City). This is a single jurisdiction plan. The term "Planning Area" as used in this Plan refers to the jurisdictional boundaries of the City. The City covers about 620 square miles and stretches into four different counties – Canadian, Cleveland, Oklahoma, and Pottawatomie. The majority of the City and the seat of City government are located in Oklahoma County.

The City shares a common border with or surrounds in whole or in part multiple incorporated municipalities. Each of these municipalities either has their own hazard mitigation plan or has participated in their county's hazard mitigation plan.

The City is served by twenty three public school districts. Many of these school districts' boundaries stretch into multiple municipal jurisdictions serving more than just the City and a few cross county lines. The municipal jurisdictions they serve either have their own hazard mitigation plan or have participated in their county's hazard mitigation plan.

About Hazard Mitigation Planning

Hazard mitigation is any sustained action taken to reduce or eliminate long-term risk to people and property from natural hazards and their effects. This definition distinguishes actions that have a long-term impact from those that are more closely associated with immediate preparedness, response, and recovery activities. Hazard mitigation is the only phase of emergency management specifically dedicated to breaking the cycle of damage, reconstruction, and repeated damage. The purpose of this plan is to evaluate natural hazard threats to the City and determine appropriate hazard mitigation strategies.

The requirement for communities to prepare a hazard mitigation plan is established in the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988, P.L. 93-288 (Stafford Act), as amended by the Disaster Mitigation Act of 2000, P.L. 106-390 (DMA 2000). DMA 2000 was signed into law on October 30, 2000. DMA 2000 amended the Stafford Act to include a new section on Mitigation Planning. DMA 2000 requires state and local governments to develop and formally adopt a natural hazard mitigation plan to be eligible to apply for and receive federal assistance under the various federal hazard mitigation grant programs such as the Hazard Mitigation Grant Program (HMGP), the Pre-Disaster Mitigation Grant Program (PDM), and the Flood Mitigation Assistance Grant Program (FMA). DMA 2000 requires local hazard mitigation plans be updated every five years.

Reserved for Future use

Reserved for future use.

Chapter 2 – Planning Process

Overview

The Plan was originally developed from 2004-2006. It was adopted and approved in 2006. It was first updated from 2011-2012. The Updated Plan was adopted and approved in 2012. Since 2012 the Plan has been annually reviewed and updated. This update of the Plan was conducted from 2016-2017.

2017 Plan Update

The City's Office of Emergency Management and Planning Department were the lead entities for the 2017 Plan Update. This collaboration was an effort to better synchronize the Plan with the City's other planning efforts including PlanOKC and sustainability. The Plan Update was a collaborative effort of internal and external partners and public outreach. The Plan Update was completed by City staff and without the use of a contractor or consultant.

Scope of Work

The 2017 update of the Plan involved a collaborative process involving meetings, public outreach methods, conducting research, sharing research data and information, and conference calls. The overall goal of the planning process was to update the Plan and reduce the size of the Plan to a more manageable document. The scope of work included:

- Revise and update all natural hazard profiles
- Remove technological and manmade hazards as they are not required by federal regulations, manmade hazards are not eligible for federal hazard mitigation funds, and it is often difficult to obtain complete and accurate data on manmade hazard events.
- Reduce the number of mitigation actions to a more manageable number with at least two per natural hazard and make sure the mitigation action is eligible for hazard mitigation grant funding.
- Remove photographs. Although they make the final product more visually appealing they are not required by federal regulations and many of the photographs in the Plan are not representative of events in Oklahoma or Oklahoma City.
- Remove tables and replace them with maps in so far as practical. Maps provide a spatial relationship between the natural hazards and other community elements.
- Remove HAZUS appendix because it is not required by federal regulations and is now over ten years old.
- Combine Chapters 20 & 21 in the 2012 Plan Update into one chapter.

Planning Team Members

Name	Title	Organization Represented	Contribution to Planning Process
Franklin N. Barnes, (CEM®)	Emergency Manager	OKC Office of Emergency Management	• Lead Planning Team • Provided City hazard information • Developed City Mitigation Actions • Assembled public comments from City residents • Provided City capability assessment
Sharon Ray	EM Coordinator	OKC Office of Emergency Management	• Conduct research on weather events. • Revise hazard profiles
Christina Nguyen	Community Relations Coordinator	OKC Office of Emergency Management	• Coordinate public outreach
Ken Bryan, AICP	Senior Planner	OKC Planning Department	• Develop and oversee online survey • Conduct research • Develop maps • Revise Community Profile Chapter
Steve Rhodes, AICP	Program Planner	OKC Planning Department	• Conduct research • Develop maps • Revise Community Profile Chapter
T.O. Bowman	Program Planner	OKC Planning Department	• Conduct research • Develop maps • Revise Community Profile Chapter • Provided data and information on climate change
Mike Love, Sr.	EM Specialist	Public Works	• Provide information on dam hazards • Provide dam breach mitigation actions

Name	Title	Organization Represented	Contribution to Planning Process
Blaine Sheffield	Civil Engineer IV Floodplain Manager	Public Works	• Provided flood hazard information • Provided flood mitigation actions • Provided repetitive loss data • Provided NFIP participation information
Raymond Melton	Environmental Protection Manager	Public Works	• Provide information on storm water and environmental issues
Allen McDonald	Line Maintenance Superintendent	Utilities Department	• Provide information on vulnerability of city water and waste water pipelines to natural hazards • Provide mitigation actions for city water and waste water pipelines
Kristy Yager	Public Information & Marketing Manager	Public Information and Marketing	• Provide public outreach strategies • Provide public education and information strategies
Michael Miller	Inspection Services Superintendent	Development Services	• Provide building vulnerability information • Provide building mitigation strategies
Jim Lewellyn, PE	Civil Engineer IV Project Administrator	Public Works	• Provided information on Capital Improvement Program (CIP) Plan and Projects • Provided information mitigation plans and actions for Capital Improvement Programs
Joe Johns	Major	Fire Department	• Provided city wildfire information • Provided city wildfire mitigation actions

Besides conducting public outreach and Hazard Mitigation Planning Committee meetings the Planning Team performed a variety of activities to update the Plan:

- Spring 2016 - Requested technical assistance from the Oklahoma Department of Emergency Management (ODEM) to review the existing Plan and make recommendations to revise, update, and improve the Plan.
- June 13, 2016 - Initial Planning Team meeting to discuss concept of update and identify what other stakeholders or partners should be part of the Planning Team.
- June 14, 2016 - Met with State Hazard Mitigation Officer and ODEM mitigation plan reviewers to review and discuss their review of the existing Plan and recommendations to revise, update, and improve the Plan.
- July 15, 2016 – Planning Team meeting to develop plan of action and scope of work.
- July 2016 – Engaged the National Weather Service. Researched and gathered data on weather events from the National Centers for Environmental Information (NCEI, formerly known as NCDC).
- July 2016 through February 2017– Revision of individual chapters by Planning Team members.
- August 22, 2016 – Meeting with City Manager's Office to present proposed plan of action and scope of work and obtain guidance on mitigation actions.
- August 22, 2016 – Engaged the Oklahoma Geological Survey to gather information on earthquake faults in or near the City.
- October 2016 – Engaged the Oklahoma Climatological Survey to conduct further research, data, and reports on climatology.
- December 2016 – Researched wildland/urban interface fire risk and vulnerability from the Southern Wildfire Assessments website.
- December 2016 – Planning Team commences bi-weekly conference calls to monitor progress of work and collaborate on revision of chapters and development of maps.
- December 2016 through February 2017 – Develop maps for inclusion in the Plan
- March 2017 – Draft Plan Update submitted to City Department Heads and Municipal Counselor's Office for review and comment. The Planning Team received comments from the Public Works Department and Municipal Counselor's Office. These comments were incorporated into the Plan.
- March 2017 – Planning Team submits draft Updated Plan to City Council for acceptance and authorization to submit it to ODEM and FEMA for review and comment by resolution.

Hazard Mitigation Planning Committee

The City's Local Planning and Preparedness Committee (LPPC)(not to be confused with the county LEPC) is a standing committee of about fifty City staff, non-government organizations (NGO), private sector, and other external public and private partners which meets at least quarterly to address issues related to mitigation, preparedness, planning. The LPPC serves multiple purposes including serving as the City's Hazard Mitigation Planning Committee. LPPC provides a pool of subject matter experts (SME) representing diverse professional backgrounds, education, and experience which provides the City with the capability to address a wide range of topics and issues.

The LPPC met as the Hazard Mitigation Planning Committee to work on the Plan Update on the following dates:

- August 25, 2016 - Hazard Mitigation Planning Committee meeting. The Planning Team presented the plan of action and scope of work for updating the Plan and conducted a second in-person survey to solicit input from committee members on natural hazard risks, vulnerability, and prioritization.
- October 27, 2016 - Hazard Mitigation Planning Committee meeting. Planning Team conducted a facilitated discussion to solicit input on hazard mitigation actions for the Updated Plan.
- January 19, 2017 – Planning Team provided the Hazard Mitigation Planning Committee members with a draft of proposed mitigation actions to review and provide feedback.
- February 23, 2017 – Hazard Mitigation Planning Committee meeting. Planning Team presented the Draft Plan Update to the committee members for their review and feedback. HMPC voted to proceed with the public comment phase. HMPC voted to submit the Plan after public comment phase to the City Council for their acceptance and authorization to submit it to ODEM for review.

Public Outreach

There was effort to solicit public input during the planning process through public outreach. The public outreach was conducted in much the same way as it was during the original plan development and the previous update. Public outreach included:

- July-August 2016 – First Public Outreach using Survey Monkey conducted an on-line survey to solicit input on and prioritization of natural hazards. Six hundred and forty six (646) residents participated in the on-line survey.
- August 20, 2016 – Second Public Outreach at OKC Prepare Fest. Planning Team conducted an in-person survey to solicit input on and prioritization of natural hazards. One hundred and eight (108) residents participated in the in-person survey.
- March 2017 – Using an online tool CiviComment the Planning Team solicited community input on the Draft Plan Update. Also, made the Draft Updated Plan available at the City Clerk's Office for review and comment. No public comments were received.
- Additional opportunities for public comment occur when the Plan Update is submitted to the City Council for action by resolution.

Other Stakeholders

There are many public agencies, private organizations, and businesses that contend with natural hazards. Many of these entities are members of the LPPC and participated in the planning process as a member of the City's Hazard Mitigation Planning Committee. As necessary during the planning process they were contacted; either in person, via email, or phone to collect information on natural hazards, mitigation actions, and/or to determine how their programs could best support the City's mitigation program. Among the organizations and agencies contacted were:

Businesses and Non-Government Organizations

- American Red Cross – James Tittle, Regional Disaster Officer
- American Red Cross – Mary Jane Coffman, Disaster Program Manager
- American Red Cross – Carol Irwin, Disaster Program Specialist
- AT&T – Jason Constable, Director – Regulatory State Legislature & Regulatory Affairs
- Oklahoma Gas & Electric – Bobby Shaffer, Reliability Engineer
- Oklahoma Natural Gas – Steve Powell
- Oklahoma Electric Cooperative – Jack Harnsberger
- Oklahoma Business Roundtable – John Reid

Local, State and Federal Agencies Contacted

- Oklahoma Department of Emergency Management – Annie Vest, SHMO
- Oklahoma Department of Emergency Management – Matt Rawlins, SHMO
- Oklahoma Department of Emergency Management – Mike Bradford, Mitigation Specialist
- Oklahoma Department of Emergency Management – Linda Adams, Mitigation Specialist
- Oklahoma County Emergency Management - David Barnes, Emergency Management Director
- Oklahoma City County Health Department - Blaine Bolding
- Regional Medical Response System – Mike Murphy, Director
- Oklahoma City Public Schools – Ian Wolfe
- Francis Tuttle Technology Center – Sam Smith
- National Weather Service – Rick Smith, Warning Coordination Meteorologist
- National Weather Service – David Andra, Jr., Meteorologist in Charge
- Oklahoma Climatological Survey – Dr. Kevin Kloesel, Director
- Oklahoma Geological Survey – Jefferson Chang, Geophysical Operations Manager
- U.S. Army Corps of Engineers – William Smiley, CFM, Chief, Emergency Management and Security Office

Plans, Documents, and Literature Review

During the planning process to update the Plan the Planning Team members reviewed various plans for information regarding natural hazards, disaster history, and areas that could be or have been impacted by natural hazards.

Plan Title	Information Used
State Hazard Mitigation Plan	Hazard definitions, state hazard mitigation goals, and hazard occurrence and impact data and information for Planning Area.
OKC Emergency Operations Plan	Response and recovery capability assessment
OKC Dam Emergency Action Plan	Identification of City owned dams
OKC Utilities Emergency Response Plan	Location and vulnerability of critical infrastructure
USACE – Canton Lake Emergency Action Plan	Inundation zones along the North Canadian/Oklahoma River in the event of a dam breach involving Canton Lake Dam.

Plan Title	Information Used
Capital Improvement Plan	Provides information about flooding and drainage complaints, proposed projects to correct drainage and flooding issues, and prioritize funding. Provides information about storm damage to City owned buildings and mitigation projects to make City owned buildings more hazard impact resistant.
PlanOKC	Description of the City, planning concepts, and framework for implementing policy and code changes

To counter pertinent hazards the City has several programs that range from public education and outreach to improve resiliency, Outdoor Warning System, Accessible Hazard Alert System, safe room rebate programs, constructing storm water control projects, mosquito habitat reduction, and a program to reduce tall grass in residential neighborhoods. These programs help to mitigate the risk and impact of natural hazards, but have not eliminated the hazards or their impact.

The City takes an all-hazard approach to emergency planning and crisis and consequence management. The City develops capabilities to respond to the result and not to the cause. However, the City has developed some hazard and function specific plans or annexes. The following plans or annexes were reviewed and information in them used to develop or assess mitigation actions:

Public Protection and Evacuation Annex

This annex describes the processes for implementing and supporting public protective actions. This annex addresses shelter-in-place and large area or large-scale evacuations of Oklahoma City residents for incidents/disasters. This annex incorporates the provisions of the Oklahoma Homeland Security Region 6&8 Evacuation Plan which addresses large-scale evacuations within the Oklahoma Office of Homeland Security Regions six and eight. The information from this annex about natural hazards that may impact the City and the appropriate protective action associated with each hazard were incorporated into the Plan.

Warning Annex

This annex describes the systems that provide reliable, timely, and effective warnings to the public before, during, and after an incident/disaster. The information from this annex was incorporated into the Plan to develop mitigation actions related to warning systems.

City of OKC Dam Emergency Action Plan

This Dam Emergency Action Plan is designed to prepare and help activate the process of warning and evacuating the immediate communities downstream in the event of a potential failure situation, failure is imminent situation or failure has occurred situation of a dam. The information in this DAM EAP on the location of City owned dams and the United State Geological Survey (USGS) Dam-Breach Analysis and Flood-Inundation Mapping for Selected Dams in Oklahoma City, Oklahoma and near Atoka, Oklahoma were incorporated into the Plan to identify the inundation zones downstream of these dams.

U.S. Army Corps of Engineers (USACE) – Canton Lake Emergency Action Plan

This plan specifies the procedures to be used to protect the public from possible property damage or loss of life as a result of uncontrolled release of water from Canton Lake due to failure or severe damage to the dam or appurtenant works. The information in this plan about inundation zones in the City north and south of the North Canadian/Oklahoma River was incorporated into this Plan Update.

Capital Improvement Plan

The City maintains a Capital Improvement Plan to identify, prioritize, and fund capital improvements in the City. Information in this plan about drainage and flood issues was incorporated into this Plan Update.

Heat and Extreme Weather Impact Report

This report is based on the Climate in the Heartland Report and describes the impacts of extreme weather on the City. Information in this report about the impacts of extreme weather were incorporated into the hazard profiles of this Plan Update where appropriate.

Literature, Reports, Studies and Other Resources, used during the Planning Process to Update the Plan

During the planning process to update the Plan the Planning Team members reviewed literature, studies, reports, and other documents for information regarding natural hazards, disaster history, and areas that could be or have been impacted by natural hazards.

Literature, Reports, Studies Title	Information Used
Climate in the Heartland	Data, information, and impacts of climate change on the City
Heat and Extreme Weather Impact Report	Impacts of extreme weather, vulnerability issues, and continuity of operations.
Flood and Storm Water Drainage Studies: Chisolm Creek, Deep Fork Creek, and Downtown OKC	Identify and describe drainage basins and storm water flooding issues related to them
OKC OEM Incident/Event Reports	Previous occurrence data, hazard impacts, and disaster history
OKC OEM After Action Reports	Previous occurrence data, hazard impacts, and disaster history
USGS Dam-Breach Analysis and Flood-Inundation Mapping for Selected Dams in Oklahoma City, Oklahoma and near Atoka, Oklahoma	Inundation zones below City owned dams in the event of a dam breach involving a City owned dam
Federal Emergency Management Agency, Mitigation Planning How-To Guide #2, FEMA 386-2	Flood Zones Table

Databases and Websites used during the Planning Process to Update the Plan

During the planning process to update the Plan the Planning Team members reviewed websites and online databases for information regarding natural hazards, disaster history, and areas that could be or have been impacted by natural hazards.

The City has its own Geographic Information System (ArcGIS) with a tremendous amount of data and map layers which enables City staff to produce a variety of maps for hazard mitigation planning. The City's GIS includes the National Flood Insurance Program (NFIP) Flood Insurance Rate Maps (FIRM) for the City. Planning Team members from the Planning Department using the City's GIS produced a variety of maps to assist in the planning process and development of the Plan Update.

Data and information from the following databases/websites was used to update the hazard profiles:

- National Centers for Environmental Information (NCEI, formerly known as NCDC) – Meteorological and hydrological hazard data and events
- OK-FIRE – Wildfire hazard information
- Oklahoma City Fire Department – Wildfire frequency information and property loss costs associated with wildfires
- U.S. Geological Survey (USGS) – Hydrological and geophysical hazard information, Richter Scale, and historical earthquake information
- Oklahoma Geological Survey (OGS) – Geophysical hazard information and Oklahoma earthquake faults
- Oklahoma Climatological Survey (OCS) – Climatological information
- Oklahoma Water Resources Board – Dam Hazards Potential
- U.S. Department of Agriculture (USDA) – Drought information and historical drought data
- Federal Emergency Management Agency – Disaster declarations and flood damage assessment criteria.
- Oklahoma Health Department – Mosquito Borne Illness information
- Center for Disease Control (CDC) – Mosquito Borne Illness information
- Sperry-Piltz Ice Accumulation Index – Winter storm and ice information and the Ice Accumulation Index
- National Oceanic and Atmospheric Administration (NOAA)
    - Enhanced Fujita Tornado Intensity Scale
    - Beaufort Wind Scale
    - Lightning information and Lightning Activity Level (LAL) Table
    - Wind chill information and Wind Chill Chart
- The Tornado and Storm Research Organisation (TORRO) – TORRO Hail storm information and Hailstorm Intensity Scales
- National Drought Mitigation Center – Drought information and historical drought data
- Oklahoma Forestry Services – Ecological regions of Oklahoma

Goals

During the update of the Plan the goals were reviewed and were found to be adequate for the update of the plan. The Planning Team recommended the goals should be more closely aligned with the State of Oklahoma's adopted Hazard Mitigation Plan. The Hazard Mitigation Planning Committee agreed and approved a hazard mitigation strategy reflected through the following goals:

Goal 1:	Reduce loss of life and protect public health and safety.
Goal 2:	Minimize damage to property including critical facilities, infrastructure and key resources.
Goal 3:	Maintain or restore the capacity of the natural environment.
Goal 4:	Increase community preparedness for natural disasters.

Chapter 3 – Plan Maintenance and Update Schedule

Overview

The Plan will be reviewed and revised as necessary annually or as needed based on disaster events. The Plan will be updated every five years. The Plan will remain an active and relevant document with continued LPPC (Hazard Mitigation Planning Committee), Planning Team, and public participation. The City Office of Emergency Management will ensure that regular review and update of the Plan occurs.

Emergency Manager

The City's Emergency Manager is responsible for monitoring and evaluating the overall progress of the mitigation strategies in the Plan. The Emergency Manager will:

- Perform any necessary monitoring site visits on a monthly basis.
- Be the lead point of contact for phone calls and the scheduling of meetings.
- Monitor the hazard analysis for changes and additions.
- Monitor objectives and determine if they meet current and expected hazardous conditions.
- Determine if there were any implementation problems, such as technical, political, legal, or coordination issues with other agencies.
- Provide the City Manager with an annual monitoring update report

Department/Division Heads

Department/Division Heads are responsible for:

- Monitoring and evaluating the progress of the mitigation actions assigned to their department/division.
- Seeking out grant funding with the assistance of the Office of Emergency Management to fund their mitigation actions and projects.
- Incorporating mitigation actions into their Department/Division plans and budgets.
- Annually providing to the Emergency Manager a report on the status of their assigned mitigation actions and projects and incorporation of mitigation actions into their plans and budgets. The report should include which implementation processes worked well, any difficulties encountered, how coordination efforts were proceeding, and which mitigation actions should be revised

Local Planning & Preparedness Committee

The LPPC serves as the City's Hazard Mitigation Planning Committee. The LPPC will review the Plan's goals and objectives to determine their relevance to changing situations in the City, as well as changes in State or Federal policy, and to ensure that they are addressing current and expected conditions. The LPPC will also review the risk assessment portion of the Plan to determine if this information should be updated or modified.

Hazard Mitigation Planning Team

The Emergency Manger will be responsible for scheduling Planning Team meetings and notifying members regarding scheduled meetings and topics. The Planning Team will meet at least annually as part of the annual review and revision process. If any Planning Team members are not able to continue as part of the Planning Team the Department/Division Head of the Planning Team member will be responsible to designate a new Planning Team member to represent their Department/Division or organization.

As part of the annual review and revision process the Planning Team will meet and prepare a report covering their findings regarding the monitoring and evaluation of:

- The risk assessment to ensure the hazard information along with the vulnerabilities and impacts originally addressed are still valid for the City.
- The goals and the mitigation strategy to ensure they continue to address the priorities of the City.
- The ongoing maintenance process and requirements identified in the Plan.

Plan Update

The Plan will be updated every five years. Twenty-four months before the plan expiration, the plan update process will begin. The Planning Team will conduct plan update meetings. These meetings will increase in frequency as the Plan update process progresses. These meetings may be in-person, by conference call, or other collaboration technology. The Plan Update process will be conducted as described in Chapter 2 – Planning Process of this 2017 Plan Update. This planning process will include discussing the findings of LPPC and Planning Team meetings, updating the risk assessment, and revising mitigation strategy/actions and plan components as needed.

A Draft Plan will be submitted to the City Council for authorization by resolution to submit the Draft Plan to the Oklahoma Department of Emergency Management for review before the plan expiration. Any revisions from ODEM will be incorporated into the document as necessary before submission to FEMA for review. Any revisions from FEMA will be incorporated into the Plan before it is resubmitted to the City Council for adoption by resolution. Once adopted by City Council it will be resubmitted to FEMA for approval.

Continued Public Involvement

The City will involve the public directly in the continual reshaping and updating of the Hazard Mitigation Plan. The Emergency Manager with the assistance of the LPPC and Planning Team will conduct an annual review of the Plan. Every attempt will be made to ensure the public will be able to directly comment on and provide feedback about the Plan. Citizen's comments and concerns will be discussed during the annual review and five-year update to determine if changes to the Plan need to be made.

Local media, social media, utility bill inserts, and the City's website OKC.GOV will be utilized to notify

residents and other stakeholders of the opportunity to participate in online surveys used to gather input for updating the Plan, as well as provide the opportunity to review and submit comments online on revised components of the Plan or the entire updated Plan. The City is finding with its other planning efforts that online submission of input and comments is more effective and efficient than direct in-person contact.

However, the City does not rule out the use of direct in-person contact when in the opinion of the LPPC and/or Planning Team it would help supplement online efforts or address reaching a specific segment of the population. These public meetings, forums or events will be publicized and open to the public for comment. These meetings will provide the public a forum where City residents can express their concerns, opinions, or ideas about the Plan. If a public meeting, forum, or other event is used, then the announcement will be submitted to local electronic and print media, City social media accounts, and e-mail distribution lists.

A copy of this Plan will be available online at the City's website and will be available to any resident upon request. Copies of the Plan will be posted on the City's secure SharePoint site where all city employees can access it. Department/Division heads will be directed by the City Manager to download, print, and have on-hand at least one hard copy of the Plan in their Department/Division headquarters office.

Reserved for Future use

Reserved for future use.

Chapter 4 – Community Profile

Geography and Ecological Regions

The Hazard Mitigation Plan area is defined as the land area within the corporate limits of The City of Oklahoma City. The city is located in the approximate geographic center of the State of Oklahoma with its incorporated area extending into 4 counties that include Canadian, Cleveland, Oklahoma and Pottawatomie Counties. Oklahoma City is the largest city in the state in terms of population and land area. The City, being comprised of approximately 620 square miles ranks 10 nationally in terms of land area and 27 nationally in terms of population.

The City's geographic location, size and development patterns make it susceptible to a wide range of weather related risks/extremes that include high winds, tornadoes, hail, flooding, drought, wildfire, and severe winter storms. For more information on natural hazards disasters, see Chapter 5, Hazard Identification and Risk Assessment.

Ecoregions for the State of Oklahoma and Oklahoma City are shown and described in Attachment 1: Ecological Regions. The City is divided among two ecologic regions known as the Cross Timbers to the east and the Central Great Plains.

Climate and Severe Weather Risks

Climate data and the cyclical nature of both temperature and precipitation are critically important to understanding Oklahoma City's need for long-term planning and mitigation strategies for community preparedness. Climate data for the State of Oklahoma and the Central Oklahoma Climate Division is presented on the maps titled Attachment 2: Severe Weather Threats, Attachment 3: Oklahoma Climate Divisions and Elevation, Attachment 4: Climate, Temperature, and Attachment 5: Climate, Precipitation. The City of Oklahoma City is contained within the Central Oklahoma Climate Division 5.

The **Severe Weather Threats** maps show the number of days per year between 1990 and 2009 that areas in the US experience hail 1.25 inches or larger, wind speeds at 65-knots or greater, tornadoes and lightning. The illustrations show Oklahoma to be among the highest states in the nation at risk for all severe weather threats.

The **Oklahoma Climate Divisions and Elevation** illustration shows the four counties within Oklahoma's Central Climate Division that contains portions of the corporate limits of the City. A summary of climate characteristics is also presented for Canadian, Cleveland, Oklahoma and Pottawatomie Counties. While temperature highs, lows and averages for each county are very consistent, annual precipitation increases significantly from west to east. Canadian County average precipitation is 33.37 inches while Pottawatomie County averages 40.19 inches annually.

The Oklahoma Climate Divisions and Elevation illustration also displays sea level elevation for the State.

The lowest elevation (272.31 feet) is in the southeastern part of the State and the highest elevation (4,977.53 feet) is in the northwestern corner of the Oklahoma panhandle. Oklahoma City, being in the central portion of the State ranges in elevation from 1,050 to 1,334 feet above sea level.

The Climate: Temperature illustration displays normal annual temperature distribution, average days with high temperatures greater than 90 degrees, and average days below 32 degrees for the State, as well as a temperature graph of historic temperature trends for the Central Oklahoma Climate Division. The maps show on average the panhandle and northwest portion of the State is relatively cooler, while the southeast portion is relatively warmer. The northwest portion of the State also has on average more days below 32 degrees while the southwest portion of the State has more days with temperatures that exceed 90 degrees. The central Oklahoma region amounts to a transitional area.

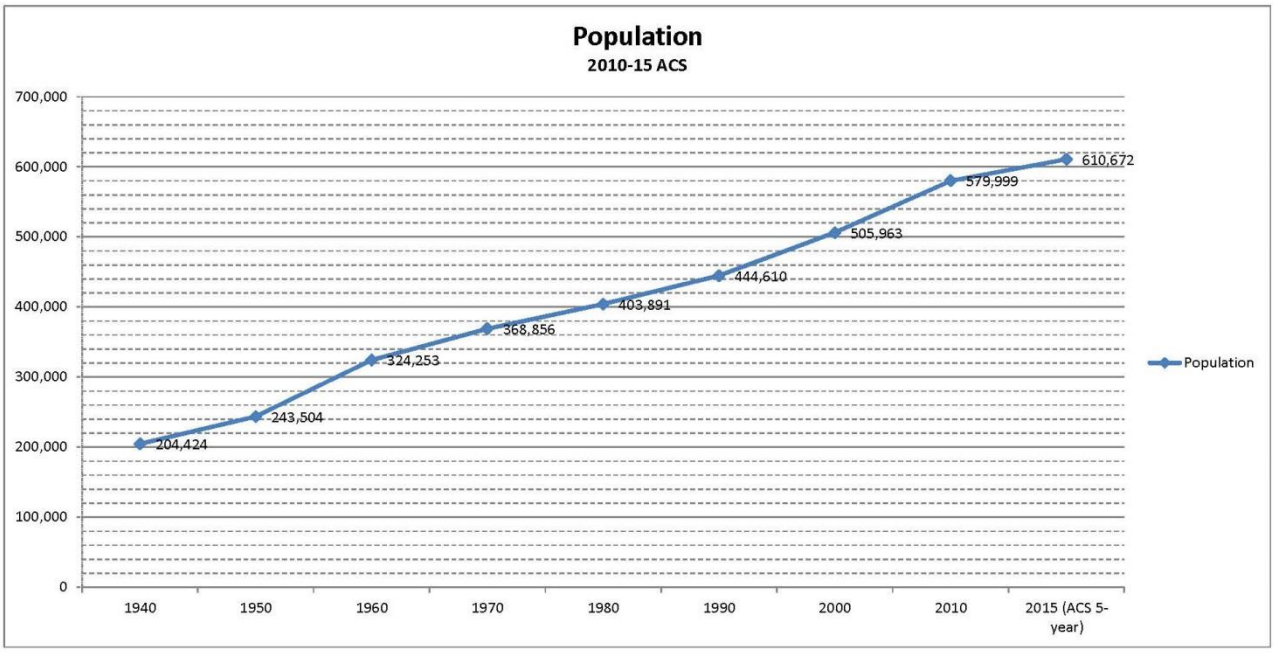
The temperature history graph shows the Central Oklahoma Climate Division experiences cyclical alternating periods of warmer average temperatures followed by periods of cooler average temperatures. The Central Oklahoma Climate Division has been experiencing warmer average temperatures since the mid-1990's. The graph shows the highest recorded average annual temperature occurred during the 2010's.

The Climate: Precipitation illustration displays normal precipitations patterns for the State, historic precipitation, and current drought monitoring data for the Central Oklahoma Climate Division. The State precipitation map shows the Oklahoma panhandle receives 20 inches or less precipitation while the southeast quadrant of the state receives 50 inches or more precipitation annually.

The precipitation graph shows historic precipitation, like temperatures, follows a cyclical pattern of extended periods of wetter than normal precipitation followed by extended periods of less than normal precipitation. The graph further shows the Central Oklahoma Climate Division in a wetter pattern even though at certain times during the year, the climate division has experienced periods of exceptional drought.

Changes in Oklahoma City Development

The following graph shows historic population growth for The City of Oklahoma City. The graph shows population has increased at a steady rate of approximately 16% from decade to decade. Between 2000 and 2015, the City's population has increased from 505,963 to 610,672, growth rate of 20.7%.



In the past five years, 23,770 building permits were issued for building activity within Oklahoma City. This activity occurred on or created more than 96,000,000 square feet of building space. Attachment 14: Change in Development shows how this development activity was distributed across the city.

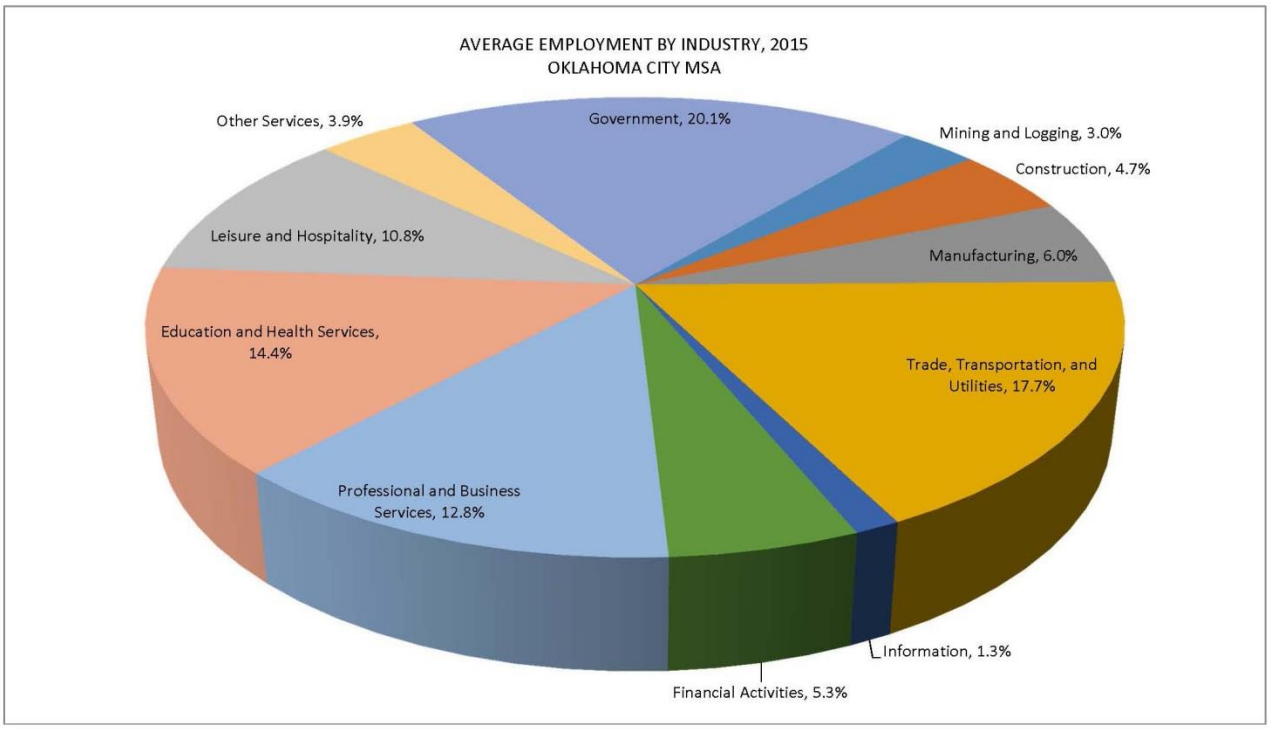
Demographics and Vulnerable Populations

A detailed socioeconomic profile of Oklahoma City, Oklahoma City MSA and State of Oklahoma is provided in Attachment 31 compiled from the 2014 American Community Survey 5-year Estimates.

Demographic information supports hazard mitigation planning to identify geographic areas where social factors increase vulnerability of population groups to some or all hazards. Social vulnerability refers to the inability of people, organizations, and societies to withstand adverse impacts from multiple stressors to which they are exposed. Socially vulnerable areas in Oklahoma City are presented through a series of illustrations titled Attachment 6: Housing Unit Density, 2016, Attachment 7: Multifamily Residential Concentration, Attachment 7: Transit Network and Percent Persons Below Poverty, Attachment 9 Elements of Social Vulnerability, and Attachment 10: Social Vulnerability Index – Overall Vulnerability.

Industry & Development

The City of Oklahoma City has a relatively diverse economy in terms of employment and major employers. The Bureau of Labor Statistics' profile of employment by sector is presented in the following chart for the Oklahoma City Metropolitan Statistical Area.



Analysis of employment centers, developments patterns, and travel hubs can provide valuable insight for both planners and first responders. This analysis can help prioritize resources and potential evacuation plans by targeting locations with large groups of people on most days.

Critical Infrastructure and Key Resources (CI/KR)

Assessing, prioritizing, protecting, and restoring critical infrastructure and key resources (CI/KR) in Oklahoma City is vital during actual or potential domestic incidents. Critical infrastructure includes the following categories: Essential; Critical transportation, utility, communication infrastructure; High potential loss facilities; and Hazardous Materials Facilities.

Compromising facilities in one of these categories will result in life-threatening situations for a potentially large number of residents. Access to electricity, drinking water, medical care, or any means of transportation will not only negatively affect residents, but can also limit first responders' ability to access areas to assess, protect, and/or restore.

Critical Infrastructure and key resources illustrations can be found in Attachment 11: Major Employers, 2016, Attachment 12: Employment Concentrations, 2015, Attachment 13: Population, Employment and Visitation Density, 2015, Attachment 14: Change in Development, Attachment 15: Transportation Infrastructure Flood Hazard Areas, Attachment 16: Transportation Infrastructure Earthquake Hazard Areas, Attachment 17: Utility Infrastructure Flood Hazard Areas, Attachment 18: Utility Infrastructure: Earthquake Hazard Areas, Attachment 19: City Facilities Flood Hazard Areas, Attachment 20: City Facilities Earthquake Hazard Areas, Attachment 21: Medical Facilities and Specialized Housing Flood

Hazard Areas, Attachment 22: Medical Facilities and Specialized Housing Earthquake Hazard Areas, Attachment 23: Educational and Child Care Facilities Flood Hazard Areas, and Attachment 24: Educational and Child Care Facilities Earthquake Hazard Areas.

Chapter 5 – Hazard Identification and Risk Assessment

Overview

In this section, an effort was made to identify and describe past and possible natural hazard occurrences that have affected or may affect the *Planning Area.*

A **natural disaster** is a major adverse event resulting from natural processes of the Earth and fall into five (5) major categories: atmospheric, geological, hydrological, extraterrestrial, and biological. They have influenced, shaped, and modified human behavior, changing the way people live with and respond to the environment. Moreover, natural disasters have resulted in enormous intangible losses, causing grief through the loss of life and personal possessions, and had a profound effect on the population's resilience or ability to recover.

During development of the previous plan the City's Hazard Mitigation Planning Committee identified hazards that are historical, typical and possible within City boundaries. These hazards were identified through a process that utilized input from planning committee members, residents, and individuals; the City's Hazard Vulnerability Assessment, researching past disaster declarations in the counties the City stretches into, and a review of current FIRMs.

As previously mentioned the City has an ArcGIS database that will map the City's infrastructure, critical facilities, and land uses in relation to known hazards. Data from this study is used to determine which hazards present the greatest risk to the City. The following Table identifies the hazards that could possibly impact the City, followed by a listing of Presidential Major Disaster Declarations declared in one or more of the counties the City stretches into since the previous plan update. Individual hazard profiles follow this chapter.

Identified Natural Hazards

The natural hazards that have a potential impact on the planning area and are addressed in this Plan Update are as follows:

1. Tornadoes
2. High Winds
3. Lightning
4. Hail
5. Severe Winter Storms
6. Flood
7. Extreme Heat
8. Drought
9. Wildfires
10. Earthquakes
11. Dam Failure
12. Mosquito Borne Diseases

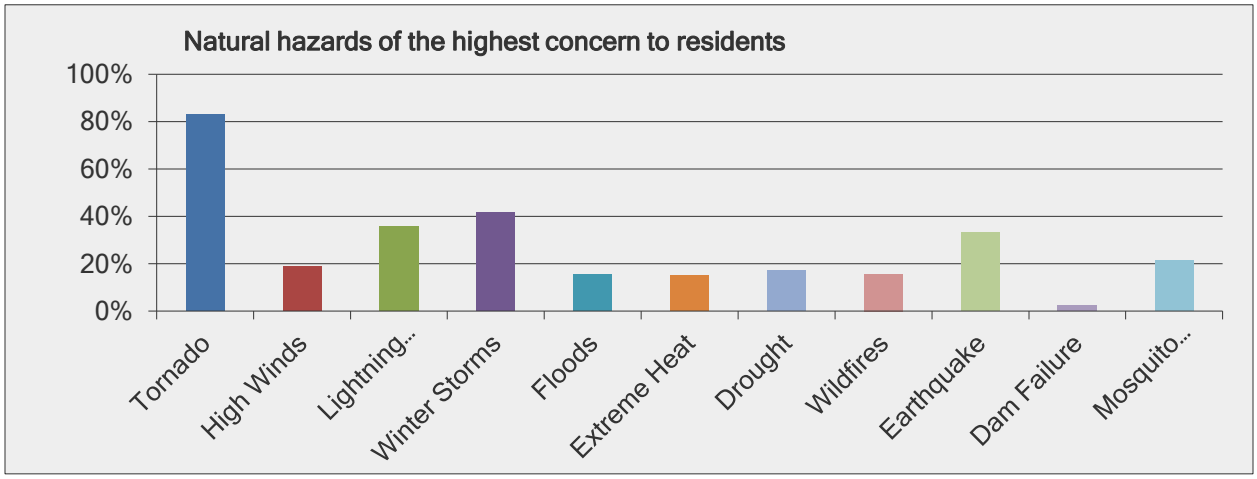
Hazards	How Identified	Why Identified
Tornado, High Winds, Lightning, and Hail	☐ Review of disaster declarations ☐ Review of OKC OEM Event/Incident Reports ☐ Input from the Emergency Manager and OKC OEM staff ☐ Input from resident surveys ☐ Input from Hazard Mitigation Planning Committee members ☐ Review of data from the National Centers for Environmental Information (NCEI) formerly known as (NCDC)	☐ History of many severe weather events including Tornadoes in 1999, 2003, 2007, 2008, 2009, 2010, 2012, 2013, 2015, and 2016 and many Severe Thunderstorms producing lightning and damaging hail and wind.
Winter Storm	☐ Review of disaster declarations ☐ Review of OKC OEM Event/Incident Reports ☐ Input from the Emergency Manager and OKC OEM staff ☐ Input from resident surveys ☐ Input from Hazard Mitigation Planning Committee members ☐ Review of data from the National Centers for Environmental Information (NCEI) formerly known as (NCDC) ☐ Input from OKC Public Works	☐ History of Severe Winter Storms including the December 24, 2009 Blizzard and many ice storms producing tree and powerline damage including those in December 2007 and November and December 2015.
Flood	☐ Review of disaster declarations ☐ Review of OKC OEM Event/Incident Reports ☐ Input from the Emergency Manager and OKC OEM staff ☐ Input from resident surveys ☐ Input from Hazard Mitigation Planning Committee members ☐ Review of data from the National Centers for Environmental Information (NCEI) formerly known as (NCDC) ☐ Input & data from OKC Public Works ☐ Review of FEMA Flood Insurance Rate	☐ History of flooding events including the flash flood events in 2007, 2010, 2013, and 2015 resulting in either Presidential Major Disaster Declarations or SBA Disaster declarations. ☐ There are 136 Repetitive Loss Structures and 11 Severe Repetitive Loss Properties in the Planning Area.

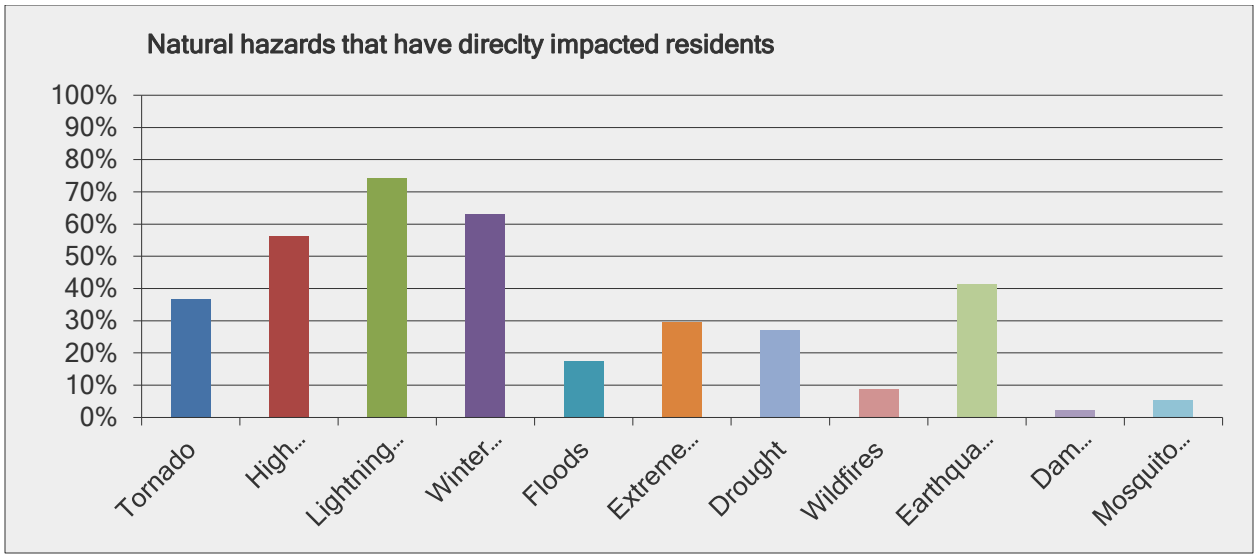
Hazards	How Identified	Why Identified
	Maps (FIRM) ☐ Review of NFIP Repetitive Loss Properties	
Extreme Heat and Drought	☐ Review of OKC OEM Event/Incident Reports ☐ Input from the Emergency Manager and OKC OEM staff ☐ Input from resident surveys ☐ Input from Hazard Mitigation Planning Committee members ☐ Review of data from the National Centers for Environmental Information (NCEI) formerly known as (NCDC) ☐ Input from the OKC Utilities Department ☐ Input from the Emergency Medical Service Authority (EMSA)	☐ History of periods of drought and extreme heat events in the summer in the Planning Area.
Wildfire	☐ Review of disaster declarations and/or Fire Management Assistance grants (FMAG) ☐ Review of OKC OEM Event/Incident Reports ☐ Input from the Emergency Manager and OKC OEM staff ☐ Input from resident surveys ☐ Input from Hazard Mitigation Planning Committee members ☐ Input from OKC Fire Department including grass fire data	☐ History of grass/wildfires some resulting in FMAGs and/or SBA Disaster declarations in the Planning Area including events in 2009, 2011, and 2012. ☐ Planning Area has a significant wildland/urban interface.
Earthquake	☐ Review of OKC OEM Event/Incident Reports ☐ Input from the Emergency Manager and OKC OEM staff ☐ Input from resident surveys ☐ Input from Hazard Mitigation Planning Committee members ☐ Historical records of earthquakes ☐ Input from USGS ☐ Input and data from Oklahoma Geological Survey	☐ History of earthquakes occurring in Oklahoma County and in close proximity to the Planning Area. Some of the State's strongest earthquakes have been felt in OKC in 2011 and 2016. ☐ Numerous identified faults in the Planning Area including the large Nemaha Fault.

Hazards	How Identified	Why Identified
Dam Failure	☐ Review of OKC OEM Event/Incident Reports ☐ Input from the Emergency Manager and OKC OEM staff ☐ Public input from resident surveys ☐ Input from Hazard Mitigation Planning Committee members ☐ OKC DAM Emergency Action Plan ☐ OK Water Resources Board – Inventory of Dams	☐ Multiple private and public owned low and high hazard dams in the Planning Area. ☐ History of one potential dam failure (2008) and one dam failure (2015) in the Planning Area.
Mosquito Borne Disease	☐ Input from the Emergency Manager and OKC OEM staff ☐ Input from resident surveys ☐ Input from Hazard Mitigation Planning Committee members ☐ Input and data from the Oklahoma City County Health Department ☐ Input and data from OKC Public Works Storm Water Quality ☐ Input and data from Oklahoma State Department of Health	☐ Mosquitoes carrying the West Nile Virus (WNV) are present in the Planning Area and are detected during each mosquito season. ☐ History and deaths and hospitalizations attributable to WNV occurring in the Planning Area.

Results of Surveys

As part of the Plan Update planning process surveys were conducted online, in-person, and with members of the LPPC/HMPC. The below graphs depict a summary of the results of those surveys:





Disaster History

Oklahoma has 179 federal declarations since 1955. Oklahoma ranks third for the number of federal declarations. These declarations include Major Disaster declarations, Emergency Declarations, and Fire Management Assistance Grants (FMAG). The Planning Team researched the FEMA database of Declarations by State and downloaded the Excel Spreadsheet. Each Major Disaster Declaration (Declaration) and Fire Management Assistance Grant (FMAG) listed was further researched to identify whether the Declaration or FMAG included one or more of the counties the Planning Area stretches into.

Major Disaster Declarations. The below list represents the Major Disaster Declarations for one or more of the counties the Planning Area stretches into for the past ten years. Although frequently only one or two of the four counties the Planning Area stretches into are listed this does not mean that the remaining counties were not affected by the event, it may simply mean the thresholds for Individual and/or Public Assistance were not met by those counties.

Declaration Number	Declaration Date	Incident Description	Declaration Type	County or Counties
1678	2/1/2007	Severe Winter Storms	Major Disaster Declaration	Canadian
1707	6/7/2007	Severe Storms, Tornadoes, and Flooding	Major Disaster Declaration	Canadian
1712	7/7/2007	Severe Storms, Flooding, and Tornadoes	Major Disaster Declaration	Canadian, Oklahoma & Cleveland
1718	8/24/2007	Severe Storms, Tornadoes, and Flooding	Major Disaster Declaration	Canadian & Cleveland
1735	12/18/2007	Severe Winter Storms	Major Disaster Declaration	Canadian, Oklahoma & Cleveland
1820	2/15/2009	Severe Storms and Tornadoes	Major Disaster Declaration	Oklahoma February 10th Tornado

Declaration Number	Declaration Date	Incident Description	Declaration Type	County or Counties
1846	6/19/2009	Wildfires	Major Disaster Declaration	Oklahoma April 2009 Fires
1876	2/25/2010	Severe Winter Storm	Major Disaster Declaration	Canadian & Cleveland
1883	3/5/2010	Severe Winter Storm	Major Disaster Declaration	Canadian & Cleveland
1917	5/24/2010	Severe Storms, Tornadoes, and Straight-Line Winds	Major Disaster Declaration	Oklahoma & Cleveland May 10th Tornado
1926	7/26/2010	Severe Storms, Tornadoes, Straight-line Winds, and Flooding	Major Disaster Declaration	Oklahoma June 14th Flood
1989	6/6/2011	Severe Storms, Tornadoes, Straight-line Winds, and Flooding	Major Disaster Declaration	Canadian - Mutual Aid to Piedmont
4117	5/20/2013	Severe Storms and Tornadoes	Major Disaster Declaration	Canadian, Oklahoma & Cleveland
4222	5/26/2015	Severe Storms, Tornadoes, Straight-line Winds, and Flooding	Major Disaster Declaration	Canadian, Oklahoma & Cleveland
4247	12/29/2015	Severe Winter Storms and Flooding	Major Disaster Declaration	Canadian & Oklahoma
4256	2/10/2016	Severe Winter Storms and Flooding	Major Disaster Declaration	Canadian

Fire Management Assistance Grants. The below list represents the FMAGs for wildfires that occurred in the past ten years within the Planning Area and were the responsibility of the City of Oklahoma City Fire Department to contain and extinguish.

FMAG Number	FMAG Date	Incident Description	Declaration Type	County or Counties
5001	8/3/2012	Luther Fire	Fire Management Assistance Declaration	Oklahoma
2951	8/30/2011	63rd and Sooner Road Fire	Fire Management Assistance Declaration	Oklahoma
2954	8/31/2011	Westminster Fire	Fire Management Assistance Declaration	Oklahoma
2941	8/1/2011	Mustang Road Fire	Fire Management Assistance Declaration	Canadian
2942	8/2/2011	Anderson Road Fire	Fire Management Assistance Declaration	Cleveland
2883	4/6/2011	Jones-Spencer Fire	Fire Management Assistance Declaration	Oklahoma

Note: There were four other FMAGs issued for wildfire occurring in adjoining jurisdictions in close proximity to the Planning Area in the past ten years which the City of Oklahoma City provided mutual aid to the agency having jurisdiction.

Small Business Administration Disaster Declarations. Not all events result in a Major Disaster Declaration. If the Governor's request for a Major disaster declaration is denied by the President of the United States, then the Small Business Administration (SBA) acting under its own authority may issue a Disaster Declaration. A SBA Disaster Declaration limits federal disaster assistance to low interest disaster loans only. The Planning Team researched Small Business Administration Disaster declarations. The below list represents standalone SBA Disaster Declarations not associated with a Major Disaster Declaration for one or more of the counties the Planning Area stretches into for the past ten years.

Declaration #	County	Incident	Incident Period
14263, 14264	Cleveland	OK-00091 – Tornadoes, Severe Storms, Straight-Line Winds, and Flooding	03/25/2015 through 03/26/2015
12231, 12232	Oklahoma	OK-00041 - Tornadoes, Severe Storms, Straight Line Winds and Flooding	06/13/2010 through 06/15/2010
12260, 12261	Oklahoma	OK-00042 – Tornadoes, Severe Storms & Flooding	07/06/2010 through 07/12/2010
12841, 12842	Oklahoma	OK-00056 – Oklahoma County Wildfire	08/30/2011 through 09/01/2011

Hazard Probability Rating

The probability rating in the hazards below is based on the following criteria:

High = Event probable in next year
Medium = Event probable in next 3 years
Low = Event probable in next 5 years
Very Low = Event probable in next 10 years

Based on history and using the previously mentioned probability statements, probability was quantified as follows:

High = Event has 1 in 1 year chance of occurring ……. 100%
Medium = Event has 1 in 3 years chance ……. 33%
Low = Event has 1 in 5 years chance ……. 20%
Very Low = Event has 1 in 10 years chance …….. 10%

Which result in the following ranges of probability:

High = greater than 33%
Medium = greater than 20%, but less than or equal to 33%
Low = greater than 10%, but less than or equal to 20%
Very Low = 10% or less

Example: The Big City USA has had 158 Hail events recorded in the last 58 years.
158 / 58 =2.724 x 100% = 272% which would make it "High".

The Planning Team gathered data and information from various sources to identify the frequency of events over a given time period. The Planning Team then used this data to calculate the probability of the natural hazard event occurring in the Planning Area. The results are displayed in the below table:

Hazard	Source	Frequency	Time Period	Frequency/ Time Period		Result	Rating
Extreme Heat	NCEI	32	20 years	1.6	X 100	160%	High
Flooding	NCEI	33	12 years	2.75	X 100	275%	High
Hail	NCEI	298	12 years	24.83	X 100	2,483.33%	High
High Winds	NCEI	474	66 years	7.18	X 100	718.18%	High
Lightning	NCEI	48	22 years	2.18	X 100	218.18%	High
Tornadoes	NCEI	84	66 years	1.27	X 100	127.27%	High
Winter Weather	NCEI	36	12 years	3	X 100	300%	High
Drought	NCEI	6	16 years	0.375	X 100	37.5%	Medium
Wildfire	OCFD	7,728	10 years	772.80	X100	77,289%	High
Earthquake	OGS	3,393	4 years	848.25	X100	84,825%	High
Dam Failure	OKC OEM	1	8 years	0.125	X100	12.5%	Low
Mosquito Borne Disease	OCCHD	5	5 years	1	X100	100%	High

All but one natural hazard has a high probability of occurring in the Planning Area. However, the number of damage producing events those that result in death, injury, or property destruction or damage are low for some of the natural hazards. For example there have been 3,393 recorded earthquakes of a magnitude greater than 2.0 with epicenters in Oklahoma County from 2013-2016, however, none have caused death or injury and relatively few have produced damage and the damage that has occurred would fall in the category of “affected damage”. Another example is there have been 7,728 reported grass fires in the Planning Area but only two produced sufficient damage to result in either a Major Disaster Declaration or SBA Disaster declaration. Finally, there have been five mosquito borne disease events in five years which looks like a low number. However, each event lasts months and over the five year period has produced a low of 18 to a high of 161 hospitalizations and from zero to a record 15 deaths statewide.

Illustrations for natural hazards that include tornadoes, flood hazard areas, wildland fires, dam risk and fault zones can be found in Attachment 25, Historic Tornado Tracks, 1893-2016, Attachment, Attachment 26: FEMA Flood Hazard Areas, Attachment: 27, Wildland Urban Interface, Attachment 28: Wildland Urban Interface Risk Index, Attachment 29: Dam Inventory and Risk Assessment, and Attachment 30: Earthquake Fault Lines.

Chapter 6 – Tornadoes

Description

A tornado is traditionally defined as a violently rotating column of air that reaches from the bottom of a cumulonimbus cloud to the ground. Tornadoes are found in severe thunderstorms, but not all severe thunderstorms will contain tornadoes. While all tornadoes touch both the ground and the bottom of a cloud, it is possible for only part of the tornado to be visible. A tornado may be on the ground for only a few seconds, or last for over an hour.

Tornadoes can appear in a variety of shapes and sizes ranging from thin ropelike circulations to large wedge shapes greater than one mile in width. However, a tornado's size is not necessarily related to its wind speed. The strongest tornadoes can have wind speeds in excess of 200mph. Over 80% of Oklahoma tornadoes have struck between 3PM and 9PM, but can still occur anytime. Spring is the peak season for Oklahoma tornadoes, but they can form during any season when the necessary atmospheric conditions of wind shear, lift instability, and moisture are present.

According to the National Centers for Environmental Information (NCEI) storm events database and Oklahoma City Emergency Management Reports the majority of tornadoes in Oklahoma City are EF-3 or less in intensity. However, more destructive EF 4 and EF 5 tornadoes have occurred in Oklahoma City.

Research conducted at the National Severe Storms Laboratory in Norman, OK (Brooks et al 2014); found that, excluding the weakest tornadoes, the average number of tornadoes in the United States each year has remained constant since the 1970s. However, tornado variability has increased due to a decrease in the number of days with tornadoes coupled with an increase in the number of days with many tornadoes. Other research (Brooks 2013) indicates that, in the future, the percentage of spring and summer storms that produce tornadoes and hail may decrease and the percentage that produce high, non-tornadic winds may increase. Whether the overall number of spring and summer storms will remain stable or change over time is unknown.

Location

Tornadoes affect the entire Oklahoma City area. In regard to geographical location, although several tornado "corridors" are suggested for Oklahoma City, it is likely that these distributions are no more than statistical fluctuations. Therefore, according to the NWS, past tornado frequencies in any given location do not imply similar frequencies in the future.

Furthermore, since there are no critical facilities or assets in Oklahoma City that are exposed to an increased incidence of tornadoes as a result of their geographical location, all residents and property in Oklahoma City is considered to have a similar risk to tornadoes.

Previous Occurrences

According to the National Centers for Environmental Information (NCEI) storm events database, 84 tornadoes of magnitude F1 or higher were reported in Oklahoma County between January 1, 1950, and August 31, 2016. Of these 84 tornadoes, 38 were classified as F1, 24 were classified as F2, 18 were classified as F3, and 4 were classified as F4. However, the May 3, 1999, tornado (discussed below) that hit portions of Oklahoma City was rated as an EF3 while classified as an F4 in the NCEI data base.

The deadliest tornado with the most property damage to occur is still the May 3, 1999, tornado. This tornado was in fact a series of tornadoes with the most notable one rated as an F5 and forming over Grady County near Amber, Oklahoma and tracking northeast for 37 miles eventually into the Oklahoma City metropolitan area. Bridge Creek, Oklahoma City, Moore, Del City, and Midwest City suffered tremendous damage. Thirty-six direct fatalities and 583 direct injuries were recorded. An estimated 1800 homes were destroyed, and 2500 homes were damaged, resulting in approximately 1 billion dollars in damage from this tornado.

On May 8, 2013, an F4 tornado carved a total path of 17.3 miles moving across Oklahoma City metropolitan area affecting Moore, southern Oklahoma City, Midwest City, and Choctaw. At least 89 injuries sustained as a result and multiple homes and business received significant damage estimated over $370 million.

The F4 tornado which occurred May 10, 2010, was part of a significant outbreak of severe thunderstorms and tornadoes affecting a large part of northern, central, and southern Oklahoma. This round of storms would directly impact a large part of the Oklahoma City metro area at rush hour, and posed a significant threat to the area. Two lives were reported lost and at least 450 injuries sustained as a result of the tornadoes. Property damage was substantial with unofficial estimates exceeding $595 million.

On May 24, 2011 there were several tornadic super cell thunderstorms which developed over parts of western and much of central Oklahoma with extensive damage occurring over many areas of central Oklahoma. At least 7 tornadoes occurred: One rated EF5, Two rated EF4, One rated EF3, One rated EF2, and Two rated EF1. In addition to the damaging tornadoes, hail sized reached at least 3” in diameter.

On the early morning hours of April 14, 2012 at about 12:55 am a tornado touched down in the City of Mustang and traveled north into the City of Oklahoma City for several miles before dissipating. Around a dozen tornadoes, as well as large hail, and strong wind gusts were produced by the numerous thunderstorms that occurred during this event.

In May 2013, the City of Oklahoma City was impacted by tornadoes on May 19th, May 20th, and May 31st. On May 19, 2013 an EF-4 tornado touched down in Norman and tracked northeast through NE Norman, into unincorporated Cleveland County (served by the Little Axe Volunteer Fire Protection District), and across the extreme southeast corner of the City of Oklahoma City affecting about two square miles of the City with about 31 structures damaged or destroyed in a one square mile area of the City.

On May 20, 2013 a tornado outbreak from central Oklahoma down through south central Oklahoma near the Red River occurred during the afternoon and evening hours. The strongest tornado touched down near Newcastle and traveled through south Oklahoma City, Moore, and back into Oklahoma City. This tornado caused catastrophic damage in these areas, with a maximum rating of EF-5. The NWS team survey teams determined that the tornado began 4.4 miles west of Newcastle and ended 4.8 miles east of Moore, yielding an approximate tornado path length of 17 miles. The Preliminary maximum damage path width is 1.3 miles. The tornado claimed 24 lives (three of these were in the City of OKC) and caused billions of dollars in damage. In addition to the tornadoes, large hail and damaging winds cause damage in many areas. In Oklahoma City 1,038 structures were identified by OKC Emergency Management as destroyed or damaged.

May 31, 2013 saw multiple tornadic events impacting Oklahoma City. An EF-1 tornado moved into Oklahoma County from Canadian County in western Oklahoma City and moved generally east along and near SW 15th Street before dissipating near SW 15th and Meridian Avenue. Buildings, power lines and trees were damaged, including broken windows at a couple of motels along Meridian Avenue. An EF-0 tornado traveled from Creekwood Terrace southeast to Keith Drive near SE 54th Street. Minor damage to trees and power lines was noted. An EF-1 tornado touched down just west of SW 59th Street and Pennsylvania Avenue in southwest Oklahoma City, and moved east to just southwest of SW 59th Street and Western Avenue. Roof and tree damage occurred with this tornado.

On May 6, 2015 an EF-3 tornado touched down in southeast Oklahoma City. The tornado had a length of 1.3 miles and a maximum width of 700 yards. It began near SE 59th and Eastern Ave and traveled in a northwest arc to SW 44th Street to just west of High.

Extent

The severity of tornados is measured on the Fujita tornado scale and Enhanced Fujita tornado scale. On February 1, 2007, the Fujita tornado scale was decommissioned in favor of the more accurate Enhanced Fujita tornado scale. None of the tornados recorded on or before January 31, 2007 will be re-categorized. Therefore maintaining the Fujita tornado scale will be necessary when referring to previous events. The scale is described below and is based on wind speed and type of damage done. The most severe impact by a tornado would be the result of an EF5 tornado moving through Oklahoma City. The Planning Area has experienced Tornados that range from EF0-EF5. The Planning Area may experience any of the EF Scale intensity tornadoes at any time during the year. Based on statistical analysis from 1950 to 2016, the extent of future tornadoes in Oklahoma City is expected to be: EF0 at 25.3%, EF1 at 35.1%, EF2 at 20.7%, EF3 at 15.3%, EF4 at 2.7%, and EF5 at 0.9%. Weak tornadoes (EF0 to EF1) are expected to account for 60.4% of future tornadoes. Strong tornadoes (EF2 to EF3) are expected to account for 36% of future tornadoes. Violent tornadoes (EF4 to EF5) are expected to account for 3.6% of future tornadoes. A well-built residential structure can provide survivable protection to the occupants when they shelter in place on the lowest level inner most room from 96.4% of future tornadoes of EF3 or less.

FUJITA SCALE			DERIVED EF SCALE		**OPERATIONAL EF SCALE**	
F Number	Fastest 1/4-mile (mph)	3 Second Gust (mph)	EF Number	3 Second Gust (mph)	**EF Number**	**3 Second Gust (mph)**
0	40-72	45-78	0	65-85	**0**	**65-85**
1	73-112	79-117	1	86-109	**1**	**86-110**
2	113-157	118-161	2	110-137	**2**	**111-135**
3	158-207	162-209	3	138-167	**3**	**136-165**
4	208-260	210-261	4	168-199	**4**	**166-200**
5	261-318	262-317	5	200-234	**5**	**Over 200**

(http://www.spc.noaa.gov/faq/tornado/ef-scale.html)

Enhanced Fujita (EF) Scale		
Enhanced Fujita Category	**Wind Speed (mph)**	**Potential Damage**
EF0	65-85	**Light damage.** Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over.
EF1	86-110	**Moderate damage.** Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	111-135	**Considerable damage.** Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	136-165	**Severe damage.** Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF4	166-200	**Devastating damage.** Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.
EF5	>200	**Incredible damage.** Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 m (109 yd); high-rise buildings have significant structural deformation; incredible phenomena will occur.

Enhanced Fujita (EF) Scale		
Enhanced Fujita Category	**Wind Speed (mph)**	**Potential Damage**
source: http://en.wikipedia.org/wiki/Enhanced_Fujita_Scale		

Probability of Future Events

Due to annual tornado events in the Oklahoma City area, the probability is high these events will continue every year.

Vulnerability and Impacts

The National Weather Service (NWS) advises that tornadoes strike at random, and therefore all areas within the community are equally at risk. Furthermore, tornadoes follow the path of least resistance making people living in valleys, which normally are the most highly developed areas, at the greatest risk of exposure.

Differences in vulnerabilities do exist for different populations: people are generally more vulnerable if they fall into one or more of the following categories:

- They are located where community early warning systems are ineffective.
- They are in housing that is not as structurally sound as standard housing (i.e., mobile homes).
- They do not have ready access either to individual storm shelters (safe rooms, underground storm shelters, etc.) or to community storm shelters.
- At the time of a tornado, they are caught outside or in an automobile.

In regards to structures, damage levels are typically the result of such factors as storm intensity, duration, objects in the tornadoes path, and distance between structure and tornado. Furthermore, the construction materials and site location of a structure can influence the amount of damage it and its occupants may incur. Also, mobile homes can be more easily damaged than permanent structures and thus are likely to place their occupants at greater risk of injury.

In regard to geographical location, although several tornado "corridors" are suggested for Oklahoma City, it is likely that these distributions are no more than statistical fluctuations. Therefore, according to the NWS, past tornado frequencies in any given location do not imply similar frequencies in the future. Furthermore, since there are no critical facilities or assets in Oklahoma City that are exposed to an increased incidence of tornadoes as a result of their geographical location, all residents and property in Oklahoma City is considered to have a similar risk to tornadoes.

Attachment 25: Historic Tornado Tracts 1893-2016 shows the severity and distribution of tornadoes in the City of Oklahoma City from 1893 to 2016. The legend uses colors to show the severity of each tornado based on the Enhanced Fujita Scale. There is a public perception that some portions of the city are more vulnerable to tornadoes than other portions of the city. This map displays a random distribution of tornadoes both by location and intensity showing the entire city is vulnerable to

tornadoes and one part of the city is no less vulnerable than another.

Chapter 7 – High Winds

Description

Wind is defined as the movement of air relative to the earth's surface. High winds can result from thunderstorms, strong cold front passages, or gradient winds between high and low pressure moving across Oklahoma. High winds, sometimes referred to as "straight-line" winds, are speeds reaching 58 mph or greater, either sustaining or gusting. Downdraft winds are a small-scale column of air that rapidly sinks toward the ground, usually accompanied by precipitation as in a shower or thunderstorm. A downburst is the result of a strong downdraft associated with a thunderstorm that causes damaging winds near the ground. These winds can range from light breezes to sustained speeds of 80 to 100 mph.

The ratio of spring and summer storms that produce high, non-tornadic winds is expected to increase relative to storms that produce tornadoes, according to a study by the National Severe Storms Laboratory (Brooks 2013). Whether the overall number of spring and summer storms will remain stable or change over time is unknown.

Location

The entire Oklahoma City area is at risk from damaging winds. Winds are always part of severe storms such as thunderstorms, tornadoes, and blizzards but do not have to accompany a storm to be dangerous. Down-slope windstorms, straight-line winds, and microbursts can all cause death, injury, and property and crop damage.

Previous Occurrences

The National Centers for Environmental Information (NCEI) Storm Events Database classifies wind events as "High Wind or Thunderstorm Wind events. Since January 1, 1950, through September 30, 2016, in Oklahoma County there have been 474 significant wind events with wind speeds of 50 knots (57.5 mph) or greater.

On July 24, 1995, a thunderstorm with sustained winds of 74 mph and wind gusts over 94 mph caused widespread damage to the Oklahoma City area. Power poles and trees were blown down throughout the City causing power outages to approximately 75,000 homes. Hundreds of commercial buildings and residential properties suffered damage to roofs and other parts of their structures from the high winds. Will Rogers World Airport and Wiley Post Airport suffered over $1,700,000 in damage. The Oklahoma City Fairgrounds received over $850,000 in damage to buildings and had over 200 trees twisted or uprooted. Estimates of damage to private property were in excess of $6,500,000 with cleanup costs estimated at another $2,000,000.

On May 27 and 28, 2001, high wind events in excess of 90 mph, resulted in a federally declared disaster, FEMA-1384-DR-OK, with cleanup costs near $900,000 for the City.

Another costly thunderstorm and severe wind event (wind speeds of 65 mph) involving property damage in Oklahoma City occurred on July 21, 2000, when approximately 50 windows were either cracked or blown out at Integris Baptist Hospital, and numerous doors were blown off their hinges. Large plate glass windows were blown out at Landmark Towers near Northwest 58th and Portland, and also in other buildings nearby. Evan's Furniture on South Portland Ave. was severely damaged by wind allowing rain to fall onto and ruin approximately 1700 pieces of furniture. The roof was peeled back at Henry Hudson's Pub on Northwest 58th, while at Citizens for Caring on Northeast 50th, the roof was peeled back, allowing rain to damage or destroy most of the interior. Numerous power poles were downed on Wilshire Blvd. just east of County Line Road. Approximately 75,000 customers were left without power. No direct injury results have been associated with this storm and the National Weather Service (NWS) estimated $2.3 million in damages.

From January 1, 2004, through September 2016, there were 475 thunderstorms and high wind events over this 12.75-year period reported in Oklahoma County. These events resulted in $6.37 million in property damage. The most destructive wind event since the initial HMP was adopted occurred on September 2, 2010. The storm had wind speeds of 65 knots (75 mph). Widespread damage was reported between Council Road and MacArthur Avenue, and between NW 150th and Hefner Road. Thousands of tree limbs were blown down. A roof at a nursing home was partially removed. A large portion of the roof at James L. Dennis Elementary school was also removed. Property damage estimates from this storm total $2.5 million.

Extent

The extent of winds is generally measured by the Beaufort Wind Scale shown below. The Beaufort wind scale is used to measure wind classifications between 0 and 12. Oklahoma City experiences wind speeds in each classification under this scale.

Force	Wind (Knots)	WMO Classification	Appearance of Wind Effects	
			On the Water	On Land
0	Less than 1	Calm	Sea surface smooth and mirror-like	Calm, smoke rises vertically
1	1-3	Light Air	Scaly ripples, no foam crests	Smoke drift indicates wind direction, still wind vanes
2	4-6	Light Breeze	Small wavelets, crests glassy, no breaking	Wind felt on face, leaves rustle, vanes begin to move
3	7-10	Gentle Breeze	Large wavelets, crests begin to break, scattered whitecaps	Leaves and small twigs constantly moving, light flags extended
4	11-16	Moderate Breeze	Small waves 1-4 ft. becoming longer, numerous whitecaps	Dust, leaves, and loose paper lifted, small tree branches move
5	17-21	Fresh Breeze	Moderate waves 4-8 ft taking longer form, many whitecaps, some spray	Small trees in leaf begin to sway
6	22-27	Strong Breeze	Larger waves 8-13 ft, whitecaps common, more spray	Larger tree branches moving, whistling in wires
7	28-33	Near Gale	Sea heaps up, waves 13-20 ft, white foam streaks off breakers	Whole trees moving, resistance felt walking against wind

8	34-40	Gale	Moderately high (13-20 ft) waves of greater length, edges of crests begin to break into spindrift, foam blown in streaks	Whole trees in motion, resistance felt walking against wind
9	41-47	Strong Gale	High waves (20 ft), sea begins to roll, dense streaks of foam, spray may reduce visibility	Slight structural damage occurs, slate blows off roofs
10	48-55	Storm	Very high waves (20-30 ft) with overhanging crests, sea white with densely blown foam, heavy rolling, lowered visibility	Seldom experienced on land, trees broken or uprooted, "considerable structural damage"
11	56-63	Violent Storm	Exceptionally high (30-45 ft) waves, foam patches cover sea, visibility more reduced	
12	64+	Hurricane	Air filled with foam, waves over 45 ft, sea completely white with driving spray, visibility greatly reduced	

Source: http://www.spc.noaa.gov/faq/tornado/beaufort.html

The City of Oklahoma City has identified a minor severity wind event with wind speeds of 34-40. A major severity is winds in excess of 55 mph or higher.

Probability of Future Events

The probability of High Winds occurring in the Oklahoma City area is high.

Vulnerability and Impacts

Oklahoma City is at risk from high winds because of the powerful thunderstorms that frequent the region. The entire Oklahoma City area has significant exposure to high winds, and virtually all buildings in Oklahoma City are at risk. Typical structure damage includes building roof damage particularly to metal buildings, large retail buildings, schools and nursing homes. Downed power poles, trees and free standing signs are also common.

Population's most vulnerable to high wind related deaths, injuries, and property damage is those residing in mobile homes and either deteriorating or poorly constructed homes. The entire Oklahoma City area has significant exposure to high winds, and virtually all buildings in Oklahoma City are at risk. Typical structure damage includes building roof damage particularly to metal buildings, large retail buildings, schools and nursing homes. Downed power poles, trees and free standing signs are also common.

Building practices could be modified to make structures less vulnerable to low end convective windstorms, however, it may not be cost-effective to build ordinary structures to withstand the rare extreme events.

Chapter 8 – Lightning

Description

Lightning is a discharge of intense atmospheric electricity, accompanied by a vivid flash of light, from one cloud to another, or from a cloud to the ground. Lightning is formed by the separation of positive and negative charges that occur when ice crystals collide high up in a thunderstorm cloud. As lightning passes through the atmosphere the air immediately surrounding it is heated, causing the air to expand rapidly. The resulting sound wave produces thunder. The majority of lightning bolts strike from one cloud to another but can also strike the ground. Over three-quarters of the electrical discharge associated with lightning are used in heating the gases in the atmosphere in and immediately around the visible channel. According to the Federal Emergency Management Agency (FEMA), temperatures can raise to over 18,000 °F in microseconds, resulting in a violent pressure wave, composed of compression and rarefaction.

Location

The entire Oklahoma City area is at risk from Lightning which can occur anywhere in the United States. Damages from Lightning are often underreported. Lighting is responsible for property damage, significant injuries, and loss of life. Lightning can also cause significant structural damage to buildings, and can result in wildfires, downed utility lines and trees.

Previous Occurrences

The National Centers for Environmental Information (NCEI) database reports 48 lightning events from January 1, 1994, through September 30 2016, with a total of 51 injuries and an estimated $8,288,750 of property damage. However, the Oklahoma City Fire Department reports that lightning is responsible for numerous home fires in Oklahoma City each year. Many lightning strikes go unreported, since the damage they cause is minor in most instances.

According to the NCEI database, there were two storms that occurred during this period that resulted in estimated property damages of $1.5 million. Both events were described as residential structure fires. In July 2014, another storm in NCEI database resulted in an estimated property damage of 2.8 million. A search of the City of Oklahoma City's insurance claims for City owned facilities exhibits less than $7,500 of claimed damages regarding fires.

Extent

According to the National Oceanic and Atmospheric Administration (NOAA), lightning is categorized by Lightning Activity Level (LAL). The City of Oklahoma City Emergency Management has modified the LAL scale to differentiate between minor and major damage caused by lightning strikes. The City of Oklahoma City considers all lightning to have the capability to cause major damage.

Lightning Activity Level (LAL)	
Is a scale which describes lightning activity. Values are labeled 1-6:	
LAL 1	No thunderstorms
LAL 2	Isolated thunderstorms. Light rain will occasionally reach the ground. Lightning is very infrequent, 1 to 5 cloud to ground strikes in a five minute period.
LAL 3	Widely scattered thunderstorms. Light to moderate rain will reach the ground. Lightning is infrequent, 6 to 10 cloud to ground strikes in a 5 minute period.
LAL 4	Scattered thunderstorms. Moderate rain is commonly produced Lightning is frequent, 11 to 15 cloud to ground strikes in a 5 minute period.
LAL 5	Numerous thunderstorms. Rainfall is moderate to heavy. Lightning is frequent and intense, greater then 15 cloud to ground strikes in a 5 minute period.
LAL 6	Dry lightning (same as LAL 3 but without rain). This type of lightning has the potential for extreme fire activity and is normally highlighted in fire weather forecasts with a Red Flag Warning.

Probability of Future Events

The probability of Lightning occurring in the Oklahoma City area is high.

Vulnerability and Impacts

Oklahoma has a significant hazard due to the frequent occurrence of thunderstorms in the State. Virtually all structures, infrastructure and individuals in Oklahoma City are vulnerable to Lighting. Anyone outdoors during a thunderstorm is exposed and at risk of injury from lightning. Most people are injured or killed by lightning will participating in some form of recreation. Lightning is the most frequent weather hazard impacting athletic events. With regard to infrastructure, electrical power systems are also heavily affected by lighting. Oklahoma has a significant hazard due to the frequent occurrence of thunderstorms in the state.

Chapter 9 – Hail

Description

Hail is a form of solid precipitation that consists of balls or irregular lumps of ice, which are individually called hailstones. Hail formation requires an atmospheric environment of strong, upward moving air, called an updraft, within the subfreezing region of a thunderstorm cloud. Large hail stones greater than an inch in diameter (quarter size), can result from a severe thunderstorm and require a very powerful updraft to form. Most large hail is the product of supercell thunderstorms, which have a sustained rotating updraft that moves growing hailstones a long distance through the height of the cloud before falling to the ground.

The percentage of spring storms that produce hail is expected to decrease, according to a study by the National Severe Storms Laboratory (Brooks 2013). Whether the overall number of spring and summer storms will remain stable or change over time is unknown.

Location

Hail storms can occur anywhere in the Oklahoma City area.

Previous Occurrences

The National Centers for Environmental Information (NCEI) database reports 916 hail events. Of these events, 232 had hail equal to or greater than 1.0-inch in diameter and therefor classified as damaging hail. It should be noted that multiple hail events may be recorded for the same storm system. For example, 29 hail events were recorded for a wide spread thunderstorm system that struck Oklahoma County on May 16, 2010.

On April 21, 2004, at the time of the initial HMP the most damaging and costliest hail event recorded in Oklahoma City occurred. The hail event produced hail up to the size of a baseball and caused an estimated $75-100 million in damages. The City's buildings received minor damages such as the Lake Hefner Golf Course clubhouse and various outlying buildings and the Lincoln Park Golf Course buildings with approximately $60,000 and under $100,000 in damages, respectively.

That storm event was surpassed on May 16, 2010 when a long-lived super cell formed over Major County and moved southeast into the Oklahoma City metropolitan area causing widespread and significant damage. Numerous vehicles were heavily damaged or even totaled by the large amounts of damaging hail. Numerous buildings suffered roof, window and structural damage, and trees and vegetation were shredded by the large hail. Hail drifts reached several feet deep over some areas, and a few locations reported hail still on the ground more than 12 hours later. Estimates place the monetary losses in excess of $500 million.

Another significant severe weather event began during the afternoon hours of May 29, 2012 and lasted well into the night. Several long-lived supercells tracked from northwest and north-central Oklahoma

down into the Oklahoma City metro area. Very large hail, measuring from 3.5 to 5 inches in diameter, was reported in northern parts of Oklahoma City and surrounding suburbs. High winds and large hail caused significant damage to homes and businesses, and resulted in widespread power outage. Two tornadoes were reported in Canadian County, but resulted in only minor damage. Total damages from the storms were estimated to be between $400 and $500 million.

Extent

The severity of damage caused by hail storms depends on the hailstone sizes (average and maximum), number of hailstones per unit area, and associated winds. The magnitude of a hail storm is as follows.

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
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

Sources: www.noaa.gov and www.torro.org

The City of Oklahoma City classifies a hail storm of H1 to be minor severity. A major severity is H9 and above.

Probability of Future Events

The probability of Hail occurring in the Oklahoma City area is high.

Vulnerability and Impacts

Oklahoma City is at risk from hail because of the powerful thunderstorms that frequent the region, there is no geographical preference within Oklahoma City. Hail storms are most prevalent during the middle to late spring months of April, May, and June which coincide with Oklahoma City's major tornado season.

People engaged in outdoor activities that may include recreation or attending sporting events are the most vulnerable to injuries. During Hail events, virtually all personal property, buildings, and infrastructure are vulnerable to hail related damage.

Hail can produce devastating damage, as demonstrated by the May 16, 2010 and May 29, 2012 storms. According to historical research, there have been 273 hail events in Oklahoma County over the last 10 years and 221 of these events were classified as damaging hail. Generally these hail storms are fairly localized and the property damage is minimal. However, The Oklahoma City metropolitan area has experienced two major hail storms in this 10 year period which together resulted in excess of $900 million in damages evidencing that hail pose a significant risk to people and property. Without proper mitigating action the City can expect similar damages to occur in the future.

Chapter 10 – Winter Storms

Description

Winter Storm can refer to any combination of winter precipitation, including snow, sleet, and freezing rain. A severe winter storm can range from freezing rain or sleet to moderate snow over a few hours up to blizzard conditions and extremely cold temperatures that lasts several days.

- **Severe winter storm** is one that drops 4 or more inches of snow during a 12–hour period, or 6 or more inches during a 24- hour span.
- **Blowing snow** is wind-driven snow that reduces visibility and causes significant drifting. Blowing snow may be snow that is falling and/or loose snow on the ground and picked up by the wind.
- **Blizzards** occur when falling and blowing snow combine with high winds of 35 mph or greater reducing visibility to near zero.
- **Freezing rain** is rain that falls as liquid onto a surface with a temperature below freezing. This causes the drops to freeze on contact onto surfaces like trees, utility lines, cars, and roads, forming a coating or glaze of ice. Even small accumulations of ice can cause a significant hazard.
- **Sleet** is frozen precipitation that has melted by falling through a warm layer of the atmosphere and then refreezes into ice pellets before reaching the ground. Sleet usually bounces when hitting a surface and does not immediately stick to objects. However, it can accumulate like snow and cause a hazard to motorists.
- **Ice storms** are extended freezing rain events, lasting several hours to sometimes days, when the freezing rain accumulates a thick enough glaze on surfaces to damage trees, utility lines, and cause major travel hazards. Ice storms can result in a heavy glaze an inch thick or more, but even a quarter inch ice accumulation can cause problems under windy conditions.
- **Wind chill** is used to describe the relative discomfort and danger to people from the combination of cold temperatures and wind. The wind chill chart below from the National Weather Service shows the apparent temperature derived from both wind speed and temperature.

The NWS will issue advisories for potential severe winter storms as follows.

- **Winter Storm Watch:** There is the potential for severe winter weather developing within the next day or so. The storm has not yet arrived, but if it does, it might include heavy snow, blizzards, freezing rain, ice, and sleet.
- **Winter Storm Warning:** There is severe winter weather occurring or imminent.
- **Blizzard Warning**- Snow and strong winds will combine to produce a blinding snow (near zero visibility), deep drifts, and life-threatening wind chill.
- **Winter Weather Advisory:** Winter weather conditions are expected to cause significant inconveniences and may be hazardous. If caution is exercised, these situations should not become life- threatening. The greatest hazard is often to motorists.

- **Frost/Freeze Warning:** Below freezing temperatures are expected and may cause significant damage to plants, crops, or fruit trees. In areas unaccustomed to freezing temperatures, people who have homes without heat need to take added precautions.

The limited research that has examined future changes in winter storm risk is inconclusive. It is not known at this time how changes in temperature and precipitation will affect the development of severe winter weather events.

Location

The entire Oklahoma City area is at risk from Winter Storms. Winter storms are often accompanied by cold temperatures and can produce damaging weather in the way of ice capable of knocking out power lines, closing roads, and above ground electrical and telephone lines can be knocked out. The majority of winter related incidents (70%) involve automobiles. Historically there have been three significant storms in the last 10 years that have produced extensive damage totaling an estimated $150 million.

Previous Occurrences

The 2006 HMP identified 28 snow and ice events from November 25, 1993, through April 30, 2004, that had some effect on Oklahoma County as reported by the NCEI. Snow and ice events include the following: 1) ice; 2) heavy snow; 3) freezing drizzle; 4) freezing rain and sleet; 5) heavy snow and ice; 6) freezing rain; 7) ice storm; and 8) winter storm. Between May 1, 2004 and September 30, 2016 an additional 36 winter storm events have been recorded.

On March 4, 2015, a strong cold front surged through Oklahoma, bringing an Arctic air mass into much of the Southern Plains. During this time a large scale upper level trough shifted eastward across the Southern and Central Plains region, resulting in widespread wintry precipitation. Several inches of snow and sleet fell, with significant impacts to travel. Light freezing rain mixed with sleet during the morning, transitioning to snow during the afternoon and evening. By the time snow had ended, Oklahoma City, Midwest City, and Bethany had received 3 inches, while Edmond and Newalla recorded 2 inches. Reports were submitted by NWS employees and members of the public.

On December 5 and 6, 2013 a double shot of winter weather impacted Oklahoma during the day. Initially, wintry precipitation came in all forms, with freezing rain, sleet and snow. The second round of winter weather came as primarily snow, though some sleet and freezing rain continued into the morning hours of December 6th. Substantial snow, sleet and ice accumulations occurred over a large part of central, southern and western Oklahoma. By the time the storm was over, several areas across Oklahoma County reported substantial snow. Edmond and Warr Acres both saw between 4 and 5 inches of snow, with a thin layer of sleet.

On February 8, 2013 a strong surface high pressure developed south out of Canada into Kansas early on the 8th behind a cold front that ultimately moved into Oklahoma. Behind the arctic front were very cold

temperatures, with temperatures falling into the single digits, and even sub-zero readings across many areas of the northern and central Plains (sub-zero temperatures would soon overspread much of Oklahoma). Precipitation, some of it heavy, developed behind the front as a strong low-level jet transported relatively warm and moister air north over-top of the front. During the day, the cold front made substantially more southward progress over the Texas panhandle into western Oklahoma, with additional heavy snow accumulations developing behind the boundary by late afternoon. Additional support for precipitation development had developed ahead of a potent mid-level disturbance that moved southeast toward Oklahoma. Normally, progressive storm systems such as this one would not big snow-producers over the southern Plains, but with strong warm advection and very cold temperatures at the surface and aloft (and getting colder through the event), snow growth was maximized, which in turn caused moderate to heavy snowfall to occur. By mid-evening, the main snow band had developed over northern Oklahoma, with moderate to heavy snowfall occurring over the northern two or three tiers of counties for several hours. Further to the south, an area of moderate to heavy snowfall progressed east, but started a little later and did not last near as long. Four to six inches of snow was measured around Oklahoma County, including 5.9 inches at Will Rogers World Airport. Numerous wind gusts over 30 mph were reported for several hours greatly reducing visibilities and causing considerable blowing and drifting of the snowfall. Around 240 injuries statewide were reported by the Oklahoma State Department of Health, with 33 injuries associated with around 84 automobile accidents.

On January 28, 2010 a major winter storm impacted much of Oklahoma. While the storm produced a variety of wintry precipitation, it's most significant impacts came with an extended period of heavy freezing rain across southern parts of central Oklahoma. Significant icing on trees and power lines resulted in widespread damage to trees and power lines. In total, the large storm system resulted in over 900 slip-and-fall accidents. Almost 90 accidents were reported, with over 200 non-life threatening injuries with the accidents. Almost 180,000 homes and businesses were without power at the peak of the storm, several of which (mainly in SW Oklahoma) were without power for almost a week. The initial damage estimates placed the monetary value for the damage well into the millions of dollars.

On December 24, 2009 a powerful winter storm developed over parts of the Southern Plains, resulting in one of the most widespread and damaging blizzards to affect Oklahoma. Snowfall accumulated from seven to eleven inches over of much of Oklahoma City, with isolated totals over a foot. A record 13.5 inches was measured Will Rogers World Airport. Frequent wind gusts of 50 to 60+ mph caused considerable blowing and drifting snow, and greatly reducing visibilities. Numerous automobile accidents were reported, especially given the high volume of traffic the day before Christmas. A large 50+ car accident was reported near Midwest City, which resulted in several injuries. Most area roadways were shut down for the day into Christmas morning, which included all Interstates in and around the Oklahoma City metro area, and almost of all of Interstate 44. Thousands of people were stranded in their cars for several hours, and many abandoned their vehicles, littering the roads and highways making snow removal more difficult and roads slow to reopen. The strong winds, combined with the below freezing temperatures, allowed for wind chill temperatures to drop to near zero making it even more dangerous for people that were abandoning their vehicles. Total damage from the blizzard exceeded $18 million across Oklahoma. Unfortunately, nine people lost their lives, either in weather-related traffic

accidents, or being struck by cars while assisting stranded motorists.

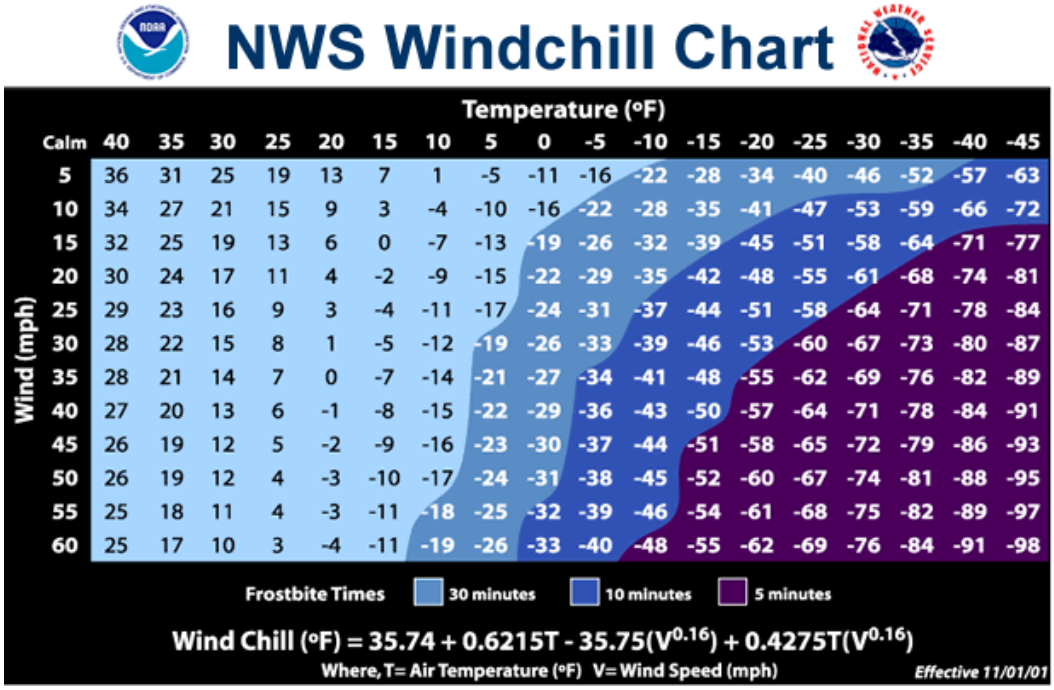
On January 29-30, 2002, freezing rain began across the northwest third of the state with significant accumulations of ice developing. Freezing rain shifted southward during the early morning of the 30th with moderate to occasionally heavy freezing rain occurring. In many areas, the freezing rain continued for 12 to 24 hours, with ice accumulations of 1 to 2 inches. The worst damage resulting from ice accumulations occurred from near Ponca City, Blackwell, Red Rock, Perry, and Stillwater, southwestward through Enid, Canton, Watonga, Hennessey, Kingfisher, and Guthrie, to near Clinton, Weatherford, El Reno, northwest side of Oklahoma City, Edmond, Cordell, Binger, and Minco. The damage was catastrophic in places, with thousands of utility poles brought down by the weight of the ice, along with thousands of trees. Dozens of towns were left completely without power for days, with some residents without power for weeks. At one point, nearly 250,000 residents were without power. Total damage across the state was estimated to be in the hundreds of millions of dollars. The NCEI database estimate was $300,000,000.

On December 25-26, 2000, a major winter storm developed across all of western, central, and southeast Oklahoma, with significant accumulations of snow and ice. Mainly snow fell across northwest Oklahoma, however even in areas where snow amounts were light, significant disruptions in travel and power outages were reported. Farther east, 2 to 4 inches of a snow/sleet/freezing rain mixture fell from near Ponca City and Oklahoma City. The worst ice storm in decades affected much of south central and southeast Oklahoma. Where the precipitation fell as mainly freezing rain, ice accumulations were about 1 inch. Damage to property was extensive with the greatest damage observed in a narrow corridor south of Oklahoma City. Thousands of homes and vehicles were damaged by falling trees and ice, while thousands of additional trees and utility poles were damaged or destroyed. Tens of thousands of residents were left without electricity for nearly a week, while thousands of residents were without water or phone service for several days. Statewide, nearly 170,000 residents were without electricity on the 26th and 27th. Six indirect fatalities are believed to be associated with the winter storm. One woman died on the 26th after falling on the ice in Oklahoma City. The estimated property damage, according to the NCEI database, was $76,125,000.

Extent

The National Weather Service implemented the current Wind Chill Temperature (WCT) index during the 2001/2002 winter season. The WTC Index makes use of advances in meteorology, biometeorology and computer modeling to provide a more accurate, useful formula for calculating the dangers form winter winds and freezing temperatures.

NOAA Wind Chill Chart



Wind (mph)	Calm	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	19	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

An index scale used by the utility industry to anticipate impact and damage of an icing event to transmission lines is the Sperry-Piltz Ice Accumulation Index (SPIA). As a tool for risk management and winter weather preparedness, the index uses the National Weather Service forecast parameters to predict the spatial coverage, total ice accumulation, and potential damage from ice storms. The City of Oklahoma City classifies a minor severity winter storm of 2 or below on the SPIA index. A major severity is classified as 3 and above. Based statistical analysis of winter weather events the extent of future winter storms is expected to be: (a) one-third will be classified as major winter storms and (b) two-thirds will be classified as minor winter storms.

The Sperry-Piltz Ice Accumulation Index, or "SPIA Index" – Copyright, February, 2009

ICE DAMAGE INDEX	DAMAGE AND IMPACT DESCRIPTIONS
0	Minimal risk of damage to exposed utility systems; no alerts or advisories needed for crews, few outages.
1	Some isolated or localized utility interruptions are possible, typically lasting only a few hours. Roads and bridges may become slick and hazardous.
2	Scattered utility interruptions expected, typically lasting 12 to 24 hours. Roads and travel conditions may be extremely hazardous due to ice accumulation.
3	Numerous utility interruptions with some damage to main feeder lines and equipment expected. Tree limb damage is excessive. Outages lasting 1 – 5 days.
4	Prolonged & widespread utility interruptions with extensive damage to main distribution feeder lines & some high voltage transmission lines/structures. Outages lasting 5 – 10 days.
5	Catastrophic damage to entire exposed utility systems, including both distribution and transmission networks. Outages could last several weeks in some areas. Shelters needed.

(Categories of damage are based upon combinations of precipitation totals, temperatures and wind speeds/directions.)

www.spia-index.com

Probability of Future Events

The probability of Winter Weather occurring in the Oklahoma City is high.

Vulnerability and Impacts

Oklahoma City is affected periodically by heavy snow and ice that cause property damage. Trees and power lines fall due to the weight of ice and snow damaging buildings in the vicinity as well as blocking streets and sidewalks. Icy roads cause accident rates to increase and impair the ability for emergency vehicles to respond which can result in more injuries and a higher loss of life.

Winter storms can range from accumulating snow and/or ice over just a few hours to blizzard conditions with blinding wind-driven snow that can last several days. The aftermath from a damaging winter storm can continue to impact a region for weeks and even months. Carbon monoxide poisoning is always a possibility as homeowners and businesses use alternative heat sources to keep warm. Personal health can be affected in a variety of ways including mental and physical stress, frostbite or related injuries and inability to travel for care.

Chapter 11 – Flood

Description

Floods are one of the most common hazards in the United States including Oklahoma. Flooding is the deadliest thunderstorm hazard in the U.S. annually (followed by lighting). Flood effects can be local, impacting a neighborhood or community; or very large, affecting entire river basins and multiple states. The two general types of flooding are river flooding and flash flooding.

A flood is a natural event for rivers and streams. River flooding is when a river rises to its flood stage and spills over the banks. The amount of flooding is usually a function of the amount of precipitation in an area, the amount of time it takes for rainfall to accumulate, previous saturation of local soils, and the terrain around the river system. For instance, a river located in a broad, flat floodplain will often overflow to create shallow and persistent flood waters in an area that do not recede for extended periods of time. The excess water can be from upstream snowmelt or rainfall.

Flash flooding occurs when the precipitation rate becomes so large that local waterway drainage cannot evacuate the runoff. It can develop very quickly during or immediately after a nearby heavy rainfall. Driving through water covered roadways during a flash floods is especially dangerous since as little as 6 inches of fast moving water can compromise control of a vehicle.

The primary threat from flash flooding is often to human life and safety, while the slower onset and more widespread nature of river flooding creates greater economic and property damage threats.

The National Flood Insurance Program (NFIP) defines flooding as a general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties from, overflow of inland or waters or the unusual and rapid accumulation or runoff of surface waters from any source.

While the overall amount of annual precipitation is expected to remain fairly stable over the remainder of the century, the pattern of precipitation is expected to change. The number of days with heavy precipitation is expected to increase by mid-century, with more heavy rain events punctuated by more dry spells (NCA 2014).

Location

The conditions that lead to flash flooding can happen anywhere in Oklahoma City, during any season, and at any time of day. River Flooding may occur anywhere near a river, creek, or stream. Those creeks and streams in the urbanized portions of Oklahoma City are more prone to flash flooding then creeks and streams in rural undeveloped portions of Oklahoma City. This is because the urbanized portions of Oklahoma City have a built environment that contributes to excessive rainfall runoff.

Previous Occurrences

According to the National Centers for Environmental Information (NCEI) storm events database, 33 flood events were reported in Oklahoma County between May 2004 and September 31, 2016. Estimated property damage resulting from these events totaled $7.228 million.

The flood hazard events described for Oklahoma County on the NCEI storm events database are for the most part classified as flash floods that are the result of severe thunderstorms which quickly fill small streams and creek beds and cause localized street flooding. The most severe event occurred June 14, 2010. Heavy rain fell on already saturated ground and quickly led to flash flooding. Several roadways had to be barricaded due to very high water. Some areas received over a foot of rainfall for the day. Much of it fell in only a few hours. Significant flooding occurred over parts of central Oklahoma. Numerous homes and cars were flooded. Statewide one person died, and at least 136 people were injured, but in Oklahoma City there were no deaths and only 34 emergency medical service calls relater dot the storm. Damage was estimated at $5.5 million in Oklahoma County alone. Two hundred and nine (209) structures in Oklahoma City were identified during the Joint PDA as damaged by flood waters with 104 receiving “Affected” damage, 75 with “Minor” damage, 27 with “Major damage, and three classified as destroyed.

On July 8, 2010, heavy rain and flash flooding affected Oklahoma City for a second time in less than a week. The record-breaking daily rainfall event on Tuesday, July 6, 2010 saturated the ground. As heavy rainfall producing thunderstorms moved across Oklahoma City on July 8th, 2010, instant and excessive runoff caused flash flooding near and around several streams and reservoirs in the Southern part of Oklahoma City. The National Weather Service estimated that 4 inches of rain an hour may have fallen during the evening hours. There was a death associated with the July 6, 2010 event, but not with the July 8, 2010 event. A Joint PDA found 226 structures damaged with 136 with “Affected” damage, 66 with “Minor” damage, 19 “Major” damage and 5 classified as destroyed.

On May 31, 2013 a stalled front and deeply mixed dry line served as a focus for thunderstorm development. The front/dry line triple point was where the most intense supercells initiated. These storms traveled eastward, eventually impacting the Oklahoma City metropolitan area with tornadoes, very large hail and heavy rains led to flash flooding in Oklahoma City. This flash food event ranked as one of the worst in Oklahoma City history in terms of fatalities and damages to property. The event lasted well into the overnight hours. Several vehicles were partially submerged in flood waters. Per Oklahoma City Police Department, a total of eleven individuals seeking shelter in drainage ditches were swept away by flood waters and died in Oklahoma City area.

On May 31, 2014 slow moving Severe Thunderstorms moved across Oklahoma City producing heavy rainfall that set new records for the day. The heavy rainfall produced flash flooding and ponding especially in downtown Oklahoma City damaging many business and flooding 100 N. Walker which houses OKC Finance and Information Technology departments.

On May 6, 2015 Severe Thunderstorms moved across Oklahoma City. These storms produce at least one tornado. Heavy rainfall was also a major player in this event. Some parts of central Oklahoma received up to 4 to 7 inches of rain, triggering several flash flood warnings. Flash flooding was experienced in many parts of the City including Lighting Creek.

On May 23, 2015 Severe Thunderstorms produced heavy rainfall in Oklahoma City resulting in flash flooding and ponding. The City experienced its second flash flooding event in a month with many of the same areas impacted on May 6th being impacted on May 23rd.

On June 12, 2015 a cold front moved across the Southern Plains, stalling in northwest Oklahoma, resulting in heavy rainfall and Flash Flooding across Western and Central Oklahoma during the afternoon through evening of the 12th through the early morning hours on the 13th, along with a few severe thunderstorms across Northwest Oklahoma. High water rescues in the vicinity of N Western Ave and NW 36th Street.

On July 8, 2016 as a cold front pushed forward, a line of storms formed across Oklahoma on the afternoon and evening of the 8th. Several roads had high water and became nearly impassable due to very heavy rainfall.

On August 31, 2016 scattered showers and isolated storms formed near a weak boundary as a shortwave moved through the area on the evening of the 31st. This produced a case of flooding and a few severe wind gusts. There were several reports of street flooding/high water on a few streets in south Oklahoma City generally between downtown and I-240 as well as the east Oklahoma City metro.

On October 4, 2016 a line of storms extending down from Kansas into northern Oklahoma formed along a cold front on the evening of the 4th. These storms marched eastward across the state, and additional storms formed out ahead of the front later that evening. I-240 and S Eastern Ave were impassable due to flooding.

Extent

The extent of flooding and flood damage can be measured and categorized using the following FEMA Flood Damage Categories and Criteria:

- Affected: 0-6 inches of water in the structure
- Minor: 6-18 inches of water in the structure
- Major: 18-48 inches of water in the structure
- Destroyed: 48+ inches of water in the structure

The flood plain is divided into two basic zones; Zone A or the 100 year flood plain, and Zone B or the 500 year flood plain. The 100 year flood plain is the area with a 1% chance of flooding in a given year while the 500 year flood plain is the area with a 0.2% chance of flooding in a given year. The City of Oklahoma City has identified a flooding event in the less than 100 year flood event to be considered a minor

severity. A major severity is flooding that occurs in the 500 year flood event and above. Based upon prior flooding events in the City of Oklahoma City, it is determined that an rainfall of 4" an hour constitutes flooding that could occur and cause major damages to the 4,714 structures located in the 100 year flood plain.

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

Probability of Future Events

The probabilities of flood event occurring in the Oklahoma City area are high.

Vulnerability and Impacts

The risk of flooding can affect virtually every structure within the city limits given proper conditions and quality of construction. For purposes of this Plan and per FEMA guidelines, the vulnerable population for

the natural hazard of flooding will be identified as the population and structures that reside within the 100-year floodplain as they are at the greatest risk of experiencing flooding. These areas are designated as Special Flood Hazard Areas (SFHA) on FEMA's Flood Insurance Rate Maps (FIRM). The SFHA identifies NFIP's minimum national standard, and reflects existing development conditions at the time of the study.

In regard to geographic location, vulnerabilities to flooding can relate to factors within particular drainage basins. As noted, Oklahoma City covers over 620 square miles and its limits stretch across four major drainage basins; Deer Creek, Deep Fork, South Canadian, and North Canadian. It could be possible that one of these major basins presents a greater degree of vulnerability based on the degree of storm water management and flood control mitigation projects and development trends. Further, since a major drainage basin is often the accumulation of several smaller drainage basins, it is possible that differing vulnerabilities could exist within smaller drainage basins and therefore present different risk levels to the resident and structures residing within the basin.

Attachment 15: Transportation Infrastructure Flood Hazard Areas shows the spatial relationship of the 500-Year Flood Hazard Areas to the transportation infrastructure comprised of interstates, highways, major arterial roadways, bridges, railroads, and bus routes to identify which ones may be vulnerable to flooding resulting in damage and/or disruption of the transportation system.

Attachment 17: Utility Infrastructure Flood Hazard Areas shows the spatial relationship of the 500-Year Flood Hazard Areas to the utility infrastructure comprised of solid waste facilities, electric facilities (electric substations and power generation plants), sewer facilities (lift stations and waste water treatment plants), and water facilities (booster pump stations, water storage, and water treatment plants) to identify which ones may be vulnerable to flooding resulting in damage and disruption of the solid waste management, electrical power, sewer, and water systems.

Attachment 19: City of Oklahoma City Facilities Flood Hazard Areas shows the spatial relationship of the 500-Year Flood Hazard Areas to government buildings and public safety facilities comprised of government buildings (City Hall, municipal office buildings, maintenance facilities/yards), police stations and facilities, and fire stations and facilities to identify which ones may be vulnerable to flooding resulting in damage and disruption of the delivery of city services and public safety.

Attachment 21: Medical Facilities and Specialized Housing Flood Hazard Areas shows the spatial relationship of the 500-Year Flood Hazard Areas to general medical facilities or hospitals, kidney dialysis centers, nursing care facilities, psychiatric or substance abuse facilities, homeless shelters, and retirement and assisted living centers to identify which ones may be vulnerable to flooding forcing evacuations and/or causing damage thereby disrupting the delivery of these services.

Attachment 23: Educational and Child care Facilities Flood Hazard Area shows the spatial relationship of the 500-Year Flood Hazard Areas to colleges, universities, professional schools, primary and secondary schools, and day care centers to identify which ones may be vulnerable to flooding forcing evacuations and/or causing damage thereby disrupting education and child care.

Attachment 26: FEMA Flood Hazard Areas simply shows the floodways, 100-Year Flood Zones, and 500-Year Flood Zones in Oklahoma City. It shows the location of watersheds and flood prone areas in Oklahoma City including rivers and creeks.

In order to better understand these location specific vulnerabilities and risk, individual basin estimated losses would require further study. However, that is not within the present scope of this Plan. Therefore, this assessment is the cumulative total of all assets in the City within the FEMA designated 100-year flood hazard area and serves as an overall survey of vulnerable populations and structures.

Oklahoma City has a total of 4,698 structures located either partially or completely within the 100-year floodplain. Structures located in the 100-year floodplain indicate that it has a one percent chance of experience flooding annually. As mentioned previously, this risk assessment does not take into consideration factors that may influence a structures individual risk such as flood proofing or time of development in terms of the urbanized floodplain.

According to U.S. Census 2016 data, the average household size for the City is 2.57 persons. Oklahoma City has a total of 3,942 residential structures located within the floodplain. Based on average household size, 10,130 persons are estimated to reside in the 100-year flood hazard area.

Flooding can also impede infrastructure and the services provided by facilities in the floodplain. More importantly, some of these services are considered critical and could result in a community-wide impact. Critical facilities are defined as those facilities that deliver vital services, and in the event of a closure, can cause greater damages to other sectors of the community, or can put special populations at risk.

General Statistics on Structures – Oklahoma City

Occupancy Class	Total Number of Structures	Total Number of Structures within 100-Year Floodplain	Percentage of Structures in 100-Year Floodplain
Commercial & Retail	5,632	175	3.1%
Industrial, Airports & Tinker AFB	5,264	382	7.3%
Office	2,484	43	1.7%
Mixed Use, Parking & Unspecified	4,751	13	0.3%
Residential	206,531	3,942	1.9%
Education & Churches	360	4	1.1%
Cultural/Entertainment & Hospitality	301	7	2.3%
Government & Utilities	40	0	0.0%
Hospital, OU HSC and Institutional	30	0	0.0%
Undeveloped & Agricultural	9,611	132	1.4%
Total	**235,004**	**4,698**	**2.0 %**

Flooding events impact single family homes, businesses, and multifamily dwellings (e.g. apartments) as well as infrastructure. The City of Oklahoma City experiences flash flooding and flash ponding events. These events typically occur in residential areas adjoining creeks and their tributaries and in downtown Oklahoma City. Neither event produces water flow rates and velocities to sweep or move homes off their foundations. The impact of these two types of flood events is water intrusion into homes and businesses ranging from a few inches producing affected damage up to 48" or more resulting in major damage. The flood waters are mixed with the red clay soil and other contaminates which ruin the surfaces they come into contact with. The flood waters can damage flooring, carpets, baseboards, sheetrock, finish carpentry (e.g. cabinets), systems (e.g. electrical, plumbing, and mechanical), and household/business contents. The clean-up, drying out/dehumidification, demolition, and repairs/restoration to pre-flood condition can take from days, to weeks, to months depending on the extent of damage and resources of the homeowners. Most home and business owners lack flood insurance and therefore do not have the financial resources to recover from a flood event resulting in a protracted recovery.

City owned infrastructure is impacted by flood waters. The transportation infrastructure is most often impacted by flash flood waters. Flash flooding washes out roadways making them impassable resulting in longer travel times for residents, school buses, delivery trucks, businesses, and emergency services that are forced to take alternate routes. Flash flooding damages aerial crossings over creeks for water and waste water pipes which threaten public health and safety. Some government facilities such as office buildings, fire stations, and waste water treatment plants have been impacted by water intrusion in the same way homes and businesses are impacted.

Chapter 12 – Extreme Heat

Description

The Federal Emergency Management Agency (FEMA) defines extreme heat or heat wave as temperatures that hover 10 degrees or more above the average high temperature for the region and lasts for several weeks. Humid or muggy conditions, which add to the discomfort of high temperatures, occur when a "dome" of high atmospheric pressure traps hazy, damp air near the ground. Excessively dry and hot conditions can provoke dust storms and low visibility. Droughts occur when a long period passes without substantial rainfall. A heat wave combined with a drought is a very dangerous situation.

The City's Heat and Extreme Weather Impact Report indicates that the high temperature during the hottest 3-day period of the year is expected to increase from an average of 102.0°F to 105.0°F by mid-century and 108.2°F by the later part of the century.

Location

The entire Oklahoma City area can be impacted by extreme heat.

Previous Occurrences

According to the National Centers for Environmental Information (NCEI), there were 32 extreme heat events reported as affecting Oklahoma City between July 1996 and September 2016. During this 20-year period, 38 deaths occurred and 326 injuries were directly related to extreme heat.

Extent

The Heat Index table and Heat Disorders table, both listed below, 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 and it more accurately reflects what the body experiences rather than simply measuring the air temperature. For example, when the air temperature is 98 degrees Fahrenheit and the relative humidity is 50 percent, the human body experiences the discomfort and stress equivalent to 113 degrees Fahrenheit.

The City of Oklahoma City has identified a heat event with a heat index of 80-90 degrees is considered a minor severity. A major severity is a heat index of 130 degrees and higher.

Heat Index Table

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution Extreme Caution Danger Extreme Danger

Heat Disorders

	Heat Index	Possible Heat Disorder:
	80°F - 90°F	Fatigue possible with prolonged exposure and physical activity.
	90°F - 105°F	Sunstroke, heat cramps and heat exhaustion possible.
	105°F - 130°F	Sunstroke, heat cramps, and heat exhaustion likely, and heat stroke possible.
	130°F or greater	Heat stroke highly likely with continued exposure.

Probability of Future Events

The probability of an extreme heat occurring in Oklahoma City is high.

Vulnerability and Impacts

People suffer heat-related illness when their bodies are unable to compensate and properly cool. The body normally cools itself by sweating but under some conditions, sweating is not sufficient. In such cases, a person's body temperature rises rapidly and very high body temperatures may cause damage to the brain or other vital organs.

Several factors affect the body's ability to cool itself during extremely hot weather. When the humidity

is high, sweat will not evaporate as quickly, preventing the body from releasing heat in order to cool itself. Summer time outdoor activity, whether on the playing field or the construction site, must be balanced with measures that aid the body's cooling mechanisms and prevent heat-related illness such as resting in cool places and replacing the body’s essential fluids (water).

People should be aware of who is at greatest risk and what actions that can be taken to prevent a heat-related illness or death. The elderly, the very young, people with mental health issues, and persons living with chronic diseases are at highest risk. However, even young and healthy individuals can succumb to heat if they participate in strenuous physical activities during hot weather. Other people that may be at risk include individuals that take certain prescription drugs, consume alcohol, have poor circulation, or experience other factors have increased vulnerability to extreme heat.

In regards to facilities, structural collapse is highly unlikely in the event of extreme heat. However, roadway and bridges may experience buckling from high temperatures if expansion joints are not properly designed.

Chapter 13 – Drought

Description

A drought is a period of drier-than-normal conditions that results in water-related problems. Precipitation (rain or snow) falls in uneven patterns across the country. When no rain or only a small amount of rain falls, soils can dry out and plants can die. When rainfall is less than normal for several weeks, months or years the flow of streams and rivers declines causing water levels in lakes and reservoirs to fall, and the depth of water in wells decreases. If dry weather persists and water supply problems develop, the dry period can become a drought.

Average annual precipitation is expected to remain relatively stable throughout the rest of the century, but patterns of precipitation may change, with more inundation events and more excessive drought. A NASA study predicts that the future length of droughts will increase by 80% across the US by 2100**.**

Location

All areas in Oklahoma City are susceptible to drought.

Previous Occurrences

According to the Oklahoma Drought Contingency Plan, published in 1997, the 1995-96 Oklahoma droughts was one of the most severe on record. The drought, beginning around October 1995 and persisting through at least the first half of 1996, initially impacted western Oklahoma. From October 1995 through May 1996, the state-averaged precipitation total was only fifty-two percent (52 percent) of normal, the driest for that period this century.

According to the National Centers for Environmental Information (NCEI), six drought events (some continued over multiple months), were reported in Oklahoma County as follows. Oklahoma City experience intermediate drought conditions that were not severe enough to be reported on NWS or NCEI.

In early August 2000, the NCEI reports an extended period of unusually dry weather and lasted for two months. Many parts of the state did not receive rain in August, with portions of southwest and south central Oklahoma remaining dry for almost 90 days, starting in June. Due largely to Oklahoma's major crops of wheat, cotton, and peanuts, which greatly suffered, total agricultural losses were estimated between $600 million and $1 billion statewide. Seven Oklahoma counties near the Texas border, including Carter, Comanche, Cotton, Jefferson, Love, Marshall, and Tillman, were declared federal disaster areas. Reservoir levels were also low across southwest and south central Oklahoma, averaging fifty (50 percent) percent of normal volumes.

In July 2001, the NCEI reports an extended period of excessive heat affected all of western and central Oklahoma. Daily mean temperatures ranged from the mid-80s to near 90 degrees Fahrenheit, which is

four to five degrees above normal. Most areas regularly experienced high temperatures at or above 100 degrees, particularly western and north central Oklahoma. Eight fatalities resulted from the heat and rainfall averaged about one-third of normal, resulting in a drought. No crop damage estimates were listed.

From December 2005 through January 2007, NCEI reported an extended period of drought. The worst conditions were in south central and southeast Oklahoma where drought conditions were in the extreme to exceptional drought categories. The drought affected the agriculture industry, both summer and winter crops. Farm ponds continued to dry up or remain dry. The lack of pasture and hay crop affected farmers and ranchers (they continued to sell part or all of their livestock herd's dues to the lack of adequate water and food). The drought adversely affected the agriculture industry led to concerns in the banking and insurance industries due to lack of money to pay loans, paying crop insurance claims, etc. The recreational industry also continued to be affected by the dry conditions. Lake levels remained low keeping many boat docks and ramps on dry land. Boating accidents occurred on some lakes due to the lake beds and debris at the bottom of the lakes being closer to the surface. Hunting activities were also hit by the drought, because the dry conditions have affected the habitats of wildlife with fewer animals prospering in the region. Many communities continued voluntary or mandatory water rationing programs. The drought combined with warm temperatures also helped to increase the potential for wildfires across the area. The winter storm from January 12th and 14th 2007 provided much needed precipitation to improve these areas. Lake levels remain at or near record lows and many boat docks and ramps remained on dry ground, but lakes are showing some improvement, rising slowly during the last half of the month. Even at low levels, most lakes are still considered at safe levels for every day. The recent precipitation has helped the top 12 inches of the soil, but the soil below this remains very dry. Costs associated with property damage and crop failure are unknown. No fatalities or injuries were reported.

From January 2011 through November 2011, NCEI reported an extended period of drought. Summer and fall crops, hay forages, and alfalfa were hit hard by the lack of any significant precipitation. Farm pond water levels continued to decrease, or dry up altogether, which added insult to injury for area livestock. Since Thanksgiving, much of central and western Oklahoma has seen its driest precipitation totals since the 1920s and 30s. Much of the wheat crop planted in the fall had all but been declared a total loss. In fact, the conditions have gotten worse with the emergence of the wheat crop. The lack of precipitation has made for low water levels on stock ponds for livestock, and the water level in irrigation reservoirs used for crops is falling. The dry conditions also gave rise to enhanced fire weather concerns, with the normal increase in wind speeds during the spring months. By May, precipitation-wise, most of the region remained below normal. Even those that did get it were hampered by periods of hail and wind, and a few tornadoes. In June, burn bans were established over several counties. However, several grass fires were reported due to the exceptionally dry conditions and very hot temperatures. The cotton crop took a hit, with the majority likely to be abandoned. The wheat crop had already taken a huge loss. July 2011 was officially the hottest month on record locally and nationally. High temperatures were over 100 degrees for almost the entire month. Rainfall totals, especially for those over western and southern Oklahoma were little more than a trace. The dry vegetation contributed to several grass fires. Some

municipalities had restricted water use, as water levels in area lakes have dropped to very low levels. Drought that lasted more than a year deteriorated to exceptional drought conditions by the end of November 2011 and many communities had limited watering activities along with a concern over the availability of adequate drinking water. The low water levels also continued to affect outdoor recreation. Many boat docks and ramps remained on dry ground. Boaters, who were able to get in the water, also had to be careful due to the lakebed being too close to the surface. This led to the closure of several lakes due to safety concerns. Outdoor recreation activities such as hunting were also affected due to the wildlife dealing with the lack of water and proper vegetation for food. The agriculture industry continued to be hit hard by the drought. Costs associated with property damage and crop failure are unknown. No fatalities or injuries were reported.

From July 2012 through April 2013, NCEI reported an extended period of drought. A mid-level ridge of high pressure built into the Southern Plains late in July lead to expanding drought conditions across much of Oklahoma. Abnormally dry conditions were present at the beginning at the month, but drought developed by the end of month with persistent dry conditions. Hot and dry conditions continued for much of August beneath a persistent upper-level ridge over the southern plains. This led to worsening of the already severe drought. Drought conditions continued over the southern plains following a hot and very dry summer. With lack of any appreciable rainfall during the month of October, November, and December; drought conditions persisted and/or worsened during the month. Severe drought continued through the month in Oklahoma County with persistent dry conditions. By January drought conditions had worsen from severe to extreme. Several winter's storms occurred during middle to late February which allowed drought conditions to improve slightly from extreme to severe. Precipitation totals for arch were below normal resulting in a continuation of the long-term drought. Severe drought continued through the month with persistent dry conditions. Drought conditions persisted across much of Oklahoma during the month of April. Severe drought was present at the beginning of the month, but had improved to abnormally dry by the end of the month.

From March 2014 to July 2014, NCEI reported an extended period of drought. During March a gradually warming temperatures and little to no precipitation through the month, drought conditions worsened across much of Oklahoma. Severe drought developed across the northern half of Oklahoma County by the end of the month. In April, several rainfall events allowed for modest improvement across portions of central Oklahoma. Severe drought was present at the beginning of the month, but had improved by the end of the month. In May, rain was fairly sparse through the month and a bout of very warm temperatures through the first half of the month allowed for substantial surface and drought conditions worsened across all of Oklahoma. Severe drought was present at the beginning go the month but extreme drought became more prevalent by the end of the month. During June, rains brought widespread moderate improvements to the drought. Most of these improvements were seen over northern and central Oklahoma, which experienced above normal precipitation for the month. Extreme drought conditions retreated to the northeast, leaving the rest of the county with severe drought conditions. During July, several rainfall events occurred throughout the month; drought conditions remained mostly unchanged across Oklahoma. With a few meaningful rainfall events, drought conditions improved somewhat. Severe to Extreme drought was prevalent at the beginning of the

month, with only severe drought present by month's end.

Extent

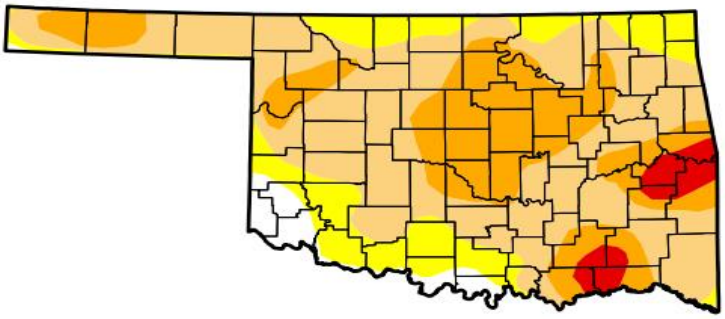
The PDSI is a "meteorological" drought index and responds to weather conditions that have been abnormally dry or abnormally wet. When conditions change from dry to normal or wet, for example, the drought measured by the PDSI ends without taking into account stream flow, lake and reservoir levels, and other longer-term hydrologic impacts. The PDSI is calculated based on precipitation and temperature data, as well as the local Available Water Content (AWC) of the soil. From the inputs, all the basic terms of the water balance equation can be determined, including evapotranspiration, soil recharge, runoff, and moisture loss from the surface layer. Human impacts on the water balance, such as irrigation, are not considered.

The Palmer Index varies between -4.0 and +4.0. Weekly Palmer Index values are calculated for the Climate Divisions during every growing season and are on the Internet from the Climate Prediction Center. The City of Oklahoma City has identified a drought with a PDSI classification of -1.00 to -1.99 is considered a minor severity drought. A major severity drought is a PDSI classification of -3.00 to -3.99 or higher.

Palmer Drought Severity Index

	< -4.0	Extreme Drought
	-3.99 to -3.0	Severe Drought
	-2.99 to -2.0	Moderate Drought
	-1.99 to -1.0	Mild Drought
	-0.99 to -0.5	Incipient Drought
	-0.49 to 0.49	Near Normal
	0.5 to 0.99	Incipient Moist Spell
	1.0 to 1.99	Moist Spell
	2.0 to 2.99	Unusual Moist Spell
	3.0 to 3.99	Very Moist Spell
	> 4.0	Extreme Moist Spell

The National Weather Service (NWS) provides a map, released every Thursday at 8:30 a.m. Eastern Time that shows the various intensities of drought throughout the United States. At the time of this map, Oklahoma City was in D2 (Severe Drought) conditions.



January 31, 2017
(Released Thursday, Feb. 2, 2017)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	4.44	95.56	79.46	30.95	3.90	0.00
Last Week 1/24/2017	4.49	95.51	79.90	30.95	3.90	0.00
3 Months Ago 11/1/2016	42.61	57.39	36.44	7.90	0.00	0.00
Start of Calendar Year 1/3/2017	5.61	94.39	83.21	55.75	5.55	0.00
Start of Water Year 9/27/2016	57.82	42.18	19.04	3.05	0.00	0.00
One Year Ago 2/2/2016	100.00	0.00	0.00	0.00	0.00	0.00

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
David Simeral
Western Regional Climate Center

http://droughtmonitor.unl.edu/

Probability of Future Events

The probability a drought occurring in the Oklahoma City area is Medium.

Vulnerability and Impacts

All of Oklahoma City is vulnerable to the effects of drought. The impact and adverse consequences of drought are more economic as opposed to loss of life or the immediate destruction of property. The impacts of drought can be felt across many sectors of everyday life because water is needed to sustain industry, agriculture, and individual consumers. However, those portions of Oklahoma City zoned for agricultural are typically the first to be affected because of its heavy dependence on stored soil water that can be rapidly depleted during dry periods. Drought impacts crops especially hay, alfalfa, and grasses used for feed in livestock production. Reduction in these feed products will cause ranchers to reduce the size of their herds reducing production or to import feed from other areas increasing their costs.

Drought causes reduced rainfall runoff to fill reservoirs. Reduced reservoir levels require water

conservation. On April 30, 2013, Oklahoma City and surrounding communities have implemented a system for managing water supply based on Progressive Water Conservation Stages. Mandatory odd/even watering (Stage 1) is permanently in effect for all residents of Oklahoma City. Additional conservations measures are implemented as warranted based on current drought conditions.

Drought causes native grasses and vegetation to dry out increasing the risk of wildfire in the Wildland Urban Interface.

Chapter 14 – Wildfires

Description

A wildfire is an uncontrolled fire in a rural or wilderness area. The majority of wildfires in Oklahoma occur in the late fall through winter and into early spring, which coincides with dormant vegetation and the time of the year the state receives the least amount of precipitation. A wildfire often begins unnoticed and can spread quickly, lighting brush, trees and even homes. It may be started by a campfire that was not doused properly, a tossed cigarette, burning debris, outdoor cooking, catalytic converters from automobiles and farm equipment, fireworks, lightning, or arson.

There are three different classes of wildfires. A surface fire is common in grasslands or areas with open vegetation and can spread quickly. A ground fire is a dense, very hot fire that has a thick fuel source and significantly damages the soil health where it occurs. Crown fires are those that move by jumping along the tops of trees. Wildfires often begin unnoticed, but are usually signaled by dense smoke that fills the area for miles around. The City of Oklahoma City Fire Department regularly responds to grass and brush fires in the undeveloped areas within the limits of the City and provides mutual aid to surrounding jurisdictions when needed.

In Oklahoma City, the special challenges wrought by the wildland urban interface were brought to the forefront by severe wildfires that destroyed a number of homes in and around juniper thickets in North Oklahoma City. According to the Oklahoma Department of Agriculture, rural homes surrounded by trees may appear to be idyllic setting, but the wildfire risk created by vegetation under drought conditions requires special attention to reduce risk.

Location

All areas in Oklahoma City are susceptible to wildfires.

Previous Occurrences

The National Centers for Environmental Information (NCEI) database reports two wildfire events for Oklahoma County between 2000 and 2016.

July 26th 2000, a large grass fire was started near the intersection of Memorial and Douglas and jumped the Turner Turnpike, causing the highway to be closed for nearly four hours. Twenty-five fire departments assisted in extinguishing the blaze, which consumed 80 acres of grass and injured two firefighters. One firefighter suffered a minor head injury, while another was treated for heat exhaustion. The cause of the fire was unknown.

August 3rd 2012, extreme temperatures coupled with a low humidity, increased winds, and an ongoing drought led to several large wildfires across parts of Oklahoma. Some of the fires burned numerous structures. A cold front entered the region late on the 4th, resulting in slightly cooler temperatures and

an end to critical fire weather conditions by the 5th. The wildfire began near North Luther road and northeast 150th street. The fire moved quickly northward and burned several structures in and around the Luther area. The fire moved into southeast Luther. Damage estimates were unavailable. The exact time the fire was extinguished is unknown.

According to the Oklahoma City Fire Department, there have been 7,728 grass fires in the last ten years. These fires are usually started during dry or drought conditions and are aided by the strong winds that are common to the Oklahoma City area. There have been no deaths reported due to wildfires in the last ten years.

Oklahoma City Fire Department Wildfires (2007-2016)

Data Type	2007	2008	2009	2010	2011	2012
Wildfire Incidents	578	1,011	701	590	1,058	792
Wildfire FF Deaths	0	0	0	0	0	0
Wildfire Civilian Deaths	0	0	0	0	0	0
Wildfire Property Loss $	$134,321	$362,651	$8,113,817	$6,600	$7,111,046	$7,550

Data Type	2013	2014	2015	2016	Total
Wildfire Incidents	558	880	589	971	7,728
Wildfire FF Deaths	0	0	0	0	0
Wildfire Civilian Deaths	0	0	0	0	0
Wildfire Property Loss $	$1,500	$168,281	$31,625	$115,404	$16,052,795

Extent

The Oklahoma Forestry Services (OFS) monitors weather and climate on a daily basis for weather conditions that might lead to unusual or extreme burning conditions. If OFS observes a prolonged periods (more than 24 hours) of this type of weather developing, they contact the National Weather Service (NWS), Oklahoma Department of Emergency Management, and the State Fire Marshal. After

general agreement that prolonged severe burning conditions are developing, OFS issues a Red Flag Fire Alert. This alert is an advisory that extra precautions are needed to safely burn anything outdoors.

Once the affected counties agree and the conditions of drought and unusual fire activity are established, the Director of the Forestry Division makes a recommendation to the Governor that those counties be placed in a Governor's burning ban. If the Governor agrees, he issues an executive proclamation that has the effect of law. Burning bans are regulatory, meaning they restrict or remove people's rights. There is a significant penalty for violation of the Governor's burning ban.

Since these burning bans are so restrictive, Forestry Services does not regularly recommend them. However a series of intense summer droughts since 1998 has resulted in burning bans being issued at some point during each summer.

OK-FIRE is a weather-based decision support system which has been developed for wildland fire managers throughout Oklahoma. Applications include both wildfire and prescribed fire. Users include the US Forest Service, Bureau of Indian Affairs, US Fish and Wildlife Services, National Parks Service, US Army Corps of Engineers, Oklahoma City Fire Department, Emergency Managers and private land owners. OK-FIRE products utilize the Oklahoma Mesonet, the States automatic weather station network, and the National Weather Service's 84-hour North American Mesoscale (NAM) Model.

OK_FIRE has a three-fold emphasis: (1) a comprehensive suite of products for fire weather, fire danger, and smoke dispersion which incorporate an 84-hour predictive component; (2) a dedicated OK-FIRE wildland fire management web site to act as the delivery mechanism for the above products; (3) regional training and customer support activities for users.

OK-FIRE is now an established program of the Oklahoma Mesonet in Norman, Oklahoma, which provides operational, programming and website support. For more information on OK-FIRE: http://okfire.mesonet.org

The City of Oklahoma City has identified a fire danger of the Fire Intensity Scale of a 2.0 or below is considered a minor severity. A major severity is a 3 or higher.

	1	Very Lowest Intensity	Very small discontinuous flames, usually less than 1 foot in length: very low rate of spread: No spotting. Fires are typically easy to suppress by fire fighters with basic training and non-specialized equipment.
	1.5		
	2	Lowest Intensity	Small flames, usually less than 2 feet long: small amount of very short range spotting possible. Fires are easy to suppress by trained firefighters with protective equipment and specialized tools.
	2.5		
	3	Moderate	Flames up to 8 feet in length: short range spotting is possible. Trained firefighters will find these fires difficult to suppress without support from aircraft or engines, but dozer and plows are generally effective. Increased potential for harm or damage to life and property.

	3.5		
	4	High	Large Flames, up to 30 feet in length: short range spotting common: medium range spotting possible. Direct attack by trained firefighters, engines and dozers is generally ineffective, indirect attack may be effective. Significant potential for harm or damage to life and property.
	4.5		
	5	Highest	Very large flames up to 150 feet in length: profuse short range spotting, frequent long range spotting: strong fire induced winds. Indirect attack marginally effective at the head of the fire. Great potential for harm or damage to life and property.

https://www.southernwildfirerisk.com/Map/index/pro?mapName=pro

Probability of Future Events

The probability of wildfires occurring in the Oklahoma City area is high.

Vulnerability and Impacts

Changing temperature and precipitation patterns may increase the risk of wildfires by the end of the 21st century per the Heat and Extreme Weather Impact Report developed by the City of Oklahoma City Planning Department, Office of Sustainability. Periods of prolonged drought present an especially high risk for wildfire.

The sparsely populated tall grassed range lands are capable of experiencing large sweeping fires. Ironically, fire suppression is capable of creating larger fire hazards, because live and dead vegetation is allowed to accumulate in areas where fire has been excluded. Oklahoma City has seen a dramatic surge in home construction in rural and forested areas, which greatly increases fire danger. A federal study found that people in rural communities, especially in areas with populations fewer than 2,500, are almost twice as likely to die in a fire as people living in communities of 10,000 or more. Residents in areas of 5,000 people or less are almost twice as likely to die in a house fire. Compared to city dwellers, rural homeowners suffer more than twice the property losses each year from fires.

Attachment 27: Wildland Urban Interface shows the locations of the Wildland Urban Interface (WUI) in the City of Oklahoma City and the density of houses per acre where the WUI occurs. The legend shows the density of housing per acre from light density (LT) which is one house per 40 acres to greatest density (GT) which is three or more houses per acre. The denser the housing within the WUI the higher the probability of homes being damaged or destroyed if a wildland fire occurs in these areas.

Attachment 28: Wildland Urban Interface Risk Index shows the risk from WUI fires based on the severity of impacts. The severity of impacts is correlated to the density of housing (houses/acre). The risk is concerned with the presence of homes that could be damaged or destroyed within the WUI. The legend shows the potential impact from a WUI fire using a severity scale from one to nine with one being a Minor Impact and nine being a Major Impact. A Minor Impact means the WUI fire will damage or

destroy few if any homes because of the lower density of homes per acre. A Major Impact means the WUI fire will damage or destroy a significant number of homes because of the higher density of homes per acre.

Wildfires can be caused by debris burns, arson, carelessness, lightning strikes, etc. Wildfires that do not encounter a human population are difficult to calculate damages. Homes and businesses that are burned in naturally occurring fires are usually privately owned. The number one cause of home loss in wildland fires is from untreated wood shingles. Structures that have not taken the necessary wildfire precautions, such as clearing back brush and trees from structures, are more at risk to fire damage.

The extent of such events is largely dependent on location and a number of factors such as recent precipitation, amount of available fuel, wind conditions, and proximity of assets to these conditions. Given the varying types of design and construction philosophies in the City, newer subdivisions with smaller vegetative growth would be less likely to be impacted by wildfires than areas that were developed and integrated into larger woody areas. The City of Oklahoma City has two Ecoregions as depicted in Attachment 1. The Northwest and Southwest portions of the City are part of the Central Great Plains Ecoregion and contain a mixture of tall and short prairie grasses and wildflowers, but very few native trees or shrubs. Wildland Urban Interface (WUI) fires in these areas tend to cause from minor to moderate impacts. The Northeast and Southeast portions of the City are part of the Cross Timbers Ecoregion and contain more forested areas with a wide diversity of trees, shrubs, grasses, and wildflowers. Wildland Urban Interface (WUI) fires in these areas tend to cause from moderate to major impacts. Wildfire can impact health and life of residents and responders, single family homes, apartments, business, parks, and recreational areas. These can cause economic impacts from the initial loss of structures, loss revenue from destroyed business, agricultural losses and decrease in tourism/recreation.

Some portions of Oklahoma City are more prone to Wildland Urban Interface (WUI) fires than other portions. Based on historical events the following geographic areas are more prone to WUI fires impacting the City's infrastructure assets:

- Northwest Oklahoma City west of N. Portland and north of Memorial Rd.
    - One Fire Station
    - Seven Schools
    - Six Parks
    - Hefner Water Treatment Plant
- Southwest Oklahoma City west of I-44 and south of SW 89th Street.
    - One Fire Station
- Northeast Oklahoma City east of N. Sooner Rd and north of NE 36th Street.
    - Two Fire Stations
    - Three Schools
    - Four City parks

- Southeast Oklahoma City east of S. Sooner Rd and south of SE 29th Street.
    - Three Fire Stations
    - Four Schools
    - Three Parks
    - Two Police Facilities
    - Draper Water Treatment Plant

Wildfire behavior and subsequent vulnerability is based on three primary factors:

1. Fuel
2. Topography
3. Weather

The type and amount of fuel, as well as its burning qualities and level of moisture, affect wildfire potential and behavior. The continuity of fuels, expressed in both horizontal and vertical components is also a factor, in that it expresses the pattern of vegetative growth and open areas. The sparsely populated tall grassed range lands are capable of experiencing large sweeping fires. Ironically, fire suppression is capable of creating larger fire hazards, because live and dead vegetation is allowed to accumulate in areas where fire has been excluded.

Topography is important because it affects the movement of air over the ground surface. The slope and shape of terrain can change how quickly the fire spreads. In some cases natural features such as rivers, lakes, rocky areas, and even areas already burnt, can hinder fires movement.

Weather affects the probability of wildfire as the risk of wildfire is highly correlated with temperature, humidity, and wind. These factors affect the severity and duration of wildfires; wildfires are more common when fuel sources are dry, especially during periods of prolonged drought. These periods are particularly dangerous as adequate water supplies may not be available to fight the fire.

Potential secondary impacts associated with wildfires may lead to the following situations:

- Indirect loss of aquatic or crop life, due to wildfires that can destroy vegetation, thus resulting in erosion and heavy silting of streams, rivers, and reservoirs
- Indirect loss of life, due to dense smoke that can occur with wildfires, thus resulting in traffic accidents

Chapter 15 – Earthquake

Description

An earthquake is a sudden, rapid shaking of the Earth caused by the breaking and shifting of rock beneath the Earth's surface. Most earthquakes occur as the result of slowly accumulating pressure that causes the ground to slip abruptly along a geological fault plane on or near a plate boundary. The resulting waves of vibration within the earth create ground motion at the surface that vibrates in a very complex manner. Earthquakes can be one of nature's most damaging hazards; the severity of an earthquake is dependent on the amount of energy released from the fault or epicenter. Earthquakes strike suddenly without warning and can occur at any time of the year, day or night, and pose a serious threat to structures and their inhabitants.

Earthquakes occur on faults. Most earthquakes occur miles deep. It is hard to link an individual earthquake to an individual fault. In most areas, the best guide to earthquake hazards is the earthquakes themselves. There are two major fault systems that pose a hazard to Oklahoma City, the NW-trending fault zone in southwestern Oklahoma associated with the Meers Fault, located near Lawton, Oklahoma and the NS-trending Nemaha Fault zone that runs from Omaha, Nebraska through Kansas and Oklahoma City. However, the New Madrid Fault zone to the northeast, centered in the Missouri Boot Heel Region, historically, is by far the most active area for earthquakes in the central U.S. and may pose the greatest risk to Oklahoma City from earthquakes.

The Meers Fault is the only known fault with evidence of a surface rupturing earthquake, evidenced by a fault scarp, in southwestern Oklahoma. The Meers Fault is 16-23 miles (26-37 km) long and is one of the few known fault scarps in the eastern and central United Sates that has documented Holocene movement. Two document Holocene slip events (1,600-1,300 years ago), each with about 2.5 m of net slip and estimated to be around magnitude 6.5, classify the Meers Fault as a potentially hazardous fault.

The causes of earthquakes are not understood well enough to predict their occurrence with reliability. East of the Rockies, an earthquake can be felt over an area as much as ten times larger than a similar magnitude earthquake on the west coast, due to the stability of the continental craton. A magnitude 4.0 eastern U.S. earthquake typically can be felt at many places as far as 100 km (60 mi) from where it occurred, and it infrequently causes damage near its source. A magnitude 5.5 eastern U.S. earthquake usually can be felt as far as 500 km (300 mi) from where it occurred, and sometimes causes damage as far away as 40 km (25 mi).

For hundreds of millions of years, the forces of plate tectonics have shaped the Earth as the huge plates that form the Earth's surface move slowly over, under, and past each other. Sometimes the movement is gradual and at other times, the plates are locked together, unable to release the accumulating energy. When the accumulated energy grows strong enough, the plates break free causing the ground to shake. Most earthquakes occur at the boundaries where the plates meet; however, some earthquakes occur in the middle of plates. Earthquakes strike suddenly without warning and can occur at any time of the

year, day or night, and pose a serious threat to structures and their inhabitants.

There are 45 states and territories in the United States at moderate to very high risk from earthquakes; Oklahoma is one of them. These areas of high risk are located in every region of the country; with California experiencing the most frequent damaging earthquakes and Alaska experiencing the greatest number of large earthquakes.

Location

The entire Oklahoma City area can be impacted by an earthquake.

Previous Occurrences

Historically, the State of Oklahoma averaged about 50 to 100 recorded earthquakes annually. Most of these earthquakes occur on deep faults that are not visible at the Earth's surface and residents had reported only one or two earthquakes as being felt each year. Oklahoma has thousands of faults in the subsurface, but most of these were last active over 200 million years ago.

In recent years, tremors have been recorded in central Oklahoma in greater frequency. The largest of these recent events occurred September 3rd, 2016 (UTC), 15km miles northwest of Pawnee, Oklahoma and about 92 miles northeast of Oklahoma City. This event measured at 5.8 on the Richter Scale and was widely felt in the neighboring states of Texas, Arkansas, Kansas and Missouri.

In 2008 the rate of earthquakes began to rise in Oklahoma, with over a dozen earthquakes occurring in the region east and northeast of Oklahoma City. That number had doubled in 2009 and skyrocketed in 2010 with 1,047 earthquakes located and reported by the Oklahoma Geological Survey (OGS). This uncharacteristic number of events has and is continuing to increase with over 2,200 earthquakes located and reported in Oklahoma already in 2014.

In 2010 the OGS located 1,047 Oklahoma earthquakes and of these 103 were reported felt. The largest earthquake to be recorded in 2010 was the October 13 magnitude 4.4 and MMI of VI, earthquake near Norman, Oklahoma.

In 2011, the OGS located 1,470 Oklahoma earthquakes and of these 99 were reported felt. The largest earthquake to be recorded in 2011 was the November 6th magnitude 5.7 and MMI of VII, earthquake near Prague, Oklahoma. This event is the second largest earthquake recorded in Oklahoma and is discussed further throughout the chapter.

In 2012, the OGS located 980 Oklahoma earthquakes and of these 75 were reported felt. The largest earthquake to be recorded in 2012 was the April 3rd magnitude 4.4 and MMI of V earthquake in Atoka County near Wardville, Oklahoma.

In 2013, the OGS located 2,848 earthquakes in Oklahoma and of these 284 were reported felt. The

largest earthquake to be recorded in 2013 was the December 7th magnitude 4.5 and MMI of VI earthquake in Oklahoma County near Arcadia Lake.

In 2014, the OGS located 5,483 earthquakes, and over 1,090 of these earthquakes have been reported as felt and 34 earthquakes have been between the magnitudes 4.0 and 4.5. The largest earthquake to be recorded in 2014 was the June 16th magnitude of 4.6 and MMI of VI earthquake in Oklahoma County.

In 2015, the OGS located 6,936 earthquakes, and 820 of these earthquakes have been reported felt. There have been 27 earthquakes between the magnitudes 4.0 and 4.7.

In 2016, the OGS located 4,284 earthquakes, and 623 of these were reported felt. There have been 15 earthquakes about magnitude 4.0. Including the largest earthquake ever recorded by OGS on September 3, 2016 with a magnitude of 5.8.

According to the OGS, The largest of these recent events occurred September 3rd, 2016 (UTC), 15km miles northwest of Pawnee, Oklahoma and about 92 miles northeast of Oklahoma City. This event was reported to the USGS by over 60,000 individuals from 34 states and was given a Modified Mercalli Intensity (MMI) of VII. At least 1 person was injured and Statewide, eleven residents submitted damage photos and information to Oklahoma Emergency Management office through the OK Emergency mobile app. The earthquake occurred on within the interior of the North America plate, far from any plate boundaries. The preliminary focal mechanism solution for the earthquake indicates rupture occurred on either a left-lateral fault striking east-southeast, or on a right lateral fault striking north-northeast.

Within an hour of the September 3 M 5.8 earthquake, 4 aftershocks have been located, the largest being a magnitude 3.6 event 56 minutes after the main shock. Three of the four aftershocks align on the NW-SE left-lateral plane of the focal mechanism solution.

Prior to the 2016 Pawnee earthquake, the other the largest earthquake recorded in Oklahoma registered as a magnitude 5.7 on the Richter Scale and occurred November 6th, 2011 (UTC), 6 miles northwest of Prague and about 40 miles east of Oklahoma City, this event was reported to the USGS by more than 60,000 individuals from 26 states and was given a Modified Mercalli Intensity (MMI) of VII. At least 2 people were injured and 14 homes had major damage and many more reported minor damage in an area approximately 25 square miles in the immediate vicinity of the epicenter. The earthquake occurred on the Wilzetta Fault, a 55 mile long strike-slip fault zone that runs from central Pottawatomie County to the western part of Creek County and is associated with the Nemaha uplift system.

This event was preceded by multiple foreshocks and followed by multiple aftershocks. The largest events in this series of damaging earthquakes occurred November 5th, 6th, and 8th, 2011. The main shock was a magnitude 5.6 on November 6th, the largest foreshock event was a magnitude 4.8 on November 5th and the largest aftershock event was a magnitude 4.8 on November 8th. These earthquakes have been the largest events recorded during the current period of increased seismicity and have been identified as slip on the Wilzetta Fault (aka Seminole Uplift).

Extent

The size of an earthquake can be expressed quantitatively as a magnitude and the local strength of shaking as intensity. The inherent size of an earthquake is expressed using a magnitude. The following Richter Scale is the most commonly used scale.

The City of Oklahoma City has identified an earthquake on the Richter scale of 4.4 to 4.8 is considered a minor severity. A major severity is 5.5 – 6.1 or higher.

The Richter Scale

Richter Magnitudes	Earthquake Effects
Less than 2.0	Micro: Micro earthquakes, not felt.
2.0-2.9	Very Minor: Generally not felt, but recorded.
3.0-3.9	Minor: Often felt, but rarely causes damage.
4.0-4.9	Light: Noticeable shaking of indoor items, rattling noises. Significant damage unlikely.
5.0-5.9	Moderate: Can cause major damage to poorly constructed buildings over small regions. At most slight damage to well-designed buildings.
6.0-6.9	Strong: Can be destructive in areas up to about 100 miles across in populated areas.
7.0-7.9	Major: Can cause serious damage over larger areas.
8.0 or greater	Catastrophic: Can cause serious damage in areas several hundred miles across.

Magnitude / Intensity Comparison:

Magnitude and Intensity measure different characteristics of earthquakes. Magnitude measures the energy released at the source of the earthquake. Magnitude is determined from measurements on seismographs. Intensity measures the strength of shaking produced by the earthquake at a certain location. Intensity is determined from effects on people, human structures, and the natural environment. The following Mercalli scale listed in the below table gives intensities that are typically observed at locations near the epicenter of earthquakes of different magnitudes.

Mercalli/Richter Scale Comparison

Mercalli Scale	Richter Scale	Full Description
I.	0 – 1.9	Not felt except by a very few under especially favorable conditions.
II.	2.0 -2.9	Felt only by a few persons at rest, especially on upper floors of buildings.
III.	3.0 – 3.9	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV.	4.0 - 4.3	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably
V.	4.4 - 4.8	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI.	4.9 - 5.4	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII.	5.5 - 6.1	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII.	6.2 - 6.5	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX.	6.6 - 6.9	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X.	7.0 - 7.3	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI.	.7.4 - 8.1	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII.	> 8.1	Damage total. Lines of sight and level are distorted. Objects thrown into the air.

http://earthquake.usgs.gov/learn/topics/mag_vs_int.php

Probability of Future Events

The probability of earthquakes occurring in the Oklahoma City area is high.

Vulnerability and Impacts

Even a small magnitude earthquake can cause damage. Vulnerabilities include all structures, homes, businesses and transportation infrastructure, roads and bridges, water, sewer, dams, oil pipe lines, electrical supply systems, etc. could suffer extensive damage. Disruption of traffic would affect routine communing as well impede critical services such as police fire, and ambulance service. Hospitals, schools, grocery stores and other critical need and economically important facilities would likely be damaged and be closed for extended periods. Employment and the economy would be affected because of business closures. The impacts caused by an earthquake would be people displaced, left unemployed, power outages, lack of potable water or water to fight fires, possible ground water contamination from broken pipelines.

Resultant injuries to people are largely the result of structure and infrastructure collapse and falling materials. Direct damages to property and injury to people as a result of earthquakes can occur from

shattered glass and ornamental objects in and on buildings that fall with the impact of an earthquake. In fact, most earthquake injuries and fatalities are the result of collapsing structures and falling objects such as glass and building façade materials.

Attachment 16: Transportation Infrastructure Earthquake Hazard Areas shows the spatial relationship of identified faults to the transportation infrastructure comprised of interstates, highways, major arterial roadways, bridges, railroads, and bus routes to identify which ones may be vulnerable to earthquake damage and disruption of the transportation system.

Attachment 18: Utility Infrastructure Earthquake Hazard Areas shows the spatial relationship of the identified faults to the utility infrastructure comprised of solid waste facilities, electric facilities (electric substations and power generation plants), sewer facilities (lift stations and waste water treatment plants), and water facilities (booster pump stations, water storage, and water treatment plants) to identify which ones may be vulnerable to earthquake damage and disruption of the solid waste management, electrical power, sewer, and water systems.

Attachment 20: City of Oklahoma City Facilities Earthquake Hazard Areas shows the spatial relationship of the identified faults to government buildings and public safety facilities comprised of government buildings (City Hall, municipal office buildings, maintenance facilities/yards), police stations and facilities, and fire stations and facilities to identify which ones may be vulnerable to earthquake damage and disruption of the delivery of city services and public safety.

Attachment 22: Medical Facilities and Specialized Housing Flood Hazard Areas shows the spatial relationship of the identified faults to general medical facilities or hospitals, kidney dialysis centers, nursing care facilities, psychiatric or substance abuse facilities, homeless shelters, and retirement and assisted living centers to identify which ones may be vulnerable to earthquake damage forcing evacuations and disrupting the delivery of these services.

Attachment 24: Educational and Child Care Facilities Earthquake Hazard Area shows the spatial relationship of the identified earthquake faults to colleges, universities, professional schools, primary and secondary schools, and day care centers to identify which ones may be vulnerable to earthquake damage forcing evacuations and disrupting education and child care.

Attachment 30: Earthquake Fault Lines simply shows the identified faults in Oklahoma City. It shows the location, size, and orientation of these faults within Oklahoma City. These faults represent the potential epicenter for future earthquakes in Oklahoma City.

Chapter 16 – Dam Failure

Description

A dam is an artificial barrier usually constructed across a stream channel to impound water. Timber, rock, concrete, earth, steel or a combination of these materials may be used to build the dam. In Oklahoma, most dams are constructed of earth or concrete. Dams must have spillway systems to safely convey normal stream and flood flows over, around, or through the dam. Spillways are commonly constructed of non-erosive materials such as concrete. Dams should also have a drain or other water-withdrawal facility for control of the pool or lake level and to lower or drain the lake for normal maintenance and emergency purposes.

A dam impounds water in the upstream area, referred to as a reservoir or lake. The amount of water impounded 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. As a function of upstream topography, even a very small dam may impound or detain several acre-feet of water. Two factors influence the potential severity of a full or partial dam failure: the amount of water impounded, and the density, type, and value of development and infrastructure located downstream.

Dam failures are generally caused by structural deficiencies or an event(s) that compromises the structural integrity of a dam. Dam failure or levee breeches can occur with little warning. Intense storms may produce a flood in a few hours or even minutes for upstream locations. Flash floods occur within six hours of the beginning of heavy rainfall, and dam failure may occur within hours of the first signs of breaching. Other failures and breeches can take much longer to occur, from days to weeks, as a result of debris jams or the accumulation of melting snow.

Dam failures are of particular concern because the failure of a large dam has the potential to cause more death and destruction than the failure of any other man-made structure. This is because of the destructive power of the flood wave that would be released by the sudden collapse of a large dam.

Structural deficiencies include undermining, seepage, erosion, cracking, poor compaction, sliding, and overturning, mainly caused by the age of a dam, lack of maintenance, and past stresses. One event that could compromise a dam's stability could be inadequate spillway capacity, which results in overtopping the dam and is caused by excessive runoff from heavy precipitation. In addition, the collection of debris or ice, which blocks the spillway and places extra force on the dam due to rising water level, could also cause failures. Other events that could also result in dam failures include a civil disturbance such a terrorist (sabotage) act designed to weaken the structure or alter flow rates, such as a bomb or fire, or natural hazard events such as an earthquake.

Location

According to the Oklahoma Water Resources Board, there are 66 dams within Oklahoma City limits, 17

owned by the City of Oklahoma City, 47 are privately owned, and 2 are owned by the State of Oklahoma. The map (Attachment 29: Dam Inventory and Risk Assessment) and table below show and describe the location and Hazard Potential Classification of these dams.

Hazard Potential Classification	Risk Involved with Dam Failure	Inspection Frequency	Number in Oklahoma City
High	probable loss of human life	annually, by a registered professional engineer	24
Significant	no probable loss of human life but can cause economic loss or disruption of lifeline facilities	every three years by a registered professional engineer	3
Low	no probable loss of human life and low economic loss	every five years	39

http://www.owrb.ok.gov/hazard/dam/dams.php

Previous Occurrences

The only significant dam failure recorded in Oklahoma City occurred in 1923 when heavy rains caused Lake Overholser dam to fail and resulted in the displacement of approximately 15,000 residents. Estimated damages, recovery costs, fatalities, and injuries are unknown. This historical failure of Lake Overholser is highly unlikely to occur with present day mitigation measures, spillway construction, and siting of structures. In the event that Lake Overholser was to fail in present day the impact would be minimal and at most a handful of homes would be impacted.

A potential dam failure occurred at the Dry Creek Detention Pond Dam on April 10, 2008. Heavy rains had occurred in the days prior to April 10, 2008. The overflow pipe that runs from the pond, under the dam, and into Dry Creek had failed and the leaking water had eroded the earthen dam above it causing two large holes, one on the back of the dam and one front of the dam. There was a potential for the remaining portions of the earthen dam to collapse and cause a sudden release of water from the pond resulting in a flash flood along Dry Creek north of the dam. Oklahoma City's Public Works Department took immediate mitigation actions and prevented any failure. Public safety personnel notified residents in the potential inundation zone of the hazard and provide information on protective actions they should take.

On June 14, 2015 a privately owned and maintained stock pond dam on private property was breached releasing all of the water impounded behind it. The following synopsis of the event was taken from the Office of Emergency Management's Incident / Event Report: On 6-14-15 at 1219 hours fire and police

units responded to the 7700 block of S. Indian Meridian on a swift water event. It was discovered that a dam of a sizable pond gave way and emptied the pond, flooding low lying areas. The flow of water washed out several private drives and flowed over Indian Meridian in the 7600 blk. It flowed down stream and flooded over the top of 89th street just east of Choctaw Rd. A homeowner had dammed a creek creating a large pond south of 89th which held some of the flow. It crested and spilled over his dam and caused the river below to rise. It came up to the bridge level at 104th but did not cross. The water receded slightly prior to officers leaving the area. Officers called Public Works to close 89th between Choctaw and Indian Meridian and also Indian Meridian in the 7600 blk. No structures were damaged and the extent of washout to the two public roads was minor mostly involving the shoulder. The dam was overgrown with small trees and bushes and there had been record rainfall in the area in May/June 2015.

Extent

A dam failure is when seepage or small breach where the water stays within the downstream river channel, Oklahoma City considers to be a minor severity. A breach large enough to exceed the capacity of the river or creek channel and overflow causing damage to homes, business, critical facilities, and putting people at risk is considered a major severity. This includes situations where the dam flow control manager releases more water than can be contained in the banks of the downstream river or creek channel.

The City of Oklahoma City partnered with the US Geological Survey to conduct a dam breach analysis and flood inundation mapping for (10) City owned High Hazard Dams in Oklahoma City. These dams represent the largest dams and posing the greatest risk to the residents of Oklahoma City. https://pubs.usgs.gov/sir/2015/5052/

Maximum flood-inundation elevation and time for the 75-percent probable maximum flood (PMF) and sunny day dam breach scenarios for the High Hazard Selected dams in Oklahoma City, Oklahoma.

Bridge Name	Cross-Section Index Number	75 percent PMF stage (ft)	Time to Peak stage (hh:mm) 75 percent PMF	Sunny-day stage (ft)	Time to peak stage (hh:mm) sunny day
Lake Hefner					
122nd Street	70,333	1,127.92	01:55	1,125.18	01:45
Val Verde Drive	65,910	1,117.15	02:00	1,114.69	01:55
John Kilpatrick Turnpike	61,574	1,108.77	02:00	1,107.59	01:55
Gaillardia Golf Course Bridge	59,586	1,098.97	02:10	1,096.66	02:05
150th Street	54,487	1,089.81	02:15	1,088.08	02:10
164th Street	46,617	1,077.59	02:30	1,075.45	02:25
178th Street	36,991	1,061.41	02:50	1,059.32	02:40
Covell Road	18,373	1,052.96	04:40	1,048.49	04:50
Portland Avenue	13,819	1,052.85	04:40	1,048.33	04:55
Sorghum Mill Road	10,691	1,052.76	04:40	1,048.22	04:55
Waterloo Road	199,517	1,037.94	04:50	1,034.94	05:05
Charter Oak Road	175,745	1,032.36	05:10	1,029.66	05:30
Pennsylvania Avenue	161,985	1,025.27	05:20	1,019.27	06:20

Bridge Name	Cross-Section Index Number	75 percent PMF stage (ft)	Time to Peak stage (hh:mm) 75 percent PMF	Sunny-day stage (ft)	Time to peak stage (hh:mm) sunny day
Western Avenue	150,196	1,024.17	05:35	1,017.82	06:30
Seward Road	125,517	1,006.70	06:10	1,000.04	07:05
Eastern Road	109,214	998.38	06:30	991.74	08:10
Phillips/Academy Road	97,761	993.44	06:40	986.58	08:25
Industrial Road	63,843	973.54	06:55	968.43	08:45
5th Street	42,879	963.11	07:55	960.09	10:35
State Highway 33	41,934	971.04	08:20	962.13	11:40
College Avenue	39,760	970.50	08:20	961.31	11:40
Railroad Bridge	20,062	969.25	08:20	959.55	11:45
Sooner Road	18,531	969.21	08:20	959.41	11:45
Lake Overholser					
Northwest 10th Street	244,632	1,242.66	02:40	1,220.45	04:00
Railroad Bridge	238,434	1,237.01	03:00	1,216.19	04:40
West Reno Avenue	236,457	1,236.95	03:00	1,214.66	04:50
Interstate 40	234,581	1,234.14	03:20	1,214.80	04:50
Council Road	227,339	1,227.11	03:30	1,209.21	05:40
MacArthur Boulevard	212,772	1,220.58	05:20	1,198.08	08:00
Meridian Avenue	207,372	1,216.45	06:00	1,187.45	08:30
Portland Avenue	201,929	1,213.53	06:40	1,184.19	08:40
Interstate 44	198,172	1,211.58	06:50	1,181.46	08:40
May Avenue	195,843	1,208.93	07:10	1,176.45	09:10
Agnew Avenue	192,611	1,205.57	07:40	1,175.56	09:20
Pennsylvania Avenue	190,486	1,202.93	08:10	1,174.75	09:20
Exchange Avenue	187,305	1,199.76	08:40	1,173.27	09:30
Railroad Bridge	186,166	1,198.77	08:50	1,172.65	09:30
Western Avenue	184,218	1,197.88	09:00	1,171.48	10:20
Walker Avenue	181,102	1,196.53	09:00	1,167.29	10:40
Robinson Avenue	179,596	1,195.07	09:10	1,166.78	10:50
Shields Boulevard	178,887	1,194.17	09:10	1,166.57	10:50
15th Street	177,841	1,190.79	09:20	1,166.32	11:00
Pipe Bridge	177,031	1,190.55	09:20	1,165.87	11:00
Railroad Bridge	175,206	1,188.12	09:30	1,165.45	11:00
Lincoln Boulevard	174,374	1,186.91	09:40	1,165.27	11:00
Interstate 35	170,982	1,185.24	09:40	1,164.20	11:30
Eastern Avenue	166,217	1,183.51	09:50	1,163.34	11:30
Reno Avenue	164,115	1,179.97	09:50	1,161.50	11:40
Interstate 40 eastbound	162,502	1,176.97	09:50	1,160.25	11:40
Interstate 40 westbound	161,683	1,176.64	09:50	1,159.65	11:40
Railroad Bridge	159,387	1,172.83	11:00	1,158.16	11:50
4th Street	158,701	1,172.38	11:00	1,157.64	12:00
10th Street	154,380	1,170.36	11:20	1,154.97	12:20
23rd Street	146,741	1,167.72	11:30	1,151.18	15:20
36th Street	141,291	1,163.32	12:20	1,150.18	16:50
Midwest Boulevard	126,973	1,154.90	12:50	1,143.39	21:20
63rd Street	118,105	1,149.45	13:20	1,136.74	24:50
Britton Road	102,658	1,145.66	13:30	1,128.51	27:30
Hefner Road	92,737	1,137.44	14:10	1,123.66	29:40
122nd Street	79,090	1,130.94	14:50	1,118.00	30:20
Hiwassee Road	57,889	1,125.90	15:10	1,108.66	33:20
Britton Road	36,801	1,110.49	16:10	1,098.17	34:50
Northwest Oklahoma City Sludge Lagoon					
Pony Road	72,013	1,138.52	00:25	1,136.50	00:20
122nd Street	69,604	1,112.71	00:25	1,112.00	00:25
Val Verde Drive	65,910	1,093.42	00:40	1,090.59	00:40
John Kilpatrick Turnpike	61,574	1,075.18	00:50	1,073.26	00:45

Bridge Name	Cross-Section Index Number	75 percent PMF stage (ft)	Time to Peak stage (hh:mm) 75 percent PMF	Sunny-day stage (ft)	Time to peak stage (hh:mm) sunny day
Gaillardia Golf Course Bridge	59,586	1,070.37	00:55	1,068.58	00:55
150th Street	54,487	1,060.53	01:20	1,059.28	01:05
164th Street	46,617	1,052.37	01:40	1,051.79	01:40
Stanley Draper Lake					
149th Street	80,925	1,126.43	01:40	1,123.14	01:35
164th Street	73,132	1,112.10	01:50	1,107.60	01:50
179th Street	66,889	1,105.84	01:55	1,101.50	01:55
Franklin Road	57,654	1,087.97	02:10	1,084.63	02:25
Alameda Street	30,123	1,065.79	03:10	1,062.50	03:10
Dry Creek Detention Reservoir					
Quail Creek Road	75,271	1,144.29	00:25	1,142.58	00:35
122nd Street	73,465	1,137.16	00:30	1,134.37	01:00
Fairway Culvert	72,722	1,133.55	00:35	1,132.78	01:25
Quail Creek Golf Course Bridge	71,754	1,124.66	00:40	1,119.57	01:25
Twisted Oak Road	71,428	1,124.59	00:40	1,118.34	01:30
Quail Creek Golf Course Bridge	71,036	1,125.74	00:50	1,117.01	01:30
Quail Creek Golf Course Bridge	70,090	1,113.48	00:55	1,109.26	01:35
Quail Creek Golf Course Bridge	68,730	1,104.62	01:05	1,100.39	01:40
Quail Creek Golf Course Bridge	68,412	1,104.10	01:05	1,099.32	01:40
Lake Hefner Parkway	66,650	1,094.36	01:05	1,090.30	01:40
John Kilpatrick Turnpike and ramp	66,157	1,091.03	01:10	1,086.80	01:40
150th Street	52,795	1,066.66	01:50	1,058.90	03:35
164th Street	44,906	1,055.67	03:20	1,051.77	05:05
Will Rogers Park Holding Pond					
Unnamed Road	117,115	1,198.86	01:30	1,181.71	01:00
Drexel Boulevard	116,131	1,198.55	01:30	1,178.95	01:00
May Avenue	114,524	1,198.42	01:30	1,175.76	01:05
Venice Boulevard	113,189	1,191.57	02:05	1,166.96	01:05
36th Street	112,664	1,173.67	02:25	1,161.69	01:05
Interstate 44	110,441	1,164.35	02:50	1,154.57	01:10
Youngs Boulevard	107,973	1,161.35	04:30	1,145.52	01:10
Pennsylvania Avenue	106,262	1,147.27	04:35	1,140.04	01:15
Interstate 44	105,561	1,142.20	04:35	1,136.81	01:20
Hemingway Drive	103,130	1,139.46	06:10	1,135.01	01:25
Interstate 44 Ramp	102,777	1,140.08	06:10	1,134.66	01:25
Northwest Expressway	102,130	1,140.75	06:10	1,134.83	01:25
Belle Isle Boulevard	101,695	1,144.40	06:15	1,134.15	01:25
Classen Boulevard	98,278	1,141.51	06:20	1,126.97	01:35
Western Avenue	96,555	1,124.12	06:25	1,110.67	01:35
Interstate 44	95,965	1,111.14	06:30	1,106.09	01:40
Interstate 44 Ramp	91,134	1,110.90	06:35	1,089.41	02:05
Interstate 235	90,723	1,110.86	06:35	1,089.24	02:05
Lincoln Boulevard Southbound	86,547	1,105.05	07:20	1,081.44	02:25
Lincoln Boulevard Northbound	86,398	1,083.18	08:45	1,074.70	02:25
Unnamed Road	82,401	1,082.20	08:45	1,068.85	02:35
Kelly Avenue	81,622	1,082.20	08:45	1,067.25	02:45
Grand Boulevard	77,565	1,082.02	08:45	1,064.14	02:55

Bridge Name	Cross-Section Index Number	75 percent PMF stage (ft)	Time to Peak stage (hh:mm) 75 percent PMF	Sunny-day stage (ft)	Time to peak stage (hh:mm) sunny day
Martin Luther King Avenue	75,220	1,060.53	08:45	1,055.32	03:05
Interstate 35	68,845	1,054.97	09:00	1,046.13	03:25
Bryant Avenue	68,398	1,065.38	09:05	1,048.13	03:25
63rd Street	67,165	1,045.04	09:10	1,040.60	03:30
Wilshire Boulevard	59,800	1,037.52	09:30	1,030.12	03:50
Northeast (Zoo) Lake					
Remington Place	69,823	1,091.21	00:30	1,081.12	00:35
Interstate 35	66,293	1,072.45	01:00	1,055.78	00:45
Bryant Avenue	65,846	1,066.69	01:05	1,051.35	00:50
63rd Street	64,614	1,063.62	01:10	1,047.63	00:55
Wilshire Boulevard	57,251	1,057.17	01:45	1,038.08	01:30
Britton Road	49,336	1,041.07	02:25	1,025.33	02:00
Hefner Road	39,157	1,031.53	03:15	1,016.83	02:55
Sooner Road	34,883	1,027.97	03:35	1,014.91	03:20
122nd Street	31,317	1,025.78	04:25	1,013.97	03:45
Interstate 44	26,411	1,024.35	04:35	1,011.55	04:25
Memorial Road	22,741	1,018.47	05:30	1,009.46	05:45
Lightning Creek Holding Pond A					
Broadway Avenue	45,492	1,282.48	00:45	1,280.31	01:05
Walker Avenue	40,777	1,269.13	01:00	1,266.91	01:15
Trafalgar Drive	39,950	1,266.31	01:05	1,265.07	01:20
Shartel Avenue	39,249	1,263.28	01:10	1,262.15	01:25
89th Street	36,805	1,254.04	01:25	1,253.11	01:35
Western Avenue	35,132	1,250.24	01:30	1,248.65	01:45
84th Street	33,548	1,246.18	01:30	1,243.34	01:55
Western Avenue	30,856	1,237.78	01:40	1,231.67	02:00
Interstate 240 Service Road	28,671	1,233.87	02:00	1,225.63	02:15
67th Street	25,830	1,225.84	02:10	1,216.34	02:20
59th Street	22,493	1,210.82	02:20	1,204.33	02:25
Walker Avenue	20,380	1,208.07	02:20	1,201.00	02:30
51st Street	18,419	1,205.24	02:25	1,198.55	02:35
Sage Avenue	17,291	1,203.44	02:25	1,195.83	02:40
Unnamed Road	16,949	1,202.16	02:25	1,195.70	02:40
44th Street	15,406	1,200.50	02:30	1,194.47	02:40
Santa Fe Avenue	14,842	1,199.43	02:30	1,193.67	02:40
Draper Park Bridge	14,118	1,197.29	02:35	1,190.82	02:45
Santa Fe Avenue	13,560	1,196.22	02:35	1,188.53	02:50
Grand Boulevard	12,090	1,194.88	02:35	1,187.06	02:55
29th Street	9,418	1,190.45	02:45	1,184.01	03:00
28th Street	8,998	1,189.22	02:45	1,183.07	03:00
27th Street	8,485	1,188.11	02:45	1,181.85	03:00
25th Street	7,480	1,181.47	02:50	1,179.60	03:00
23rd Street	6,633	1,185.46	02:50	1,177.07	03:05
18th Street	3,945	1,175.14	02:55	1,169.79	03:05
15th Street	2,934	1,168.03	02:55	1,162.67	03:05
Foot Bridge	2,623	1,166.19	02:55	1,160.56	03:10
Lightning Creek Holding Pond C					
81st Street	33,441	1,250.59	00:35	1,249.30	00:35
81st Street	31,523	1,241.50	00:45	1,239.96	00:45
Western Avenue	30,856	1,237.78	00:45	1,233.88	00:45
Interstate 240 Service Road	28,671	1,233.72	00:55	1,226.31	00:50
67th Street	25,830	1,225.82	01:05	1,216.99	00:55
59th Street	22,493	1,210.78	01:15	1,204.74	01:00
Walker Avenue	20,380	1,208.04	01:20	1,201.37	01:10
51st Street	18,419	1,205.22	01:20	1,198.86	01:10

Bridge Name	Cross-Section Index Number	75 percent PMF stage (ft)	Time to Peak stage (hh:mm) 75 percent PMF	Sunny-day stage (ft)	Time to peak stage (hh:mm) sunny day
Sage Avenue	17,291	1,203.40	01:20	1,196.09	01:15
Unnamed Road	16,949	1,202.14	01:25	1,195.96	01:15
44th Street	15,406	1,200.49	01:25	1,194.73	01:20
Santa Fe Avenue	14,842	1,199.42	01:25	1,193.93	01:20
Draper Park Bridge	14,118	1,197.30	01:30	1,190.95	01:20
Santa Fe Avenue	13,560	1,196.21	01:30	1,188.61	01:25
Grand Boulevard	12,090	1,194.88	01:35	1,187.07	01:30
29th Street	9,418	1,190.45	01:40	1,184.00	01:35
28th Street	8,998	1,189.23	01:40	1,183.06	01:35
27th Street	8,485	1,188.11	01:40	1,181.84	01:35
25th Street	7,480	1,187.48	01:40	1,179.54	01:40
23rd Street	6,633	1,185.46	01:40	1,177.00	01:40
18th Street	3,945	1,175.14	01:45	1,169.73	01:45
15th Street	2,934	1,168.03	01:45	1,162.63	01:45
Foot Bridge	2,623	1,166.20	01:45	1,160.50	01:45
Dolese Youth Park Lake					
Meridian Avenue	30,650	1,272.72	03:06	1,266.29	00:30
Meridian Avenue	29,677	1,272.72	03:06	1,245.46	00:30
60th Street	28,835	1,242.43	03:06	1,240.43	00:35
Northwest Expressway	25,532	1,212.74	04:31	1,210.85	00:40

Probability of Future Events

The probability of a dam failure occurring in the Oklahoma City area is low.

Vulnerability and Impacts

Although dam failures are rare, especially with larger engineered dams, the result can be catastrophic. Houses, businesses, and government infrastructure could suffer extensive damage in a major loss of water from a High or Significant Hazard Potential dams as well as loss of life. Disruptions of citizen's day to day traffic and critical services such as emergency police, fire, and ambulance could occur due to damaged or destroyed roads and bridges. Power and water outages would likely occur which would cause sanitation problems for communities. Employment is often affected due to business closures. Release of hazardous materials can occur and result in with associated adverse environmental impacts due to damaged and/or inundated facilities.

The City of Oklahoma City owned dams are inspected by a contractor as required by Federal and/or State regulations. Corrective action is taken to correct any deficiencies found during the inspections.
Earlier warning and evacuation when dam failure is eminent is key to saving lives. OKC Emergency Management, Public Works, Parks and Recreation, and the Utilities Department partnered to develop a Dam Emergency Action Plan which included sections on warning and evacuation.

Chapter 17 – Mosquito Borne Disease

Description

Mosquito borne diseases occur when a mosquito that is carrying a virus or a parasite bites a person and makes them sick. While there are many different types of mosquitoes in Oklahoma and worldwide, not all mosquitoes carry viruses or parasites that make people sick. Mosquitoes can transmit these harmful organisms form one hose to another.

West Nile Virus (WNV) is a virus that is spread by mosquitoes and may cause illness in birds, animals, and humans. WNV was not known to be present in the United States until the summer of 1999. Before that, WNV was only found in Africa, western Asia, the Middle East, and Eastern Europe. Currently, WNV activity has been seen in all of the lower 48 states. WNV is primarily spread through the bite of an infected mosquito. Mosquitoes pick up the virus when they feed on infected birds. The infected mosquitoes can then pass the virus to humans or animals. Rarely has WNV been spread through blood transfusions. WNV is not spread person to person through casual contact such as touching or kissing. Symptoms usually occur 3 to 15 days after a bite from an infected mosquito. Over 80% of people who are exposed to WNV never become sick. Of those that become sick, most persons will have a mild illness called "West Nile Fever" lasting two to ten days. Common symptoms of West Nile Fever include headache, fever, and tiredness. Some persons may also develop a rash. In some cases (less than 1%), WNV can cause severe neurologic disease such as meningitis (swollen membranes in brain and spinal cord), paralysis (loss of muscle function), or encephalitis (swelling and inflammation of the brain). Symptoms of West Nile meningitis or encephalitis may be intense headache, dizziness, stiff neck, severe weakness, muscle tremors, confusion, or seizures. There is currently no human vaccine or treatment beyond supportive care for WNV. Severe cases are often hospitalized.

Chikungunya (pronunciation: \chik-en-gun-ye) virus is transmitted to people by Aedes mosquitoes. The most common symptoms of chikungunya virus infection are fever and joint pain. Other symptoms may include headache, muscle pain, joint swelling, or rash. Outbreaks have occurred in countries in Africa, Asia, Europe, and the Indian and Pacific Oceans. In late 2013, Chikungunya virus was found for the first time in the Americas on islands in the Caribbean. There is a risk that the virus will be imported to new areas by infected travelers. There is no vaccine to prevent or medicine to treat Chikungunya virus infection.

Zika is a disease caused by Zika virus that is spread to people primarily through the bite of an infected Aedes species mosquito. The most common symptoms of Zika are fever, rash, joint pain, and conjunctivitis (red eyes). The illness is usually mild with symptoms lasting for several days to a week. People usually don't get sick enough to go to the hospital, and they very rarely die of Zika. Outbreaks of Zika previously have been reported in tropical Africa, Southeast Asia, and the Pacific Islands. Zika virus likely will continue to spread to new areas. In May 2015, the Pan American Health Organization (PAHO) issued an alert regarding the first confirmed Zika virus infection in Brazil. Since that time, local transmission has been reported in many other countries and territories.

Location

Mosquito borne disease poses a threat to all of Oklahoma City.

Previous Occurrences

For the West Nile Virus, there have been 675 non-fatal cases of human WNV disease have been reported and 54 Oklahomans have died from this virus from 2002 through 2016. The highest number of cases and deaths occurred in 2012 when from January 1 through December 13, 2012, 161 cases of WNV and 15 deaths due to WNV were reported, per the Oklahoma State Department of Health.
http://www.ok.gov/health/Disease,_Prevention,_Preparedness/Acute_Disease_Service/Disease_Information/Tickborne_and_Mosquitoborne_Diseases/West_Nile_Virus/

For the Chikungunya Virus, there have been 18 cases in Oklahoma from 2014 through 2016. There were no locally transmitted cases only those who had traveled per the CDC.
https://www.cdc.gov/chikungunya/geo/united-states.html

For the Zika Virus, there have been 29 cases in Oklahoma from 2015 through 2/8/2017. There were no locally transmitted cases only those who had traveled outside of the United States, per the Oklahoma State Department of Health.
https://www.ok.gov/health/Disease,_Prevention,_Preparedness/Acute_Disease_Service/Disease_Information/Zika_Virus.html

Extent

Mosquitoes breed faster when temperatures are high. Therefore the risk of mosquito borne diseases is much greater during the summer months. Low temperatures and low humidity cause slow breeding and higher mortality rates. When the temperature drops, mosquitoes are less prone to bite because, in cooler weather, they switch from a blood diet to sugar from plants to provide energy for winter survival.

Both dry and wet weather can benefit the infectious mosquito population. Dry spells can help lengthen the mosquito's life cycle, allowing time for diseases to multiply in the infected body and move to the salivary glands. When it's dry, mosquitoes retreat to cool, damp areas to wait for rain. In that type of hibernation, any infection in their saliva becomes more powerful. After rain, puddles and standing water provide ideal locations for breeding more mosquitoes. Female mosquitoes lay their eggs one at a time or together in rafts of a hundred or more eggs on the surface in fresh or any stagnant water.

While not all mosquitoes are infected with these diseases it's best to imagine that they are and take precautions to exercise mosquito safety. In evaluating vulnerability of the population in Oklahoma City, it was determined that risk/vulnerability includes the entire population of Oklahoma City since there is no way to determine the impact/magnitude of these diseases and no way to predict where and when these diseases will occur.

The Oklahoma City-County Health Department (OCCHD) has experience in actual events (surveillance, testing, breeding site reduction, larval control, adult mosquito control, etc.) which will better prepare them for future WNV events.

Probability of Future Events

The probability of Mosquito Borne Diseases occurring in the Oklahoma City area is high.

Vulnerability and Impacts

Through surveillance, testing, and citizen complaints OCCHD and the City of Oklahoma City Public Works Department Storm Water Quality (SWQ) and Streets, Traffic, and Drainage Maintenance (STDM); Utilities Department Solid Waste Management (SWM) and Water Quality; Parks & Recreation Department; and Development Services Department Code Enforcement in collaboration with key partners will modify, within the scope of their normal assigned areas of responsibility and day-to-day operations, potential habitats in which mosquitoes can develop (examples: illegally-dumped tires, uprooted trees that collect seepage and rainwater, large areas of standing water, such as from swamps, sluggishly moving streams or ditches, etc.). This is thought to be the most effective way to reduce the number of mosquitoes around homes and neighborhoods.

OCCHD currently has a "Mosquito Control" page on their website which highlights how the public can reduce their risk of contracting WNV. The campaign, known as "Fight the Bite" uses the 4 D's of mosquito safety: https://www.occhd.org/eng/consumer-protection/mosquito-control

- DRAIN standing water on your property so mosquitoes won't breed
- Use insect repellent that contains DEET
- Stay indoors at DUSK AND DAWN when mosquitoes are most prevalent
- DRESS in long sleeves and pants and spray insect repellent on the clothes

OCCHD also provide tips for breeding site reduction, larval control, and adult mosquito control. With links to a safety video, frequently asked question page, and various press releases and publications.

Chapter 18 – Capability Assessment

Each community has a unique set of capabilities, including authorities, policies, programs, staff, and funding, and other resources available to accomplish mitigation and reduce long-term vulnerability. By reviewing the existing capabilities the planning team identified capabilities that currently reduce disaster losses or could be used to reduce losses in the future, as well as capabilities that inadvertently increase risks in the planning area. The following is a capability assessment for the City of Oklahoma City.

Existing Institutions, Plans and Ordinances

This table provides a summary of the plans, codes, policies, and ordinances currently in place in the City. Existing programs and policies were reviewed in order to identify those that may weaken or enhance the hazard mitigation objectives outlined in this document. This list does not necessarily reflect every plan, ordinance, or other guidance document within each jurisdiction; however, this is a summary of the guidance documents known to and recommended for review by the members of the planning committee. The letter "X" in the box indicates the City has the authority to implement the specified regulatory tool and that the tool is currently in place.

Jurisdiction	Building Code	Zoning Ordinance	Subdivision Regulations	Special Purpose Ordinance	Growth Management Ordinance	Site Plan Review Requirements	Comprehensive Plan	Capital Improvement Plan	Economic Development Plan	Emergency Operations Plan	Pre-Disaster Recovery Plan
City of Oklahoma City	X	X	X	X		X	X	X		X	X

Legal and Regulatory Capabilities

As indicated in the previous table, the City has several policies, programs, and capabilities, which help to prevent and minimize future damages resulting from hazards. These tools are valuable instruments in pre and post disaster mitigation as they facilitate the implementation of mitigation activities through the current legal and regulatory framework. These policies, programs, and capabilities are described in greater detail for the City of Oklahoma City.

Building Code

Building codes regulate construction standards and are developed for specific geographic areas of the country. They consider the type, frequency, and intensity of hazards present in the region. Structures

built to applicable building codes are inherently resistant to many hazards such as strong winds, floods, and earthquakes, up to certain levels of severity. Due to the location specific nature of the building codes, these are very valuable tools for mitigation. The City currently uses the International Building Code for Commercial 2009 and International Residential Code 2009. The City is in the process of adopting the 2015 versions of these two codes. The Development Services Department enforces the City's Building Codes through the plan review and permitting process and through required inspections during the construction process.

Zoning Ordinance

Zoning is a useful tool to consider when developing a mitigation strategy. It can be used to restrict new development, require low-density development, and designate specific uses (e.g. recreational) in the hazard prone areas. Private property rights must be considered, but enacting a zoning ordinance can reduce or potentially eliminate damages from future hazard events. According to the State Multi-Hazard Mitigation Plan, all local communities in the State are encouraged to incorporate mitigation standards in zoning and land use ordinances. The zoning ordinance can be found in Chapter 59 – Zoning and Planning Code of the Oklahoma City Municipal Code. A copy of this ordinance may be found online at https://www.municode.com/library/ok/oklahoma_city/codes/code_of_ordinances?nodeId=OKMUCO2010_CH59ZOPLCO or they can view it and/or obtain a copy of it from the City Clerk's Office. The Development Services Department enforces the City's Zoning Ordinance through the plan review and permitting process.

Subdivision Regulations

Subdivision regulations offer an opportunity to account for natural hazards prior to the development of land as they formulate regulations when the land is subdivided. Subdivision design that incorporates mitigation principles can reduce the exposure of future development to hazard events. The City's Planning Commission reviews proposed subdivisions and upon approval forwards them to the City Council for approval by resolution.

Special Purpose Ordinance

A special purpose ordinance is a form of zoning in which specific standards dependent upon the special purpose or use must be met. For example, many special purpose ordinances include basic development requirements such as setbacks and elevations. The City's floodplain management ordinance is a special purpose ordinance. The special purpose ordinance is a useful mitigation technique particularly when implemented to reduce damages associated with flooding. The Development Services Department enforces this ordinance through the plan review and permitting process.

The City has adopted a Flood Damage Prevention Ordinance that restricts development in floodplain areas, through a building development permit system, Chapter 16 Section 16-19 of the Oklahoma City Municipal Code. A copy of this ordinance may be found online at http://www.municode.com/resources/gateway.aspx?productId=17000 or they can view it and/or obtain a copy of it from the City Clerk's Office.

Site Plan Review Requirements

Site plan review requirements are used to evaluate proposed development prior to construction. An illustration of the proposed work, including its location, site elevations, exact dimensions, existing and proposed buildings, and many other elements are often included in the site plan review requirements. The site plan reviews offer an opportunity to incorporate mitigation principles, such as ensuring that the proposed development is not in an identified hazard area and that appropriate setbacks are included. The Development Services Department conducts this review during the plan review and permitting process.

Comprehensive Plan

A comprehensive plan is a document which illustrates the overall vision and goals of a community. It serves as a guide for the community's future and often includes anticipated demographics, land use, transportation, and actions to achieve desired goals. Integrating mitigation concepts and policies into a comprehensive plan provides a means for implementing initiatives through legal frameworks and enhances the opportunity to reduce the risk posed by hazard events. The Planning Department develops and maintains the City's Comprehensive Plan commonly known as PlanOKC.

Capital Improvement Plan

Capital Improvement Plans schedule the capital spending and investments necessary for public improvements to the City's infrastructure including roads, bridges, storm water and flood control, facilities, buildings, and water and waste water pipelines. These plans can serve as an important mechanism to manage development in identified hazard areas through limited public spending. Multiple City departments contribute to the CIP and Public Works handles project management. Those City departments that have a trust have their own CIP process.

Economic Development

The City does not have an Economic Development Plan. The City has an economic development strategy and initiatives including Tax Increment Financing (TIF) and Strategic Investment Program (SIP) to improve the local economy in the future. TIF projects offer an opportunity for City staff including engineers and planners to review each proposed TIF project and identify potential natural hazards within the TIF district. SIP projects must go through plan review and permitting process described above. The City Manager's Office has responsibility for economic development and has full-time staff assigned to that function.

Emergency Operations Plan (EOP)

The Emergency Operations Plan (EOP) provides a framework, through which The City of Oklahoma City prepares for, prevents, protects, mitigates, responds to, and recovers from, the impacts of Major Emergencies, Disasters, and Catastrophic Incidents (hereafter referred to as incidents/disasters) that could adversely affect the health, safety and/or general welfare of the residents of The City of Oklahoma City. The EOP provides an opportunity to anticipate an emergency and plan the response accordingly. In the event of an incident/disaster, a previously established emergency operations plan can minimize or reduce the impacts and negative effects. The Oklahoma City Office of Emergency Management developed and maintains the City's EOP. The EOP is reviewed annually and revised as necessary. The EOP is submitted to the City Council annually for adoption by resolution.

Pre-Disaster Recovery Plan

The City's Pre-Disaster Recovery Plan is an Annex to the EOP provides a framework for the coordination of City of Oklahoma City Departments, non-profit organizations (NPOs) and the private sector to enable the community to recover from the consequences of an incident/disaster. The Pre-Disaster Recovery Plan incorporates provisions of the National Disaster Recovery Framework. When a disaster occurs the Local Disaster Recovery Manager and the Disaster Recovery Task Force will develop a detailed post-recovery plan that guides the physical, social, environment, and economic recovery and reconstruction after a disaster. Hazard mitigation principles may be incorporated into the post-disaster recovery plan in order to reduce repetitive disaster losses.

Administrative and Technical Capability

The ability of a local government to develop and implement mitigation projects, policies, and programs is contingent upon its staff and resources. Administrative capability is determined by evaluating whether there are an adequate number of personnel skilled in surveying and Geographic Information Systems.

The table below provides a summary of the administrative and technical capabilities currently in place. The letter "X" in the box indicates the City maintains at least one staff member for the given function.

Continued on Next Page

Administrative and Technical Capability										
Jurisdiction	**Planner(s) or Engineer(s) with knowledge of land development and management practices**	**Engineer(s) or professional(s) trained in construction practices related to buildings and infrastructure**	**Planner(s) or Engineer(s) with an understanding of natural and/or human caused hazards**	**Floodplain Manager**	**Surveyors**	**Staff with education or expertise to assess the communities vulnerability to hazards**	**Personnel skilled in GIS and/or HAZUS**	**Scientists familiar with the hazards of the community**	**Emergency Manager**	**Grant writers**
City of Oklahoma City	X	X	X	X	X	X	X	X	X	X

Staffing Resources

Having a planner or engineer trained in land development, construction practices, or one who has an understanding of natural or man-made hazards are great resources to a community. Having their level of knowledge and expertise will help in the process of assessing and mitigating risks while limiting risk to new development or redevelopment. The City employs fulltime engineers and planners in multiple City departments including Airports, Parks & Recreation, Planning, Public Works, Public Transportation/EMBARK, and Utilities.

Floodplain Management

By employing floodplain management, the jurisdiction can protect its citizens against much of the devastating financial loss resulting from flood disasters. Careful local management of development in the floodplains results in construction practices that can reduce flood losses and the high costs associated with flood disasters to all levels of government. The OKC Public Works is responsible for floodplain management in the Planning Area and employs fulltime engineering staff to handle this responsibility. Several of these engineers are Certified Floodplain Managers (CFM).

The City of Oklahoma City has been a National Flood Insurance Program (NFIP) Community since March 24, 1971, CID # 405378 and has adopted a Flood Damage Prevention Ordinance that restricts development in floodplain areas, through a building development permit system, Chapter 16 Section 16-

19 of the Oklahoma City Municipal Code. A Copy of this ordinance may be found online at http://www.municode.com/resources/gateway.aspx?productId=17000 or they can view it and/or obtain a copy of it from the City Clerk's Office.

There are 136 Repetitive Loss Structures (18 Commercial, 4 Industrial, and 114 Residential) and 11 Severe Repetitive Loss Properties in the Planning Area.

Surveyors

Surveyors gather information that is needed by the city engineers for city projects that involve development or redevelopment. A surveyor records geographic conditions and man-made features as they currently exist. Other noted information might include: terrain, drainage, property boundaries and ownership, soil condition, and other physical features. The OKC Public Works Department, Field Services Division has a Chief Surveyor and surveyor crews.

Vulnerability Assessment

The City has staff with the education or expertise to assess the City's vulnerability to a wide range of hazards. Public Works has staff that can assess the City's vulnerability to flooding. The City's Office of Emergency Management has staff trained and experienced in conducting threat and hazard analysis and produce the hazard vulnerability analysis (HVA) for the City's Emergency Operations Plan.

GIS/HAZUS

Geographical Information Systems (GIS) and HAZUS are powerful resources that the jurisdictions can be used to identify important facts about the community. HAZUS is methodology for estimating potential losses from earthquakes, floods, and winds. HAZUS uses GIS technology to estimate physical, economic, and social impacts of disasters. GIS technology is useful for producing map layers that can show the spatial relationship between known hazards and the built environment and the City's critical infrastructure and services. The OKC Information Technology Department maintains the City's GIS software and some base data sets. Other data sets are maintained by individual departments to meet their specific needs. Each City department has a GIS point of contact.

Scientists

The City does not employ scientists familiar with the hazards of the community. However, the City has access to scientists familiar with the hazards of the community through other government agencies and institutions of higher education. About 20 miles south of City Hall City staff can access the University of Oklahoma and the National Weather Center where the following operational, research, and development entities are located:

- Oklahoma Geological Survey
- Oklahoma Climatological Survey
- Oklahoma Mesonet
- National Weather Service Norman Forecast Office
- Storm Prediction Center
- National Severe Storms Laboratory

- NEXRAD Radar Operations Center
- Warning Decision Training Branch
- Advanced Radar Research Center (ARRC)
- Center for the Analysis and Prediction of Storms (CAPS)
- Center for Spatial Analysis
- Cooperative Institute for Mesoscale Meteorological Studies (CIMMS)
- Office of Weather Programs and Projects
- South Central Climate Science Center (SCCSC)

The City can access the scientists and subject matter experts in the U.S. Geological Survey and Oklahoma Water Resources Board which have offices in the City of Oklahoma City.

Emergency Manager

The Emergency Manager performs administrative and technical work in the development, implementation, and coordination of the City's comprehensive emergency management program. This position also acts as the subject matter expert in disaster response and recovery efforts, oversees emergency management, NIMS, and disaster related training; exercises, public education and awareness programs, and performs related duties as assigned. The Oklahoma City Office of Emergency Management has five full-time staff and two assigned liaisons. The Emergency Manager is a Certified Emergency Manager (CEM®).

Grant Writers

The City has fulltime staffs that are knowledgeable and experienced in grant writing and management. Multiple City departments routinely apply for, receive, and manage a variety of federal grant programs for transportation, traffic safety, crime prevention and reduction, community development, firefighting, homeland security, emergency management, and hazard mitigation.

Financial Capabilities

Financial Capability								
Jurisdiction	Capital Improvements Project Funding	Authority to levy taxes for specific purposes	Water, Sewer, and Solid Waste service Fees	Incur fees for new development	Incur debt through general obligation funds and/or special tax bonds	Community Development Block Grant	Federal funding programs	State funding programs
City of Oklahoma City	X	X	X	X	X	X	X	X

The City classifies its funds as either operating or non-operating. The distinction is that some funds, and, in some cases, portions of funds, directly support operations and other funds provide for capital improvements or are so limited in their purpose that they do not support daily operations.

Operating Funds

The Operating Funds category includes three major types of funds: General Operating Funds, Special Revenue Funds and Enterprise Funds. The General Fund is the City's largest fund. The General Fund has hundreds of individual revenue sources ranging from daily fishing permits to building permits to sales tax. Operating funds may fund certain mitigation actions that do not involve capital improvements.

Non-Operating Funds

Many of the Non-Operating Funds receive most of their revenue from other funds, such as the General Fund. The sources of non-operating funds limit what the funds can be used for and they do not support daily operations. Non-operating funds may fund certain mitigation actions that involve capital improvements.

Capital Improvement Projects

The funding for capital improvement projects comes from the General Fund or Enterprise Funds.

Authority to Levy Taxes for Specific Purposes

The City can levy taxes for special purposes with a vote of the residents. The Public Safety Sales Tax and Metropolitan Area Projects (MAPS) are two examples of taxes approved by residents for a specific purpose.

Water, Sewer, and Solid Waste Service Fees

The Oklahoma City Water Utilities Trust (OCWUT) sets the fees for water and waste water service in the City. The Oklahoma City Environmental Assistance Trust (OCEAT) sets the fees for solid waste removal and disposal. These fees pay for the delivery of water, waste water, and sold waste management services and for capital improvements.

Fees for New Development

These fees are commonly known as impact fees and can only be used for delivering enhanced infrastructure such a roads, bridges, parks, and water and waste water utilities. As the infrastructure is extended into areas of new development mitigation actions can be incorporated into the projects.

General Obligation Funds/Special Tax Bonds

Bonds are used to fund capital improvement projects. The City develops a list of projects to be funded with bond monies and residents vote to approve bonds to pay for the projects on the list. The bond funds pay for specific infrastructure construction projects. Mitigation actions can be incorporated into these projects. Also, bond funded mitigation projects could be proposed to voters for approval.

Community Development Block Grants (CDBG)

The City receives CDBG funds which are managed by the Planning Department.

Federal Funding Programs

The City applies for and receives a range of federal funding for a variety of projects and programs. Some funding from U.S. Department of Homeland Security, U.S. Department of Justice, and FEMA goes to emergency management and public safety programs managed by the Fire and Police Departments.

The three main sources for federal hazard mitigation funding are: Hazard Mitigation Grant Program (HMGP) which makes funds available after a Major Disaster Declaration, Pre-Disaster Mitigation (PDM) which is an annual nationwide competitive program that funds mitigation projects and Flood Mitigation Assistance (FMA) which funds a variety of flood related mitigation projects. The City has applied for and received federal hazard mitigation assistance for mitigation projects.

State Funding Programs

The City applies for and receives some state funding for its Second Chance and Youth Services programs. There are no state funding programs for hazard mitigation.

Education and Outreach Capability

Education & Outreach Capability						
Jurisdiction	Community-based and faith-based organizations providing public education and outreach programs	Ongoing public education and information programs	External public organizations providing disaster or safety related programs	StormReady Certification	Firewise Communities Certification	Media outlets providing public education and awareness presentations
City of Oklahoma City	X	X	X			X

Community and Faith Based Organizations

The American Red Cross offers a wide range of programs, services and educational opportunities that help individuals, families and communities prevent, prepare for and respond to emergencies. The American Red Cross Serving Oklahoma offers a Community Disaster Education program that helps build a steady foundation of prevention in our community. The Red Cross has been saving lives through health and safety education and training. From first aid, CPR/AED and blood borne pathogens training to swimming instruction, lifeguarding and babysitting courses, Red Cross programs help people lead safer

and healthier lives.

Ongoing Public Education and Information Programs

The Oklahoma City Office of Emergency Management has a fulltime Community Relations Coordinator to conduct natural hazard awareness and disaster preparedness public education and outreach activities. These activities involve making presentations and staffing booths/tables at community events. The Community Relations Coordinator maintains the OKC OEM social media accounts which include Facebook and Twitter. OKC OEM will partner with external organizations such as Oklahoma Office of Homeland Security and Oklahoma Public School District to conduct public education and outreach.

The Oklahoma City Public Information and Marketing (PIM) maintain the City's website OKC.GOV. This website includes a website for disaster preparedness called Prepare OKC which can be found at https://www.okc.gov/residents/prepare-okc. This website provides information on different natural hazards as well as links to guides and resources.

OKC OEM can develop and deliver custom presentations on demand to a variety of groups and businesses. Some of the more popular presentations have been on earthquakes, outdoor warning siren policy, workplace violence and active threats, and the City's emergency management program and disaster response.

External Public Organizations

In the Planning Area the Oklahoma Department of Emergency Management, Oklahoma State Department of Health, Oklahoma Office of Homeland Security, and the Oklahoma City County Health Department are engaged in public education and outreach to increase public awareness of natural hazards, disaster preparedness, and protective actions. This includes a range of activities from public service announcements, classes and presentations, media advisories, staffing booths and tables at public events.

Media Outlets

The City of Oklahoma City has a very competitive television market with regards to weather forecasting and news. Several local television stations conduct public education and outreach activities regarding weather in general, severe weather and tornadoes. Some of their activities specifically target elementary age students. These same television stations will participate in local community severe weather awareness events.

News9 offers David Payne's Weather 101 educational program for grades K-12 which provides an in depth look at how weather forms and how to stay safe when severe weather hits. KFOR offers its Weatherschool Program for grades 3-6 where each year, 20 Oklahoma public schools are chosen to have one of their award-winning meteorologists visit the campus and share science and weather insights with students in a fun and interactive way. KFOR also offers for free its 4Warn smart phone app to receive alerts, warnings, and track earthquakes, lightning, and severe storms. KOCO will on demand develop and conduct customized classes and presentation on severe weather and severe weather safety. KOKH will on demand develop and conduct presentations for schools and groups and they offer on-air public

education and awareness on severe weather and severe weather safety.

Opportunities for Public Education and Outreach

Arguably, elementary school is the best place to start for educating the public about emergency preparedness issues. However, countless other education opportunities exist for disseminating emergency preparedness information to diverse populations.

Most, if not all of the following entities / capabilities were identified in The City of Oklahoma City:

- Agribusiness organizations (OSU Extension and Future Farmers of America)
- Amateur radio organizations
- Annual calendar promotions – National Preparedness month, Fire Prevention Week et al.
- Business/fraternal groups (Lions, Rotary, Optimists, American Business Women's Association, Odd Fellows, Masons, Veterans of Foreign Wars, American Legion)
- Chambers of Commerce
- FEMA's Ready.Gov website
- FEMA's Independent Study free online training
- Oklahoma Insurance Department
- Local Emergency Planning Committees (LEPCs)
- National Weather Service storm spotter training
- Neighborhood Alliance
- The Neighborhood Alliance provides a conduit to distribute public education and information material to homeowner and neighborhood associations.
- School districts and Parent-Teacher Organizations
- Public education campaigns
- Public lectures, seminars, and presentations
- Public Service Announcement (PSAs) and other media campaigns
- Schools/student organizations
- Special events (rodeo, state fair, health fairs, street shows)
    - OKC Prepare Fest - August
    - State Fair - September
        - Various entities including multiple television stations will staff public education and outreach booths.
    - Penn Square Mall Severe Weather Awareness Expo - March
    - Trade Shows – January & February
        - The 2017 OKC Home and Garden show had multiple storm shelter and safe room vendors and emergency electrical generator vendors explaining their products and the OKC Utilities Department had a booth promoting drought awareness and water saving strategies.
- Town Hall meetings or topic specific public forums
    - These have been conducted following disasters in 2010 and 2013 to educate residents about disaster recovery efforts and disaster assistance opportunities.

- Utility companies and OKC Utility Department
    - Include inserts in their monthly bills that occasional promote emergency and disaster preparedness and safety.
- Volunteer Organizations Active in Disaster
- OKC Local Planning and Preparedness Committee (LPPC)
    - Whole community all-hazards planning and preparedness
- Web sites – OKC.GOV – Prepare OKC
- Social media – Facebook and Twitter
- Youth groups (YMCA, Boys & Girls Club, Scouting, and entrepreneurial groups).
    - The Boy Scouts of America has an Emergency Preparedness Merit Badge
    - The Girl Scouts offer a Safety Award and First Aid Award at several grade levels.

Capability Assessment Conclusion

Mitigation requires capabilities necessary to reduce loss of life and property by lessening the impacts of disasters. The City has demonstrated it possess a set of capabilities unique to their community. The capability assessment finds that the City of Oklahoma City collectively has a significant level of legal, technical, and fiscal tools and resources necessary to implement hazard mitigation strategies. It has the legal capabilities or ordinances and codes in place that might help reduce loss due to a disaster. The City has a range of staff trained or has knowledge about hazards and their impacts. The City has a fulltime professional Office of Emergency Management Department.

The City has financial resources that can be used towards mitigation. Most of those resources are capital improvement funds or bonds. The City has a range of public, private, and non-government organizations that can assist in emergency management efforts. The City utilizes burn bans to help prevent wildfires and is embarking on developing a community wildfire plan. The City has an Emergency Operations Plan in place.

The City's Hazard Mitigation Planning Team put a significant amount of effort into making this plan a useful document. Because the information in this plan is relevant, and was developed by the planning team members directly, the plan will be more easily integrated into the plans, ordinances, and activities listed in this section. The Emergency Manager through maintenance of this document will provide a copy of this plan to parties responsible for other planning processes in the Planning Area. This document can be integrated into other plans when determining future growth areas, capital improvement projects, building code and ordinance proposals, and prioritizing local funds.

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Chapter 19 – Mitigation Action Strategies

Overview

The City of Oklahoma City Hazard Mitigation Planning Committee reviewed, analyzed and prioritized the risk assessment studies. The STAPLEE guide was used to prioritize the action items and ensure that an appropriate cost benefit performance is maintained. The Mitigation Actions listed below were determined to be those that would have the greatest benefit in hazard reduction to the City and are consistent with the goals identified above in the Planning Process chapter. These priorities remain the same from the previous plan, and will be readdressed in the five-year update to account for any growth and development in the planning area.

Prioritization and Review Criteria

Evaluation Category	
Social	The Hazard Mitigation Planning Committee has a diverse membership representing City government, private sector, non-government organizations, and other external partners and had input throughout the planning process. Social media was used to invite public participation in development and review of the plan. Existing community plans were used wherever possible.
Technical	City departments and external partners were consulted as to the technical feasibility of the various projects. All of these had their comments and suggestions incorporated into the mitigation actions.
Administrative	Staffing for proper implementation of the plan currently will rely on existing members of the various City departments or external organizations involved. It is the opinion of the HMPC that currently insufficient City staff is available due to budget constraints. Technical assistance is available from a variety of government and non-government organizations; however, they too are experiencing budget shortfalls and staffing shortages which affect the delivery of requested assistance. Hazard mitigation efforts will need to be incorporated into the various departments Capital Improvement Plans in so far as practical. The Oklahoma City Local Preparedness and Planning Committee which also serves as the City's Hazard Mitigation Planning Committee led by City's Emergency Manager will provide an annual review and assessment of the Plan and its progress.
Political	City leadership was consulted on aspects of the Plan and provided input on mitigation actions.
Legal	The Municipal Counselor's Office was consulted on this plan and had an opportunity to review the proposed Mitigation Actions. It was their opinion that no significant legal issues were involved in the projects that were selected by the HMPC. They requested

	the addition of a comment about the mitigation actions being dependent upon securing adequate funding to complete them.
Economic	Economic considerations are an important factor in hazard mitigation. The State of Oklahoma and the City of Oklahoma City are both experiencing reduced revenue due to a downturn in the oil and gas sector. This reduced revenue has caused budget shortfalls resulting in budget cuts. Mitigation actions will be incorporated into existing projects and Capital Improvement Plans in so far as practical. Some mitigation projects will have to be funded using bonds and grants as they become available. These mitigation actions are dependent upon securing adequate funding to complete them. Mitigation can have a positive effect on the economy by creating a resilient infrastructure that can be easily and quickly restored resulting at fewer costs and with minimal down time for businesses. A resilient infrastructure can be used to attract businesses to the area. Mitigation projects can create short-duration jobs and inject money into the local economy especially when goods and services are procured from local contractors and businesses.
Environmental	City departments responsible for environmental, natural & cultural resources, and historical preservation were part of the Hazard Mitigation Planning Committee. This includes Storm Water Quality, the Planning Department, and Parks and Recreation Department. They reviewed the mitigation actions and found no negative impact. The City's Comprehensive Plan known as PlanOKC establishes policies for minimizing impacts to Environmentally Sensitive Areas from development. Hazard mitigation projects funded with federal money require environmental and historical preservation assessments before approving and funding the grant.

Progress of 2012 Mitigation Strategy

Much progress has been made in The City of Oklahoma City since the previous update of the Hazard Mitigation Plan.

- Developed a preparedness website within OKC.GOV. In 2016 this website was redesigned along with the new OKC.GOV website.
- Acquired new outdoor warning system software that enables the City to activate outdoor warning sirens by sector and only those sectors that are threatened by the tornado.
- Acquired new technology to provide alerts and warnings in an accessible format to people who are blind, deaf, blind and deaf, and with low literacy.
- Built a computer server building that provides near absolute protection from tornadoes for information technology equipment along with backup emergency electrical power generators.
- Built a Crew Room for Public Works Street Traffic Drainage Maintenance personnel that provides near absolute protection from tornadoes. Crew Room is sized to accommodate all City staff assigned to the Central Maintenance Facility.

- Developed, implemented, and managed a FEMA HMGP funded safe room rebate program that provided rebates to 495 homeowners who built or installed safe rooms.
- Developed, implemented, and managed an American Red Cross funded safe room rebate program that provided rebates to 835 homeowners who built or installed safe rooms.
- Built a new Police Headquarters that includes an emergency electrical power generator.
- Built a new Police Briefing Station that includes an emergency electrical power generator.
- Building two (2) fire stations with tornado safe rooms for the firefighters occupying the stations.
- Built a new Municipal Courts building that includes an emergency electrical power generator.
- Installed three industrial sized emergency electrical power generators at Draper Water Treatment Plant using federal grant dollars from FEMA Pre-Disaster Mitigation program and Community Development Block Grant - Disaster Recovery program. These generators ensure reliable electrical power during power outages which in turn and ensures reliable delivery of potable drinking water to the City and surrounding communities.
- During mosquito seasons conducted personal protection messaging that includes encouraging the use of insect repellant when playing or working outdoors.
- During mosquito seasons conducted enhanced surveillance to identify location of disease carrying mosquito habitats and breeding areas.
- During mosquito seasons applied larvicide to known mosquito breeding locations and in response to citizen complaints of mosquito breeding sites.
- During 2016-2017 provided free NOAA weather radios to residents during public education and outreach events.
- The City continued to participate in the National Flood Insurance Program.
- Following the May 2013 Major Disaster Declaration (FEMA-4117) the City required homes being rebuilt in the affected area that were in the floodplain be raised to one foot above the base flood elevation as a condition to receiving a building permit.
- Relocated the main electrical distribution panels in City owned buildings (100 N. Walker and 420 W. Main) from the basement to the first floor to protect them from flooding following two separate flood events involving those buildings.
- Conducted public education and outreach covering a range of natural hazards.

Mitigation Actions

The following action items have been reviewed, and updated as necessary for the 2017 Hazard Mitigation Plan Update. The completion of these mitigation actions are dependent upon securing funding to complete each one.

Hazard	Mitigation Action
Tornado	1, 2, 3, 4, 5, 31, 32
High Wind	1, 17, 31, 32
Winter Storm	1, 17, 31, 32
Earthquake	6, 7, 18, 19, 20, 31
Wildfire	7, 21, 22, 31, 32
Drought	7, 14, 31
Flooding	8, 9, 10, 11, 24, 31, 32, 33, 34, 35
Lightning	12, 13, 23, 31, 32
Extreme Heat	15, 31, 32
Hail	16, 31, 32
Dam	18, 25, 26, 31, 32
Mosquito Bourne Disease	27, 28, 29, 30, 31

Mitigation Action 1

Description	Install emergency power generator systems (diesel, natural gas, or bi-fuel), standby power sources, uninterrupted power supplies and/or quick connections and transfer switches to City owned facilities and buildings.
Hazards Addressed	Tornado, High Wind, Winter Storms
Vulnerable Area Affected	City Wide
Responsible Party	Fire General Services Information Technology Parks & Recreation Police Public Works Utilities
Potential Funding Sources	Grants, General Funds, or Enterprise Funds
Cost	Costs can vary from $35,000 to $1,000,000 per generator depending on size of the generator and the size and/or function of the facility it provides power to.
Potential Implementation Time Line	Ongoing as need is identified and funding becomes available.

Mitigation Action 2

Description	Add outdoor warning sirens to the City's Outdoor Warning System as needed.
Hazards Addressed	Tornado
Vulnerable Area Affected	City Wide – Areas of New Development
Responsible Party	Information Technology – Public Safety Systems
Potential Funding Sources	Grant, Bond Funds
Cost	$20,000 to $30,000 per siren with installation.
Potential Implementation Time Line	Ongoing as need is identified and funding becomes available.

Mitigation Action 3

Description	Add or enhance warning and notification systems as new technologies become available.
Hazards Addressed	Tornado
Vulnerable Area Affected	City Wide – Areas of new residential and commercial development and growth
Responsible Party	Information Technology Emergency Management
Potential Funding Sources	Grant, Bond Funds
Cost	Cost will vary based on the kind and type of technology and the number of sites
Potential Implementation Time Line	Ongoing as technology and funding become available.

Mitigation Action 4

Description	Install or construct storm shelter/safe rooms during the construction of new City owned buildings and facilities and sized to accommodate building/facility occupants (employees, contractors, visitors/customers)
Hazards Addressed	Tornado
Vulnerable Area Affected	City Wide
Responsible Party	Airports Public Works Utilities
Potential Funding Sources	Bonds, Grants
Cost	$300-350 per square foot. Size of safe room will depend on the number of building/facility occupants
Potential Implementation Time Line	Ongoing per project

Mitigation Action 5

Description	Install or construct storm shelters and safe rooms in existing homes through rebate programs funded through federal hazard mitigation assistance grants and other sources of public and private grant funding that may become available.
Hazards Addressed	Tornado
Vulnerable Area Affected	City Wide
Responsible Party	Emergency Management
Potential Funding Sources	Grants
Cost	$2,000 rebate per home.
Potential Implementation Time Line	Ongoing as grant funds become available

Mitigation Action 6

Description	Replace older clay and concrete water and wastewater lines with new pipelines made of PVC, HDPE, or other materials to prevent main breaks and reduce water loss.
Hazards Addressed	Earthquake, Drought
Vulnerable Area Affected	City Wide – About 2,000 miles of clay lines in Oklahoma City
Responsible Party	Utilities Department
Potential Funding Sources	Grants, Utilities Capital Improvements Program
Cost	$100-$750 per linear foot of water line depending on size of pipe and terrain $100-$750 per linear foot of waste water line depending on size of pipe and terrain
Potential Implementation Time Line	Ongoing with about 8-10 miles of water line and 2-5 miles of waste water line being replaced per year.

Mitigation Action 7

Description	Construct and install dry hydrants and/or acquire portable pumping equipment or systems for drafting water from the N. Canadian/Oklahoma River and City owned ponds, lakes, and reservoirs for an alternate source of water for firefighting.
Hazards Addressed	Earthquake, Wildfire, Drought
Vulnerable Area Affected	Citywide
Responsible Party	Fire Parks & Recreation Public Works Utilities
Potential Funding Sources	Grant, Bond, General Fund or Utilities Capital Improvement Program
Cost	Dry hydrants - $5,000-7000 for material and parts plus cost of labor. Portable pumps – Cost with vary based on size of pump and bid price.
Potential Implementation Time Line	2022 if funding is available.

Mitigation Action 8

Description	Improvements to drainage channels and storm water sewer lines to increase capacity.
Hazards Addressed	Flooding
Vulnerable Area Affected	City Wide
Responsible Party	Public Works
Potential Funding Sources	Bonds, Grants
Cost	Cost varies depending on the scope of work, size of the channel or pipe, and length of channel or pipe replaced.
Potential Implementation Time Line	Ongoing as projects are identified and funding becomes available.

Mitigation Action 9

Description	Acquire and demolish repetitive loss structures located in the flood plain.
Hazards Addressed	Flooding
Vulnerable Area Affected	Citywide – Floodplain areas
Responsible Party	Public Works
Potential Funding Sources	Grants, Bonds
Cost	Cost varies based on the value of the structures and scope of the project.
Potential Implementation Time Line	Ongoing as owners of repetitive loss structures volunteer to participate in the program.

Mitigation Action 10

Description	Engage consultants to conduct studies and research to develop watershed models and solutions to address flooding in various watersheds in the Planning Area.
Hazards Addressed	Flooding
Vulnerable Area Affected	Citywide
Responsible Party	Public Works
Potential Funding Sources	Grants, General Fund
Cost	$300,000 annually.
Potential Implementation Time Line	2022 if funding is available.

Mitigation Action 11

Description	Continued Participation of National Flood Insurance Program
Hazards Addressed	Flooding
Vulnerable Area Affected	Citywide – Floodplain areas
Responsible Party	Development Services Public Works
Potential Funding Sources	General Fund
Cost	No direct cost to the City. Standards are developed by Public Works. Compliance is enforced through the plain review and permitting process.
Potential Implementation Time Line	Ongoing

Mitigation Action 12

Description	Upgrade existing lightning protection systems (LPS) with new technology.
Hazards Addressed	Lightning
Vulnerable Area Affected	Citywide
Responsible Party	All City Departments that have facilities with existing lightning protection systems
Potential Funding Sources	Grants, Bonds, General Fund
Cost	$0.50 to $1.33 per square foot of roof area using copper material $0.42 to $1.16 per square foot of roof area using aluminum material
Potential Implementation Time Line	Ongoing as new technology and funds become available.

Mitigation Action 13

Description	Construction or installation of lighting protection systems (LPS) on critical infrastructure facilities/systems and backup power systems.
Hazards Addressed	Lightning
Vulnerable Area Affected	Citywide
Responsible Party	Airports Information Technology Public Works Utilities Other Departments as appropriate
Potential Funding Sources	Grants, Bonds, General Fund
Cost	$0.50 to $1.33 per square foot of roof area using copper material $0.42 to $1.16 per square foot of roof area using aluminum material
Potential Implementation Time Line	Ongoing as funding becomes available.

Mitigation Action 14

Description	Construct a second Atoka Pipeline from Atoka to Lake Stanley Draper.
Hazards Addressed	Drought
Vulnerable Area Affected	Citywide
Responsible Party	Utilities
Potential Funding Sources	Utilities Funds
Cost	Engineering estimate: $600 million
Potential Implementation Time Line	2022

Mitigation Action 15

Description	Nongovernment Organizations (NGO) provide fans and bottled water to vulnerable populations during periods of extreme heat.
Hazards Addressed	Extreme Heat
Vulnerable Area Affected	Citywide
Responsible Party	Nongovernment Organizations (NGO)
Potential Funding Sources	Private grant funding; Donations
Cost	Cost varies from summer to summer depending on weather, demand, and amount of donations.
Potential Implementation Time Line	Ongoing during the summer months.

Mitigation Action 16

Description	Construct canopies over surface parking at City owned facilities and parking lots to protect City owned vehicles and equipment from hail damage.
Hazards Addressed	Hail
Vulnerable Area Affected	City Owned facilities
Responsible Party	City Departments with outdoor parking for city owned vehicles and equipment
Potential Funding Sources	Bonds, Grants
Cost	$1,412 per covered parking space using a fabric canopy. Actual cost will vary based on design, size (width & length) of canopies, and number of canopies per site.
Potential Implementation Time Line	Ongoing as funding becomes available.

Mitigation Action 17

Description	Take actions to trim or remove tree branches and/or remove trees from close proximity to above ground electrical power lines providing electrical service to residential and commercial structures and public facilities to reduce damage and prevent power outages from falling tree branches and trees.
Hazards Addressed	High Winds, Winter Storms
Vulnerable Area Affected	Citywide - Areas with above ground electrical power lines.
Responsible Party	Oklahoma Gas & Electric (OG&E) Oklahoma Electric Cooperative
Potential Funding Sources	Electrical provider operation and maintenance funds
Cost	Annually $16.1 million system wide for OG&E
Potential Implementation Time Line	Ongoing as funding becomes available.

Mitigation Action 18

Description	Engage consulting engineers to survey and inspect City owned dams, conduct research, and prepare a report on their vulnerability to earthquake damage and develop a master plan to reduce vulnerabilities.
Hazards Addressed	Dam, Earthquakes
Vulnerable Area Affected	City owned dams and dam inundation zones below the dams
Responsible Party	Parks & Recreation Public Works Utilities Department
Potential Funding Sources	Grant, General Funds, Utilities Funds
Cost	$140,000
Potential Implementation Time Line	2022 if funding is available.

Mitigation Action 19

Description	Engage consulting engineers to analyze the water treatment and distribution system and waste water collection and treatment system, conduct necessary research, and prepare a report on their vulnerability to earthquake damage and develop a master plan with design standards that would reduce vulnerabilities.
Hazards Addressed	Earthquakes
Vulnerable Area Affected	Citywide
Responsible Party	Utilities Department
Potential Funding Sources	Grant, Utilities Funds
Cost	$300,000
Potential Implementation Time Line	2022 if funding is available.

Mitigation Action 20

Description	Engage consulting engineers to survey and inspect City owned buildings, facilities, and structures including bridges, conduct research, and prepare a report on their vulnerability to earthquake damage and develop a master plan to reduce the vulnerabilities.
Hazards Addressed	Earthquakes
Vulnerable Area Affected	Citywide
Responsible Party	All City Departments
Potential Funding Sources	Grant, General Fund, Enterprise Funds
Cost	$1.6 million for buildings & facilities $1.6 million for bridges and other structures
Potential Implementation Time Line	2022 as funding becomes available

Mitigation Action 21

Description	Develop and maintain a Community Wildland Preparedness plan.
Hazards Addressed	Wildfire
Vulnerable Area Affected	Citywide – Rural/Urban interface areas
Responsible Party	Fire
Potential Funding Sources	Grant, General Funds
Cost	Varies depending on the scope of work.
Potential Implementation Time Line	2022 if funding is available.

Mitigation Action 22

Description	Reduction of fuel load through the use of proscribed burns, fire breaks, and vegetation management
Hazards Addressed	Wildfire
Vulnerable Area Affected	Citywide – Rural/Urban interface areas
Responsible Party	Fire
Potential Funding Sources	Grant, General Funds
Cost	Varies depending on the scope of work and complexity of the project.
Potential Implementation Time Line	Ongoing as funding becomes available.

Mitigation Action 23

Description	Engage a consultant to survey and inspect City owned buildings and facilities and report on vulnerabilities to lightning strikes and develop a master plan to reduce the vulnerabilities.
Hazards Addressed	Lightning
Vulnerable Area Affected	City owned critical infrastructure facilities
Responsible Party	Airports Information Technology Public Works Utilities Department Other City Departments as appropriate
Potential Funding Sources	Grant, General or Enterprise Funds
Cost	$500,000
Potential Implementation Time Line	2022 if funding is available.

Mitigation Action 24

Description	Develop and maintain a Master Drainage Plan
Hazards Addressed	Flooding
Vulnerable Area Affected	Citywide
Responsible Party	Public Works
Potential Funding Sources	Grants; General Funds
Cost	Engineering estimate $4 million
Potential Implementation Time Line	2022 if funding is available.

Mitigation Action 25

Description	Maintain City Dam Emergency Action Plan
Hazards Addressed	Dam failure
Vulnerable Area Affected	City owned dams in OKC
Responsible Party	Emergency Management Parks & Recreation Public Works Utilities Department
Potential Funding Sources	General Fund, Utilities Funds
Cost	Cost is minimal as the plan is maintained by the stakeholders as part of their normal operating expenses.
Potential Implementation Time Line	Annual

Mitigation Action 26

Description	Conduct inspections of City owned dams, perform preventative maintenance, and make necessary repairs.
Hazards Addressed	Dam
Vulnerable Area Affected	City owned dams in OKC
Responsible Party	Parks & Recreation Public Works Utilities Department
Potential Funding Sources	General Funds and Utilities Funds
Cost	Inspections: $115,200 annually for 11 city owned dams. $130,000 every 5 years for all 18 city owned dams. The cost for preventative maintenance and repairs varies depending on the scope of work.
Potential Implementation Time Line	Annual

Mitigation Action 27

Description	Conduct personal protection messaging that includes encouraging the use of insect repellant when playing or working outdoors.
Hazards Addressed	Mosquito Borne Disease
Vulnerable Area Affected	Citywide
Responsible Party	OCCHD Emergency Management Public Information and Marketing
Potential Funding Sources	General Funds
Cost	Cost is minimal as it is included as part of the City's and OCCHD's hazard public education and outreach efforts.
Potential Implementation Time Line	Annually During Mosquito Season

Mitigation Action 28

Description	Conduct enhanced surveillance to identify location of mosquito habitats and breeding areas.
Hazards Addressed	Mosquito Borne Disease
Vulnerable Area Affected	Citywide
Responsible Party	OCCHD Public Works - Storm Water Quality Utilities Department – Solid Waste Management
Potential Funding Sources	General Funds, Utilities Funds
Cost	$2,500 - $3,000 per mosquito season
Potential Implementation Time Line	Annually During Mosquito Season

Mitigation Action 29

Description	Apply larvicide to known mosquito breeding locations and in response to citizen complaints of mosquito breeding sites. The City will only apply larvicide to City owned properties, but will provide citizens with tips for breeding site reduction, larval control, and adult mosquito control.
Hazards Addressed	Mosquito Borne Disease
Vulnerable Area Affected	City owned properties
Responsible Party	OCCHD Public Works - Storm Water Quality
Potential Funding Sources	General Funds; Grants
Cost	$2,500 to $5,000 per year depending on demand.
Potential Implementation Time Line	Annually During Mosquito Season

Mitigation Action 30

Description	Conduct mosquito habitat modification-removal and reduction to known or potential mosquito breeding locations on public lands/right-of-ways.
Hazards Addressed	Mosquito Borne Disease
Vulnerable Area Affected	Citywide
Responsible Party	Public Works – Street, Traffic, Drainage Maintenance Division Public Works - Storm Water Quality Utilities Department – Solid Waste Management
Potential Funding Sources	General or Enterprise Funds
Cost	Cost will vary depending on the scope of work and labor, equipment and material needed to complete the work.
Potential Implementation Time Line	Annually During Mosquito Season

Mitigation Action 31

Description	Using a variety of methodologies including websites, social media, mass media, and in-person presentations conduct public education and outreach to educate and inform employees, residents, businesses, and visitors about natural hazard risks and vulnerabilities and the preparedness, protective, and mitigation actions they can take to reduce the affects and impacts of natural hazards with the goal of increasing the community's resilience.
Hazards Addressed	Tornado, High Wind, Winter Storms, Earthquake, Wildfire, Drought, Flooding, Lightning, Hail, Extreme Heat, Dam Failure, Mosquito Bourne Diseases
Vulnerable Area Affected	Citywide
Responsible Party	Emergency Management Public Information Office
Potential Funding Sources	General Funds, Grants
Cost	$70,000
Potential Implementation Time Line	Ongoing

Mitigation Action 32

Description	Increase the receipt of alerts and warnings for natural hazard events by people with disabilities, vulnerable populations, and low income individuals and households providing all-hazards alert weather radios using grant funds.
Hazards Addressed	Tornadoes, Flooding, Lightning, Hail, Winter Storms, High Wind, Wildfire, Dam Failure, Extreme Heat
Vulnerable Area Affected	Citywide
Responsible Party	Emergency Management
Potential Funding Sources	Grants
Cost	$30-40 per radio
Potential Implementation Time Line	Ongoing as funding becomes available.

Mitigation Action 33

Description	Construct, install, and implement a system of stream monitoring stations along creeks, streams, and flood control channels in order to provide early detection and warning of flash flooding.
Hazards Addressed	Flooding
Vulnerable Area Affected	Citywide along stream, creek, and flood control channels
Responsible Party	Emergency Management, Public Works
Potential Funding Sources	Grants
Cost	$7,000 per monitoring site $16,500 to $30,000 initial startup costs for necessary infrastructure to support the monitoring sites $4,000 annually for maintenance of up to 10 sites
Potential Implementation Time Line	2022 if grant funds are available

Mitigation Action 34

Description	Design and construct city owned regional detention ponds with dams to alleviate downstream flooding.
Hazards Addressed	Flooding
Vulnerable Area Affected	Citywide along stream, creek, and flood control channels
Responsible Party	Public Works
Potential Funding Sources	Grants, General Obligation Bonds
Cost	Cost will vary depending on design, scope of work, land acquisition costs, and labor, equipment and materials needed to complete the work.
Potential Implementation Time Line	As need is identified and funding becomes available.

Mitigation Action 35

Description	Design and modification of existing city owned regional detention pond dam outlet structures so detention ponds can provide detention for multi-frequency storm events.
Hazards Addressed	Flooding
Vulnerable Area Affected	Citywide along stream, creek, and flood control channels
Responsible Party	Public Works
Potential Funding Sources	Grants, General Obligation Bonds
Cost	Cost will vary depending on design, scope of work, and labor, equipment and materials needed to complete the work.
Potential Implementation Time Line	Ongoing as funds become available.

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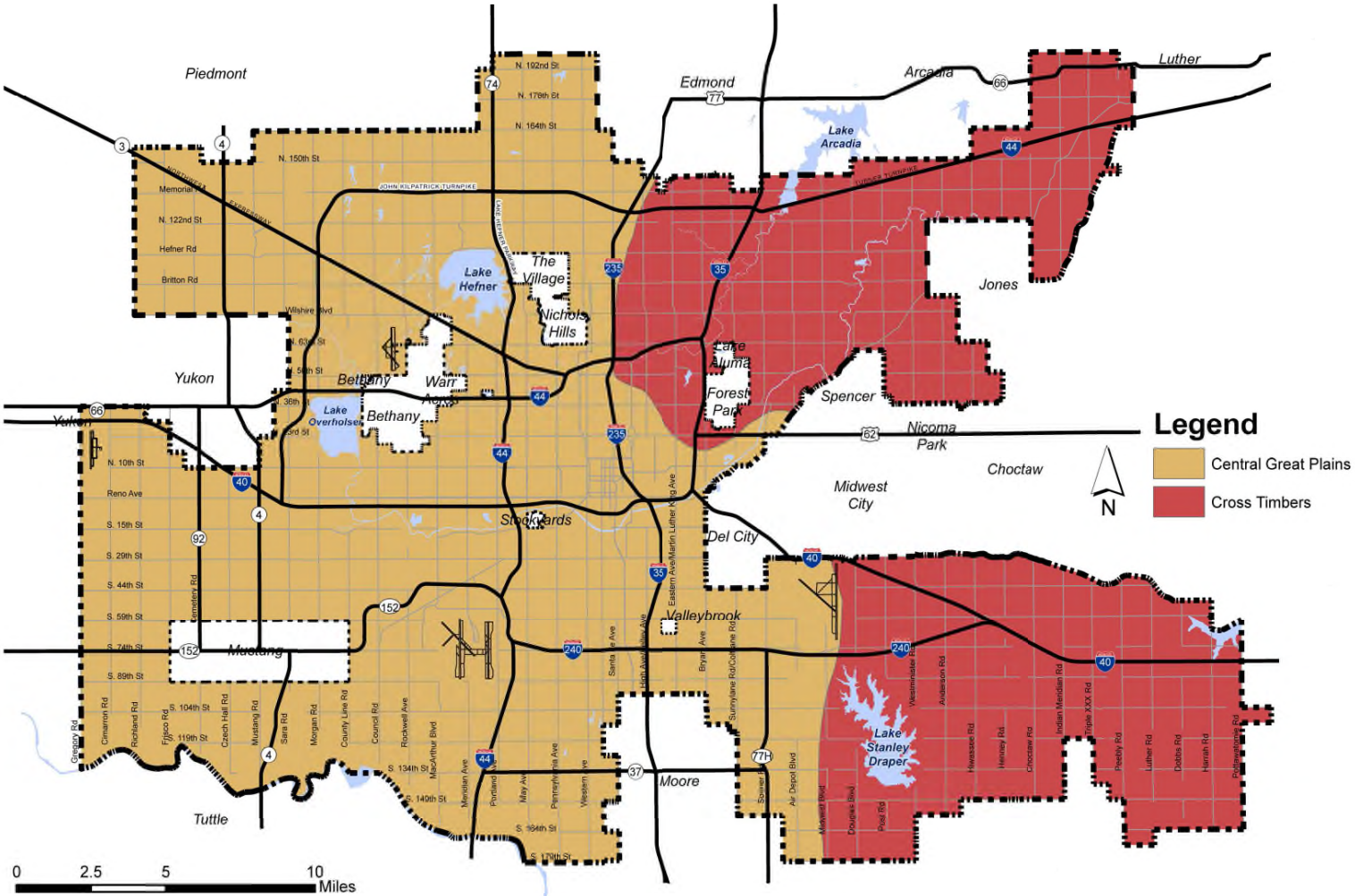
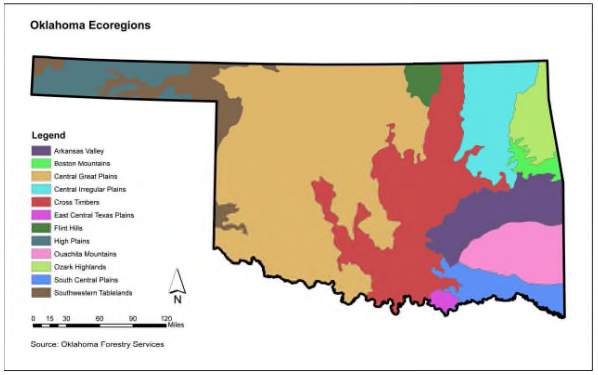
Attachment 1: Ecological Regions

Oklahoma City Ecoregions



Source: Oklahoma Forestry Services



Source: Oklahoma Forestry Services

What is an Ecoregion

For purposes of study and evaluation, Earth has been divided into eight large ecozones, which are further subdivided into 45 bioregions, and then again into more than 1,500 ecoregions. An ecoregion is an area that has similar climate, geology, soils, and plant and animal life. Oklahoma City falls within two of these ecoregions, as shown on the map.

Central Great Plains

A semi-arid prairie in much of western and central Oklahoma, this area contains a mixture of tall and short prairie grasses and wildflowers, but very few native trees or shrubs. Most of this area has been converted to farming and ranching over the past 100 years. This is the area that generated the dust for the Dust Bowl during a particularly arid period in the 1930s. The Great Salt Plains and the Wichita Mountains are examples of this ecoregion in its native form. The western portion of Oklahoma City is generally considered to be in the Central Great Plains ecoregion. This ecoregion can recover relatively quickly from distress and is considered to be an important component of our area's biodiversity.

Cross Timbers

This ecoregion is a transition zone between short-grass prairies in the western plains of the United States and the more forested areas of the Midwest. Both the plant and animal life reflect this situation and the ecoregion is home to wide diversity of trees, shrubs, grasses, wildflowers, birds, insects, and other animals. The trees in this area are usually suitable for timber, as such the Cross Timbers is one of the least disturbed forests in the United States, containing hundreds of thousands of acres of old-growth forests with millions of trees between 100 and 400 years old. The eastern portion of Oklahoma City is generally considered to be in the Cross Timbers ecoregion. This ecoregion is considered very hardy and resilient, however, due to the slow-growth of many of its characteristic trees, it recovers very slowly, if at all, from damage.

Hazard Mitigation Considerations

An understanding of our ecoregions and what type of stresses might negatively impact them is an important consideration for hazard mitigation for the following reasons:

- Native species can survive more extreme conditions, such as periods of extended drought.
- Dense native vegetation provides an effective means to mitigate impacts associated with excessive runoff.
- Naturally managed vegetated areas mitigate urban heat islands.

References:

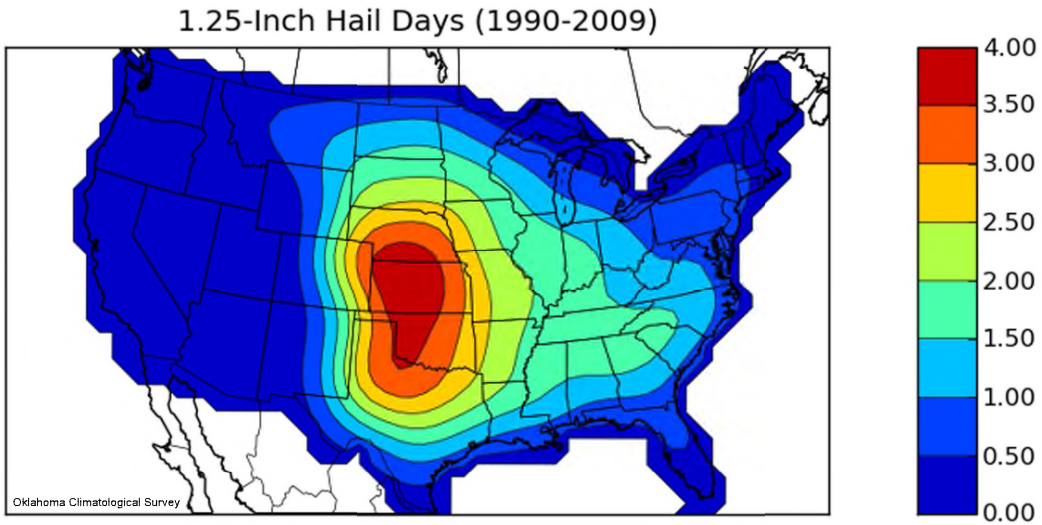
https://en.wikipedia.org/wiki/Central_Great_Plains_(ecoregion), accessed February 10, 2017

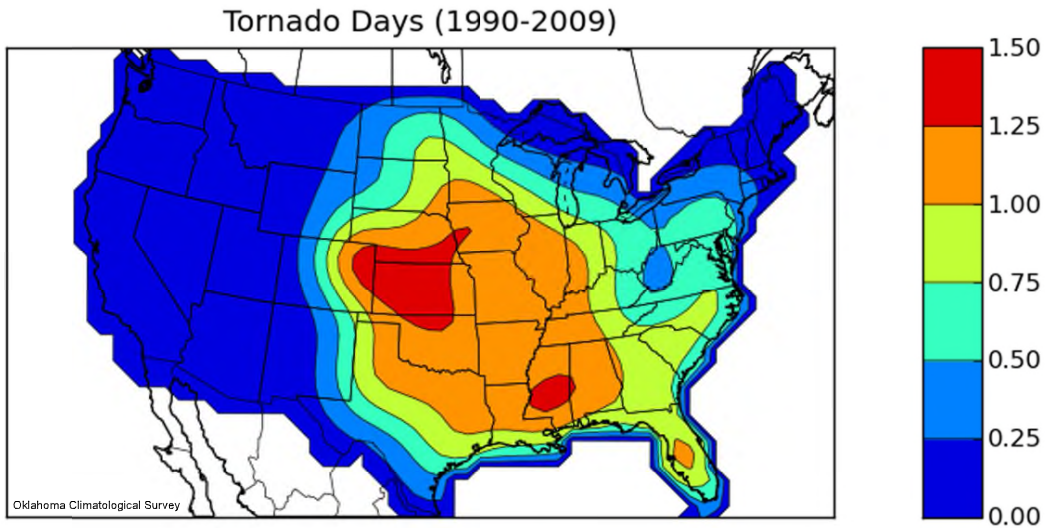
http://www.biosurvey.ou.edu/posters/CrossTimbersEcoregion.html, accessed February 10, 2017

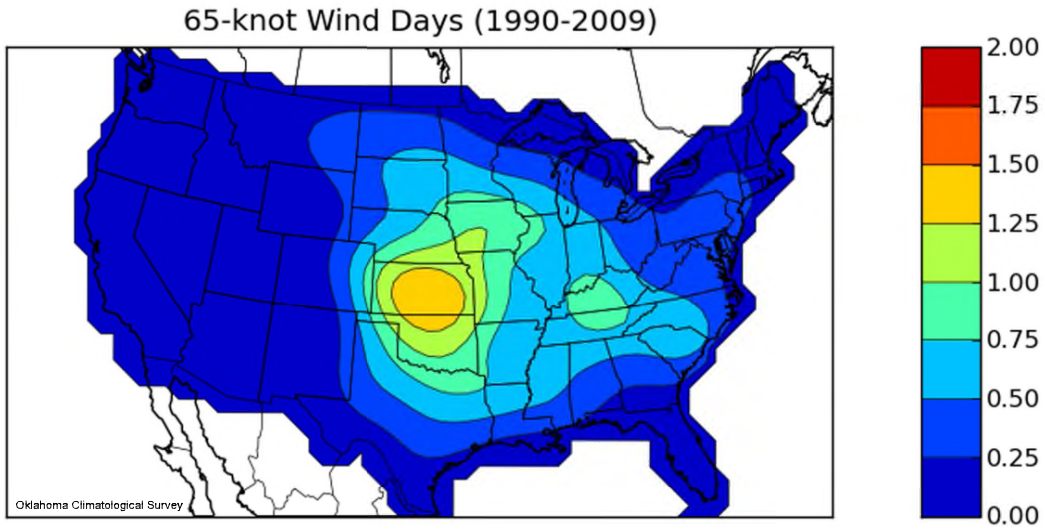
https://tpwd.texas.gov/landwater/land/habitats/cross_timbers/ecoregions/cross_timbers.phtml, accessed on February 10, 2017

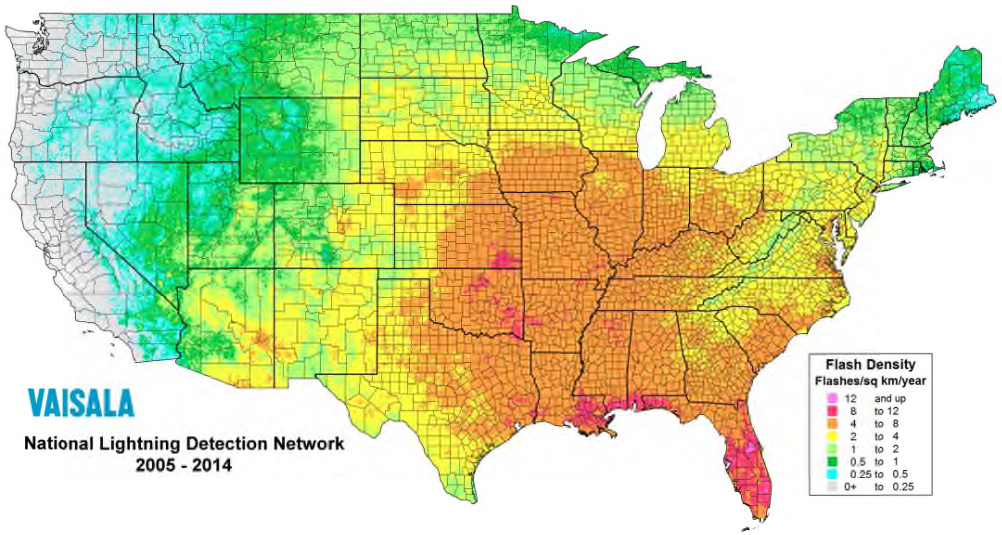
https://en.wikipedia.org/wiki/Cross_Timbers, accessed February 10, 2017

Attachment 2: Severe Weather Threats

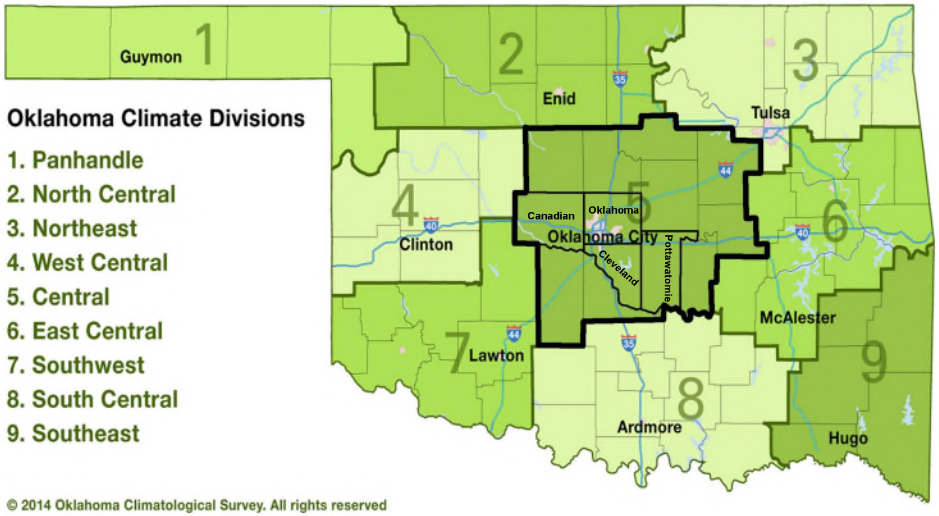








Attachment 3: Oklahoma Climate Divisions and Elevation



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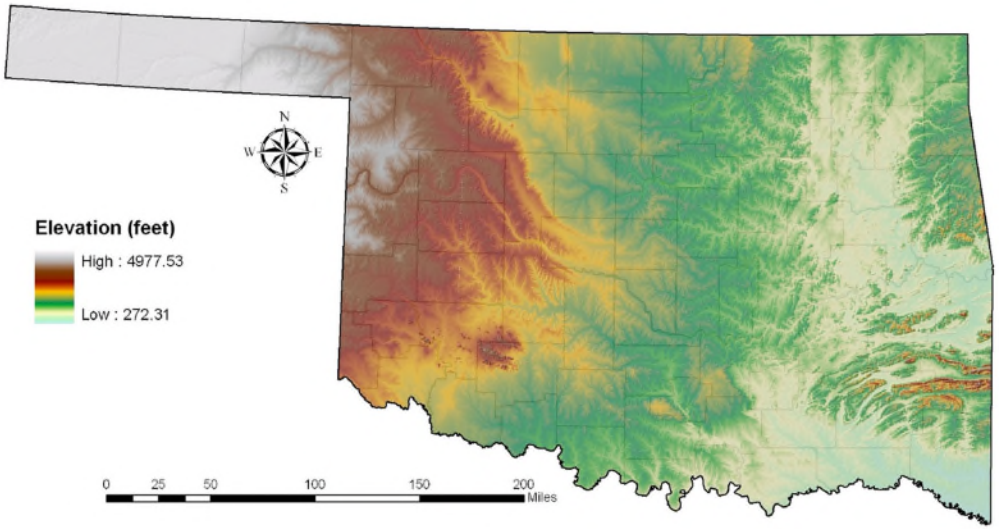
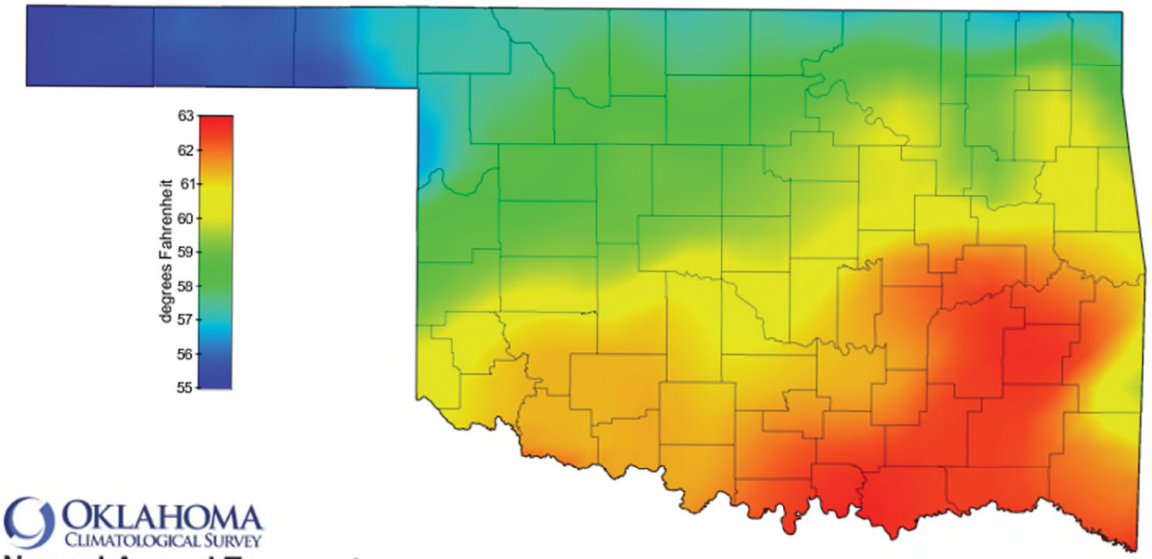


Climate Summary by County	Canadian County	Cleveland County	Oklahoma County	Pottawatomie County
TEMPERATURE				
Average Annual	60 degrees	61 degrees	61 degrees	61 degrees
Average Maximum	72 degrees	73 degrees	72 degrees	73 degrees
Average Minimum	49 degrees	49 degrees	49 degrees	50 degrees
Highest	115 degrees (El Reno, July 15, 1914)	116 degrees (Norman, August 10, 1936)	110 degrees (Lake Overholser, July 8, 1970)	116 degrees (Shawnee, August 10, 1936)
Lowest	- 15 degrees (El Reno, February 13, 1905)	-17 degrees (Norman, February 13, 1899)	-17 degrees (Edmond, February 12, 1899)	-17 degrees (Mccomb, February 12, 1899)
Days of 90 Degrees or Higher	78 days	79 days	75 days	76 days
Days of 20 Degrees or Lower	22 days	21 days	22 days	19 days
PRECIPITATION				
Average Annual	33.37 inches	37.29 inches	36.21 inches	40.19 inches
Days With Precipitation	68 days	75 days	72 days	75 days
Wettest Year	53.89 inches in 1973	56.65 inches in 1941	48.11 inches in 1973	62.27 inches in 1908
Driest Year	14.58 inches in 1954	18.04 inches in 1954	15.15 inches in 1954	18.40 inches in 1956
Greatest Daily Rainfall	8.56 inches (Union City, June 5, 1936)	8.95 inches (Norman, October 22, 1908)	7.69 inches (Oklahoma City, May 19, 1955)	10.62 inches (Shawnee, October 20, 1983)
OTHER FACTS				
Average Wind Speed	10 mph	10 mph	7 mph	10 mph
Sunshine	55- 80%	55- 80%	55- 80%	55- 80%
Average Humidity	71%	68%'	67%	69%
Thunderstorm Days	47 days	49 days	49 days	49 days
Hail Events	5 per year	3 per year	4 per year	3 per year
Tornadoes (1950-2003)	68 tornadoes	55 tornadoes	86 tornadoes	53 tornadoes
WINTER WEATHER				
Average Annual Snowfall	6.4 inches	6.8 inches	7.0 inches	5.2 inches
Days with snow on ground	3 days	5 days	4 days	2 days
Greatest Seasonal Snowfall	37.3 inches (1948-1949)	22. 1 inches (1947-1948)	24.6 inches (1967-1968)	24.1 inches (1977-1978)
Greatest Daily Snowfall	15.5 inches (El Reno, January 10, 1905)	11.0 inches (Norman, February 18, 1921)	8.4 inches (Oklahoma City, March 10, 1948)	14.0 inches (Tribbey, December 29, 1954)
Last Freeze in Spring	April 4	April 3	April 4	April 1
First Freeze in Autumn	November 2	November 2	November 1	November 3
Growing Season	211 days	212 days	211 days	215 days

Attachment 4: Climate, Temperature

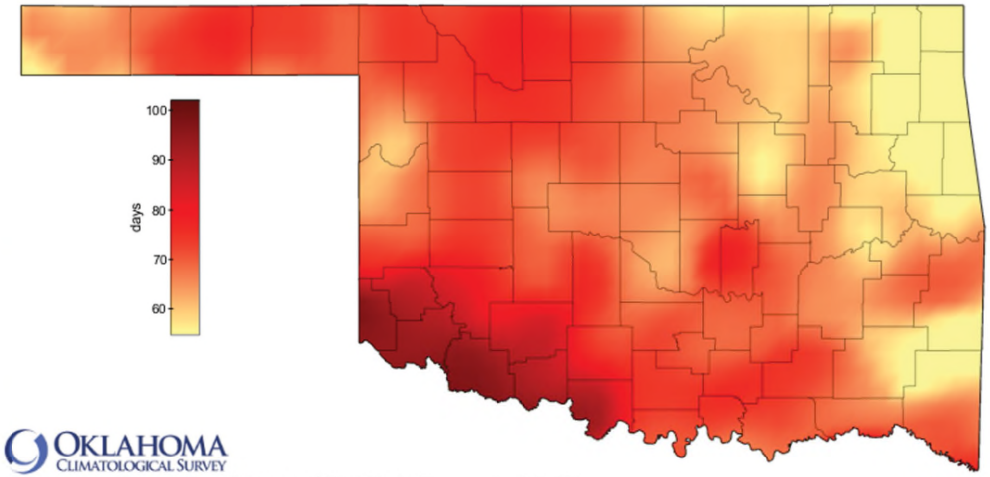


OKLAHOMA CLIMATOLOGICAL SURVEY

Normal Annual Temperature

1981-2010

Calculated using normal data provided by NCDC. Created 4:59:25 PM July 26, 2011 CDT. © Copyright 2011

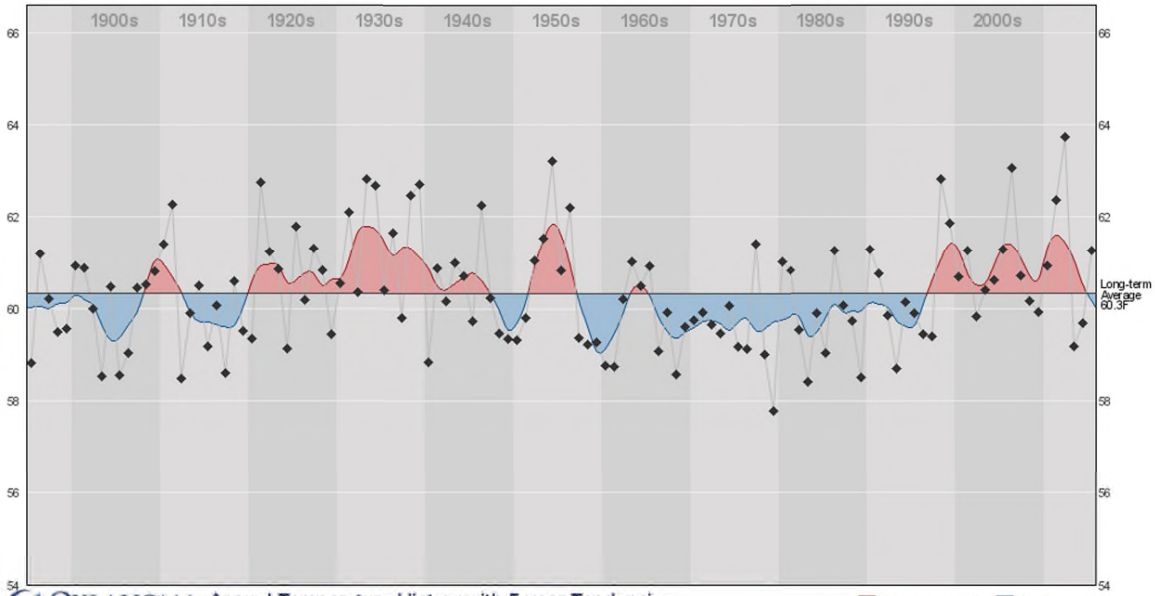


OKLAHOMA CLIMATOLOGICAL SURVEY

Average Days Per Year with High Temp ≥ 90 °F

1981-2010

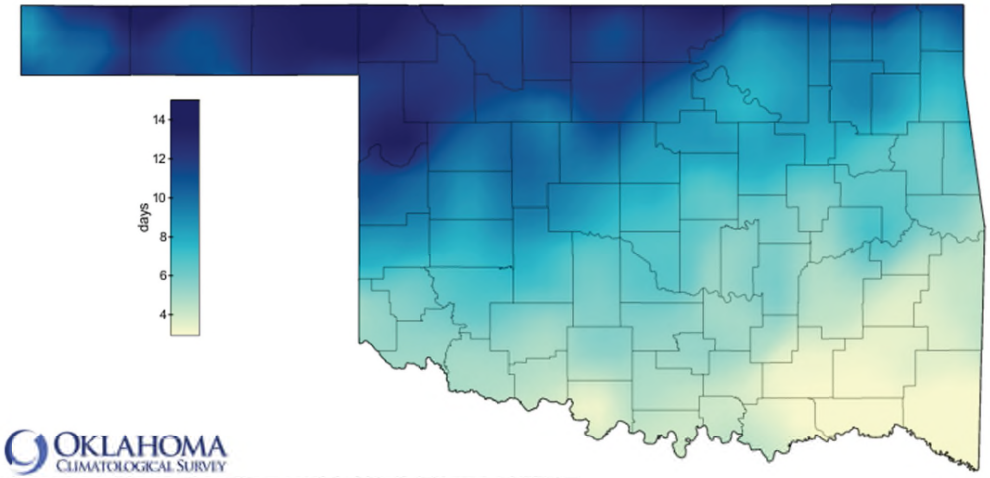
Calculated using data archived at OCS. Created 3:48:34 PM September 27, 2012 CDT. © Copyright 2012



OKLAHOMA CLIMATOLOGICAL SURVEY **Annual Temperature History with 5-year Tendencies**

OK-CD5 (5-Central): 1895-2015

Warmer periods
Cooler periods
Annual temperature value



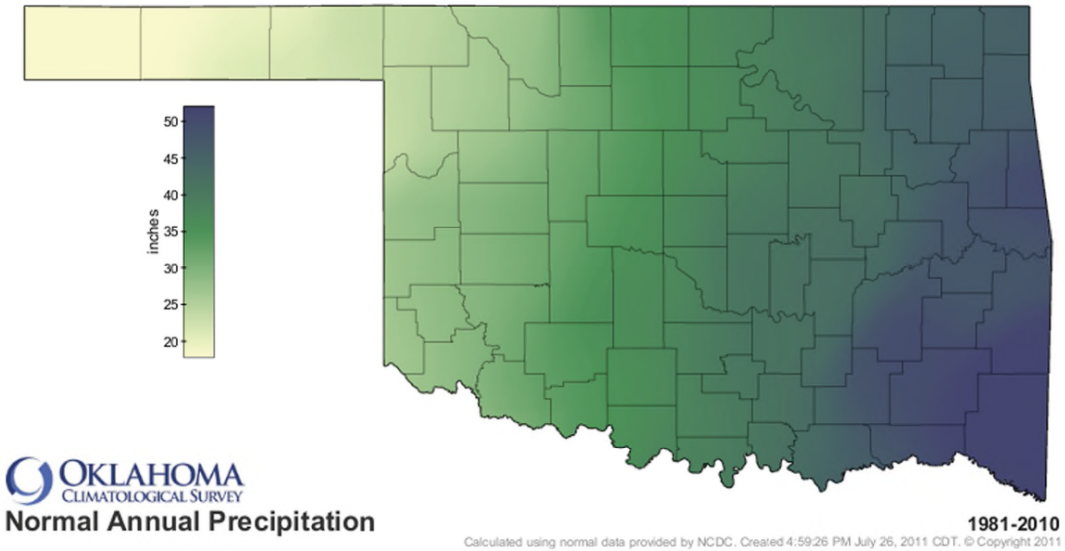
OKLAHOMA CLIMATOLOGICAL SURVEY

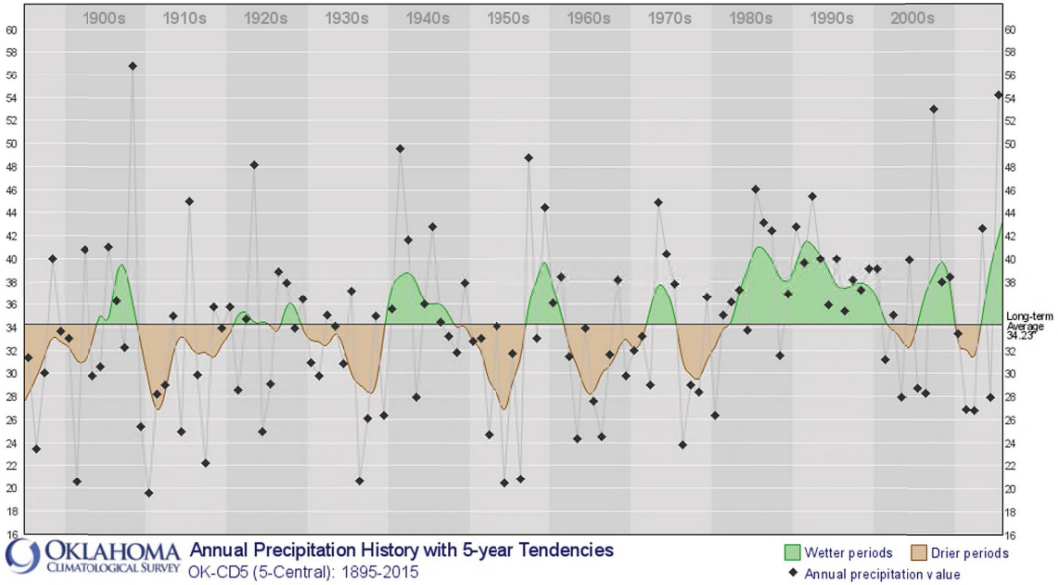
Average Days Per Year with High Temp ≤ 32 °F

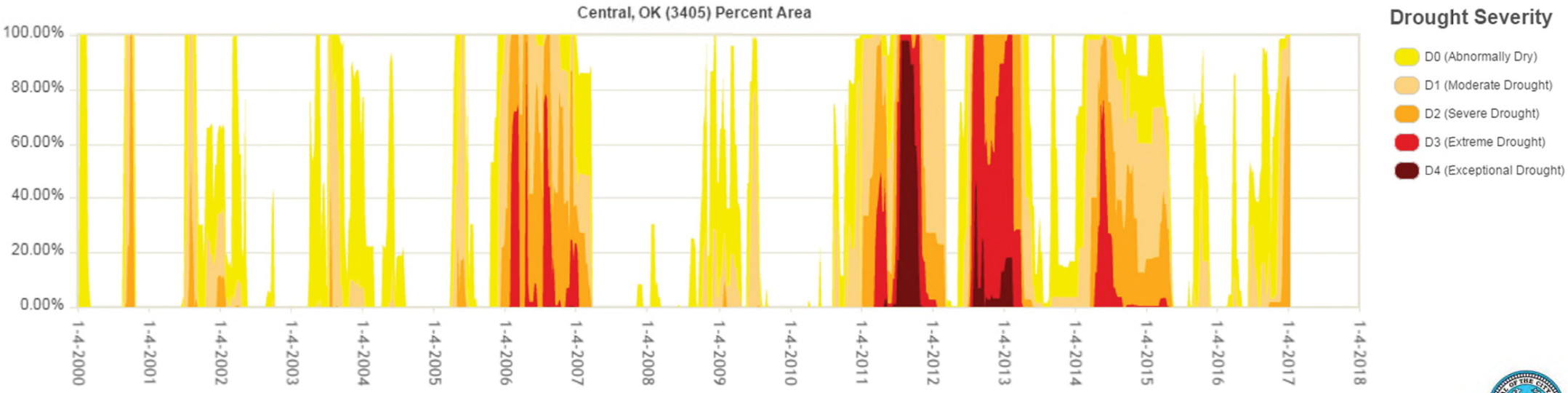
1981-2010

Calculated using data archived at OCS. Created 3:48:35 PM September 27, 2012 CDT. © Copyright 2012

Attachment 5: Climate, Precipitation

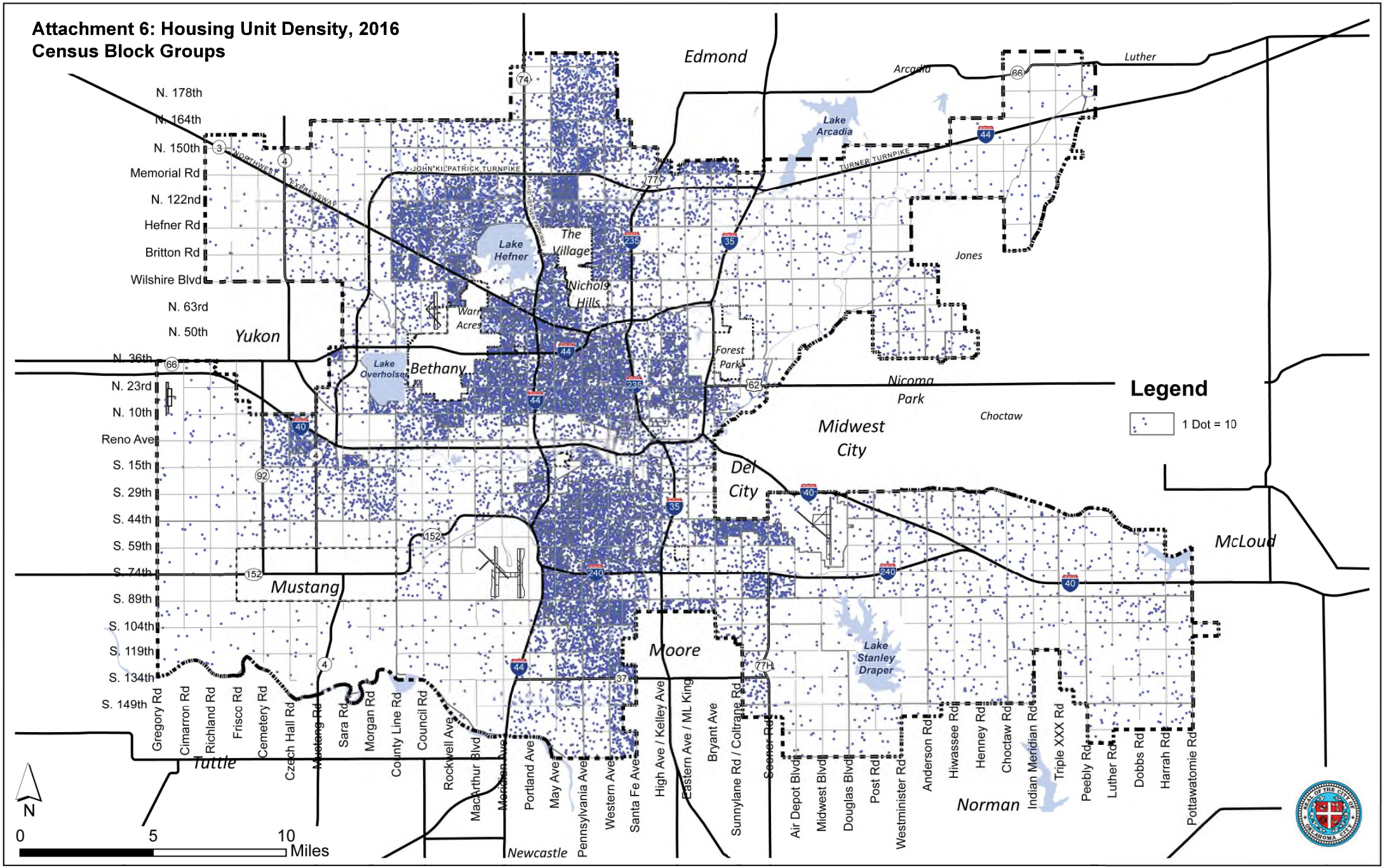




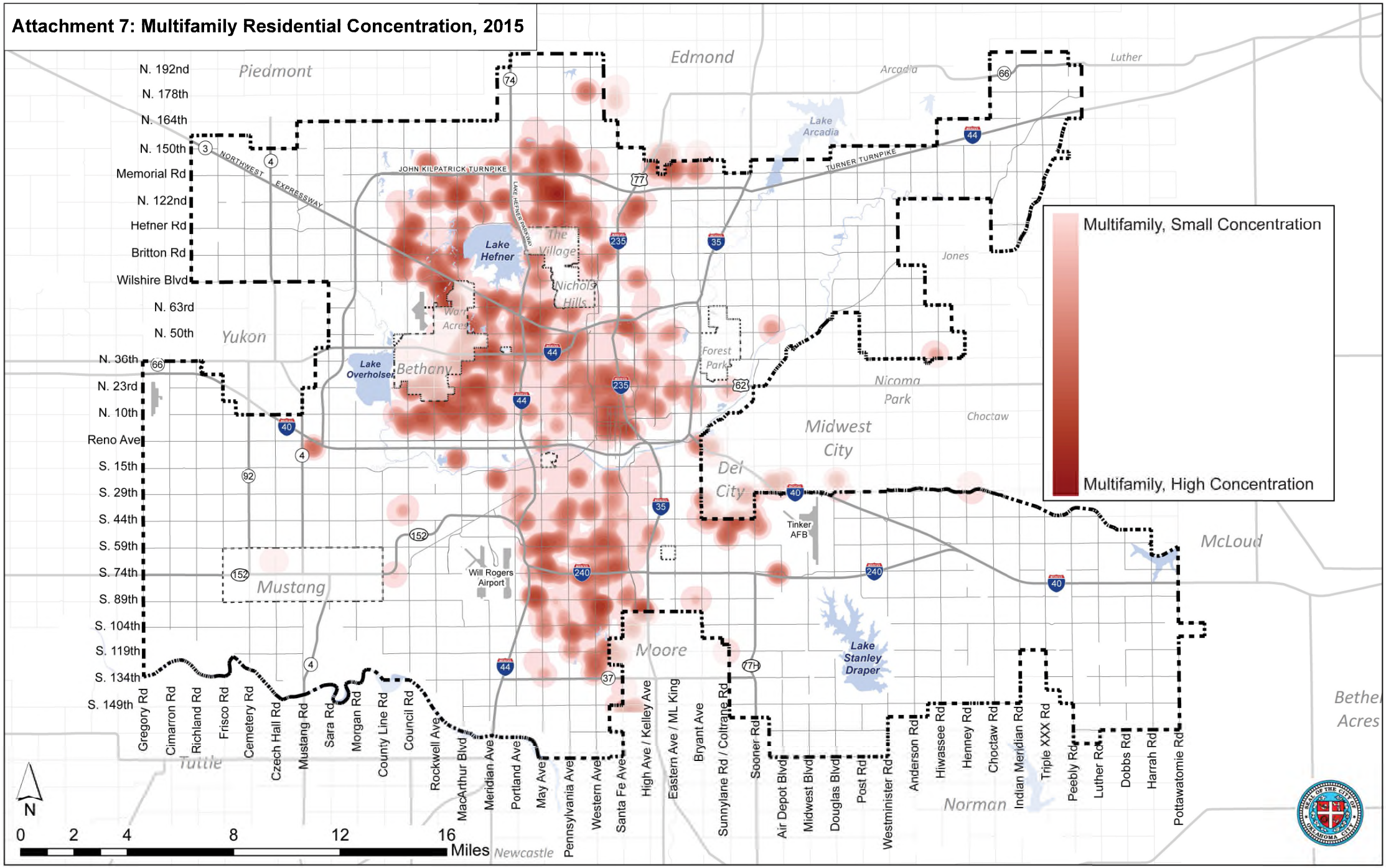


Source: US Drought Monitor - http://droughtmonitor.unl.edu/MapsAndData/Graph.aspx

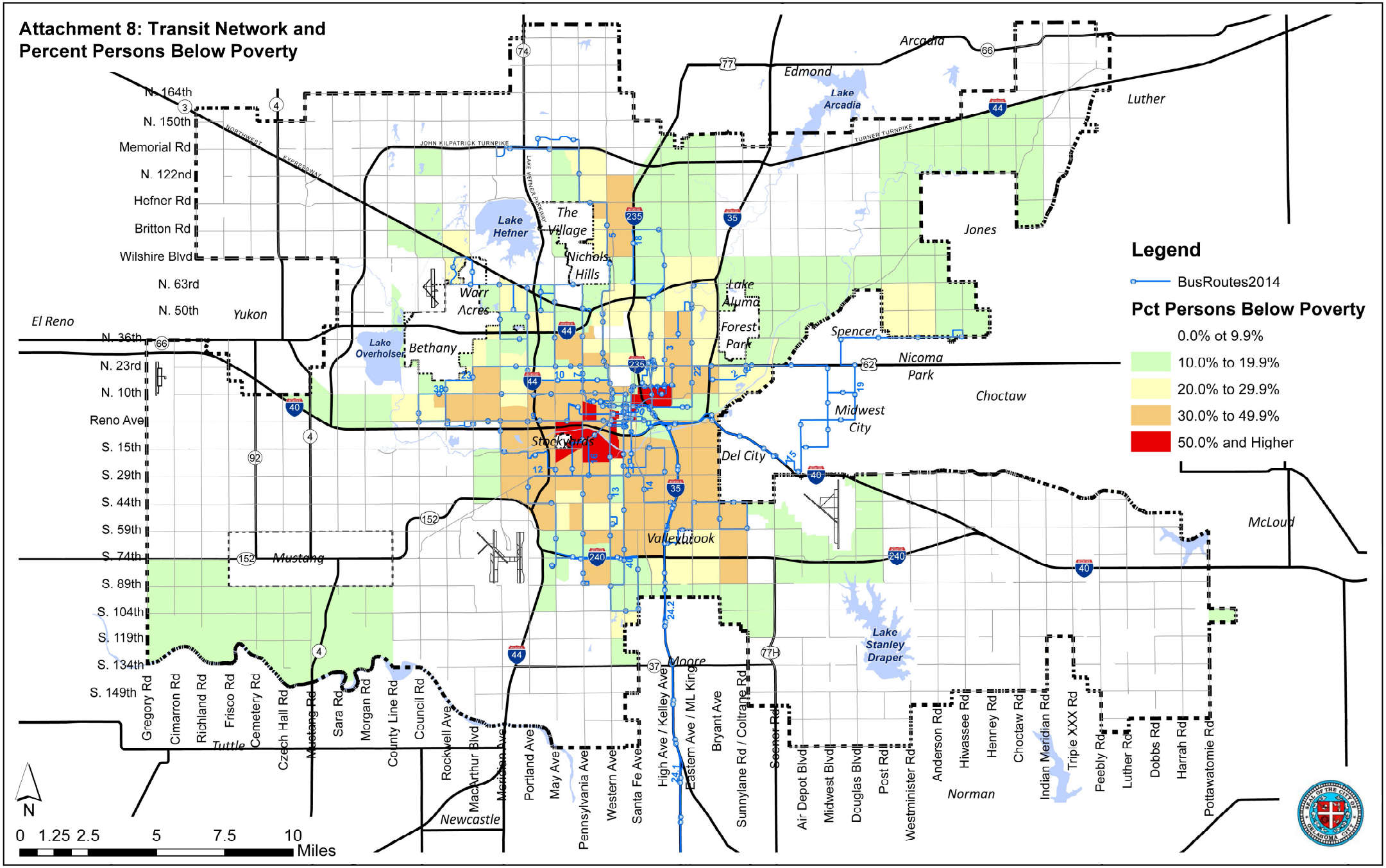
Attachment 6: Housing Unit Density, 2016
Census Block Groups



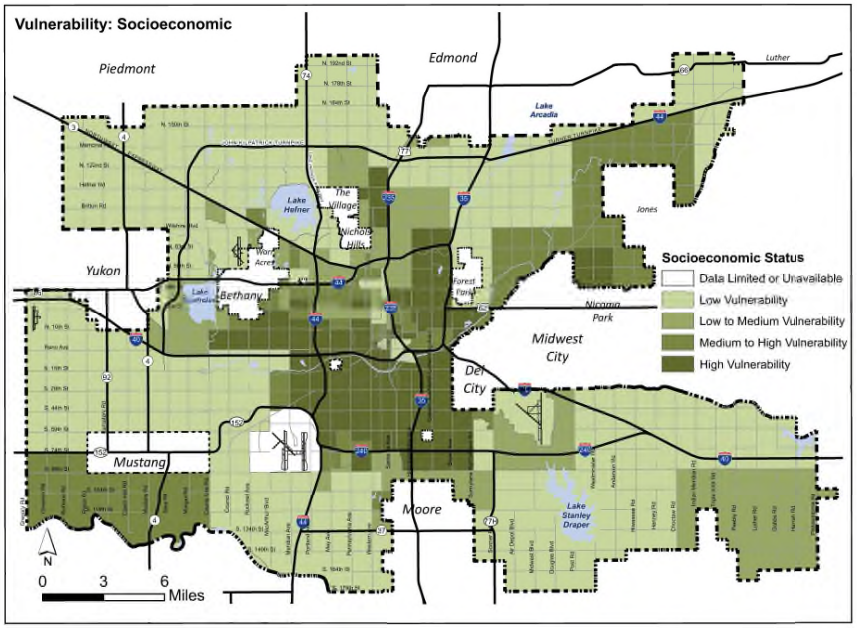
Attachment 7: Multifamily Residential Concentration, 2015

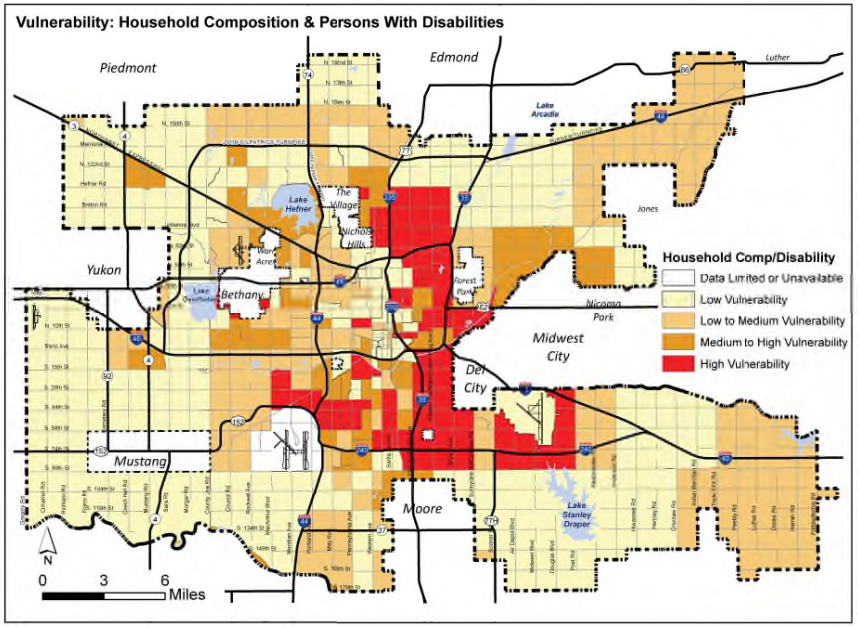


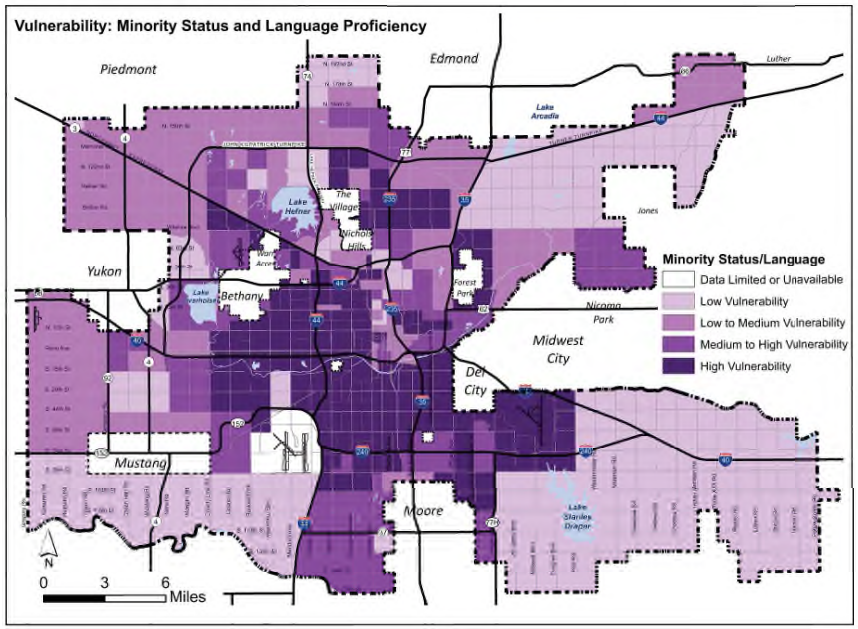
Attachment 8: Transit Network and Percent Persons Below Poverty

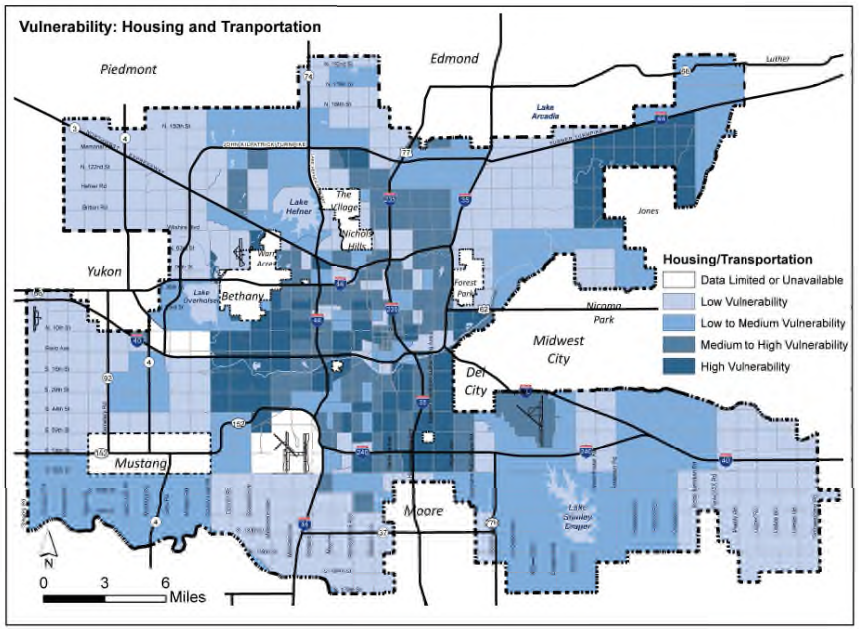


Attachment 9: Elements of Social Vulnerability









Social vulnerability refers to the socioeconomic and demographic factors that affect the resilience of communities. Studies have shown that in disaster events the socially vulnerable are more likely to be adversely affected. For example, evidence indicates that the poor are more vulnerable at all stages—before, during, and after—of a catastrophic event. The findings are similar for racial and ethnic minorities; children, elders, or disabled people; and residents of certain types of housing, particularly high-rise apartments or mobile homes.

The Centers for Disease Control and Prevention, National Center for Environmental Health, Office of Terrorism Preparedness and Emergency Response (OTPER) collaborated with the Agency for Toxic Substances and Disease Registry's Geospatial Research, Analysis, and Services Program to produce a social vulnerability index. The mapping of these data reveals geographic patterns of potential population vulnerability to disaster that can be used in mitigation, preparedness, response, and recovery.

1) *Socioeconomic Status (comprising income, poverty, employment, and education variables)*: Economically disadvantaged populations are disproportionately affected by disasters. The poor are less likely to have the income or assets needed to prepare for a possible disaster or to recover after a disaster.

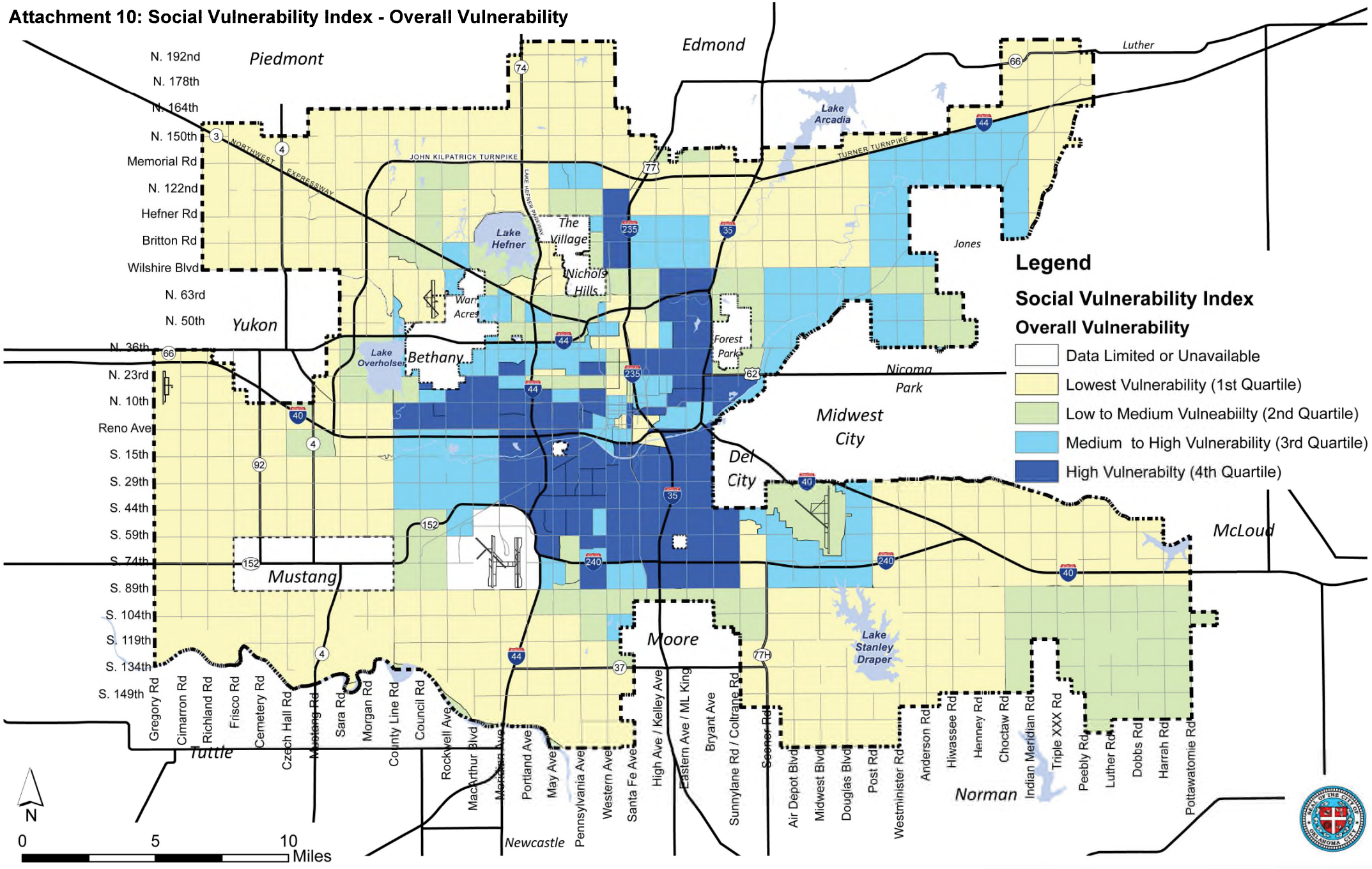
2) *Household Composition/Disability (comprising age, single parenting, and disability variables)*: Vulnerability populations regarding household composition includes dependent children less than 18 years of age, persons aged 65 years and older, single-parent households and people with disabilities. People in any of these categories are likelier to require financial support, transportation, medical care, or assistance with ordinary daily activities during disasters.

3) *Minority Status/Language (comprising race, ethnicity, and English language proficiency variables)*: The social and economic marginalization of certain racial and ethnic groups, including real estate discrimination, has rendered these populations more vulnerable. In addition, immigrants are not fluent in English, and literacy rates for some groups are lower. To the degree that immigrants have limited English proficiency, disaster communication is made increasingly difficult.

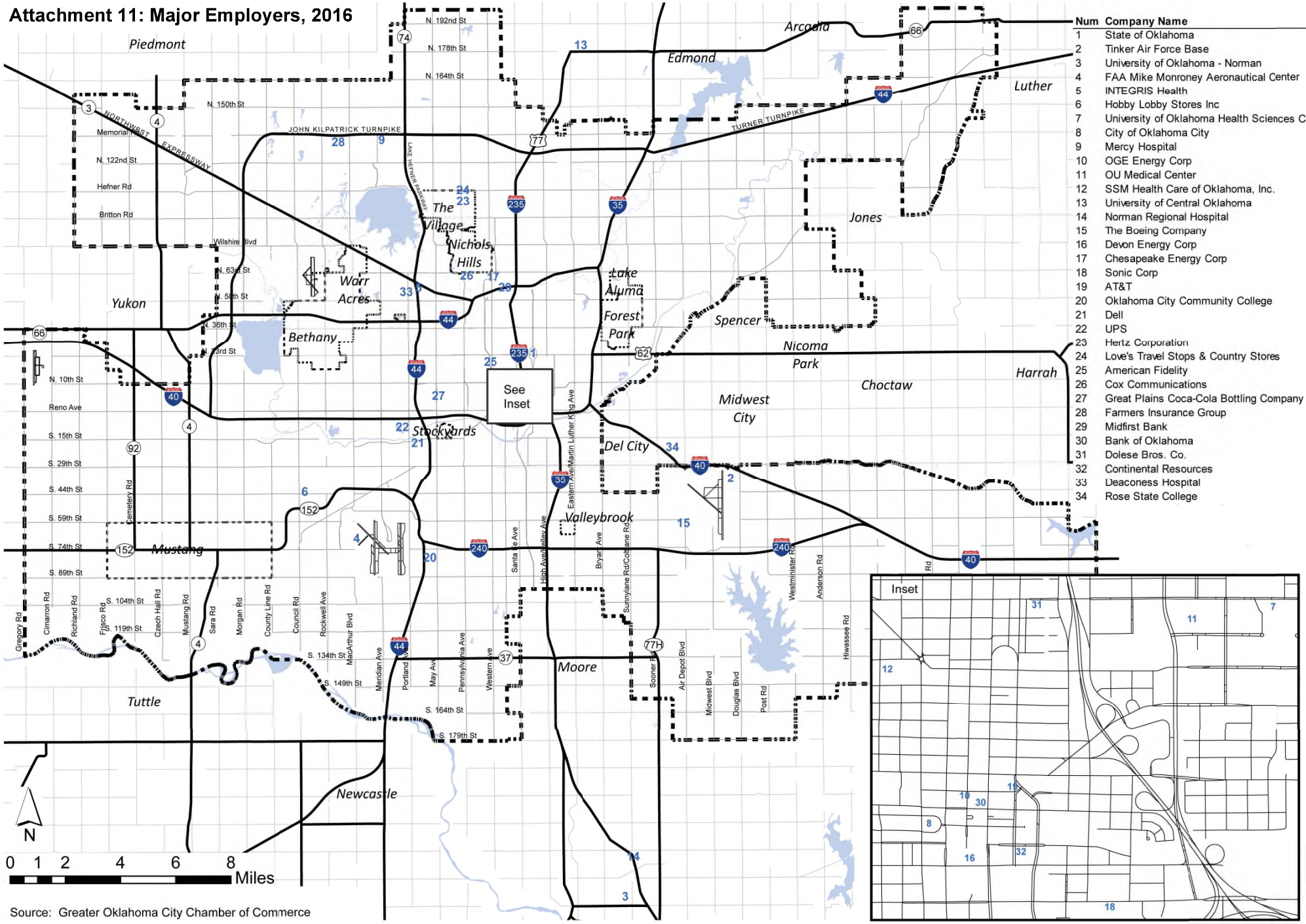
4) *Housing/Transportation (comprising housing structure, crowding, and vehicle access variables)*: Housing quality is closely tied to personal wealth; that is, poor people often live in more poorly constructed houses or mobile homes that are especially vulnerable to strong storms or earthquakes. Rates of automobile ownership are generally lower in urban areas, especially among inner city poor populations. Thus, transportation out of an evacuation zone is problematic for people who do not have access to a vehicle. Populations residing in group quarters such as college dormitories, farm workers' dormitories, psychiatric institutions, and prisons also present special concerns during evacuation. Residents of nursing homes and long-term care facilities are especially vulnerable.

Flanagan, Barry E.; Gregory, Edward W.; Hallisey, Elaine J.; Heitgerd, Janet L.; and Lewis, Brian (2011) "A Social Vulnerability Index for Disaster Management," *Journal of Homeland Security and Emergency Management*: Vol. 8: Iss. 1, Article 3.

Attachment 10: Social Vulnerability Index - Overall Vulnerability



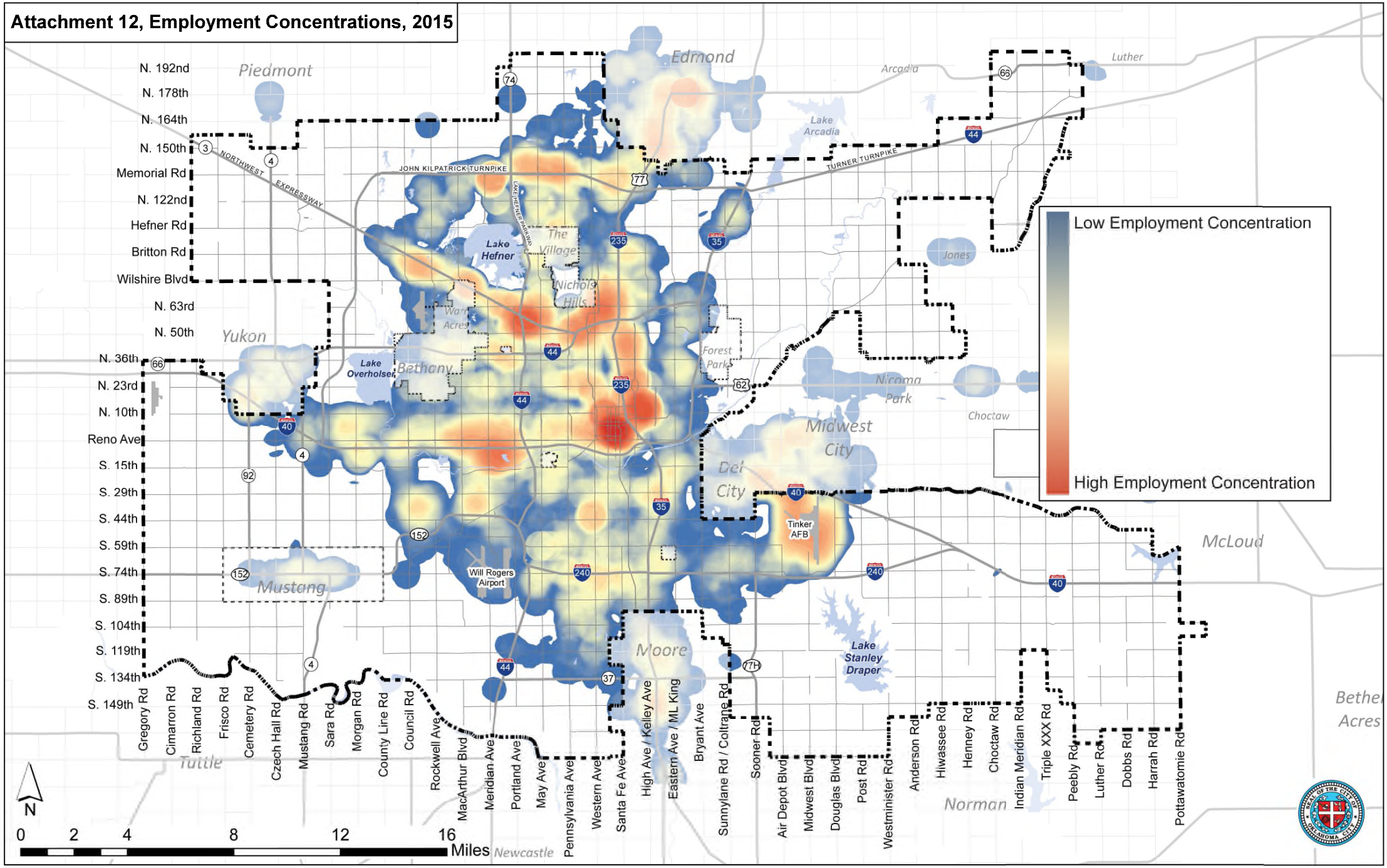
Attachment 11: Major Employers, 2016



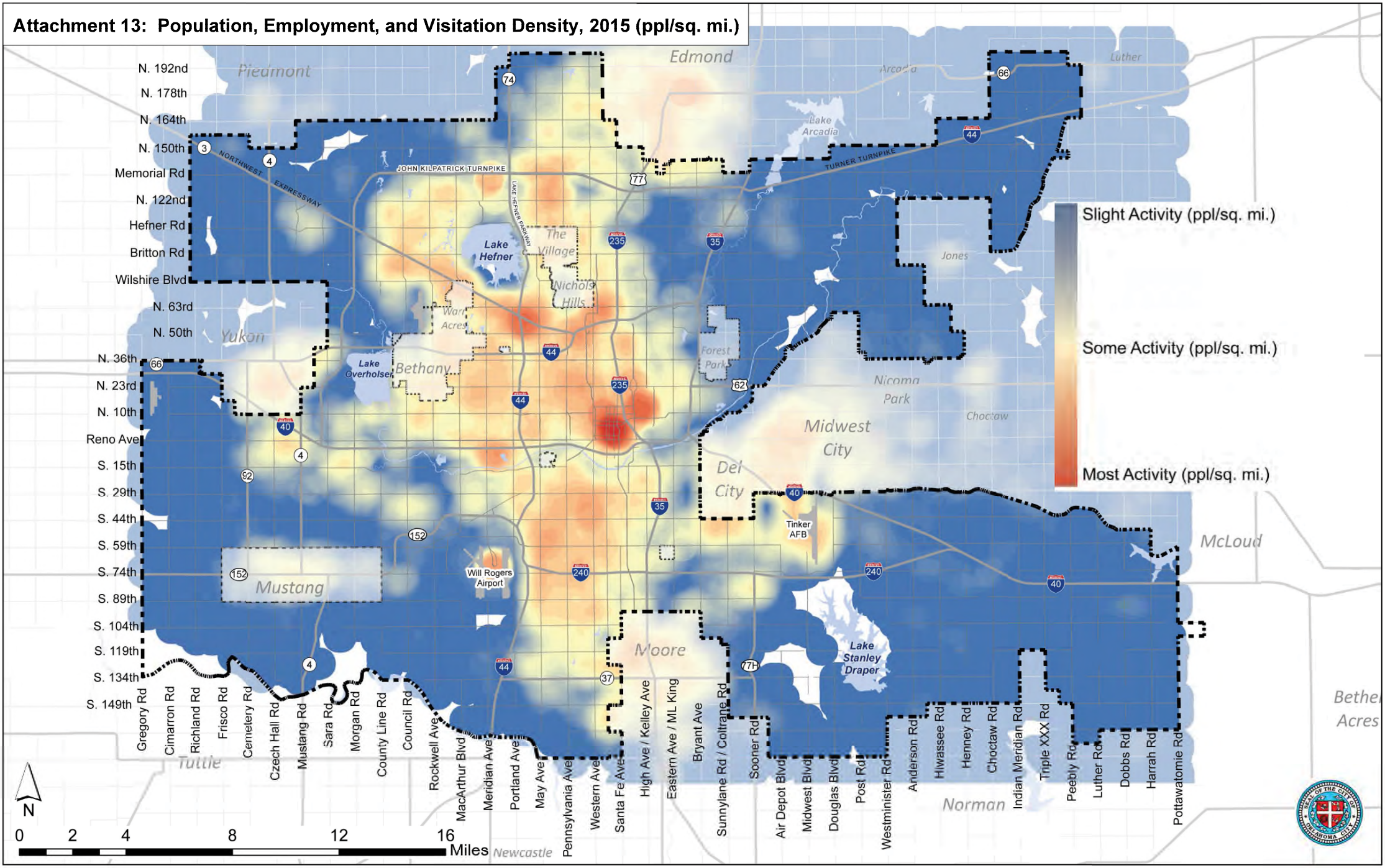
Num	Company Name	# Employees
1	State of Oklahoma	45,600
2	Tinker Air Force Base	24,000
3	University of Oklahoma - Norman	12,700
4	FAA Mike Monroney Aeronautical Center	7,000
5	INTEGRIS Health	6,000
6	Hobby Lobby Stores Inc	5,100
7	University of Oklahoma Health Sciences Center	5,000
8	City of Oklahoma City	4,700
9	Mercy Hospital	4,500
10	OGE Energy Corp	3,400
11	OU Medical Center	3,200
12	SSM Health Care of Oklahoma, Inc.	3,000
13	University of Central Oklahoma	3,000
14	Norman Regional Hospital	2,950
15	The Boeing Company	2,600
16	Devon Energy Corp	2,500
17	Chesapeake Energy Corp	2,500
18	Sonic Corp	2,460
19	AT&T	2,400
20	Oklahoma City Community College	2,100
21	Dell	1,800
22	UPS	1,800
23	Hertz Corporation	1,700
24	Love's Travel Stops & Country Stores	1,700
25	American Fidelity	1,650
26	Cox Communications	1,400
27	Great Plains Coca-Cola Bottling Company	1,300
28	Farmers Insurance Group	1,300
29	Midfirst Bank	1,150
30	Bank of Oklahoma	1,100
31	Dolese Bros. Co.	1,100
32	Continental Resources	1,000
33	Deaconess Hospital	1,000
34	Rose State College	1,000

Source: Greater Oklahoma City Chamber of Commerce

Attachment 12, Employment Concentrations, 2015

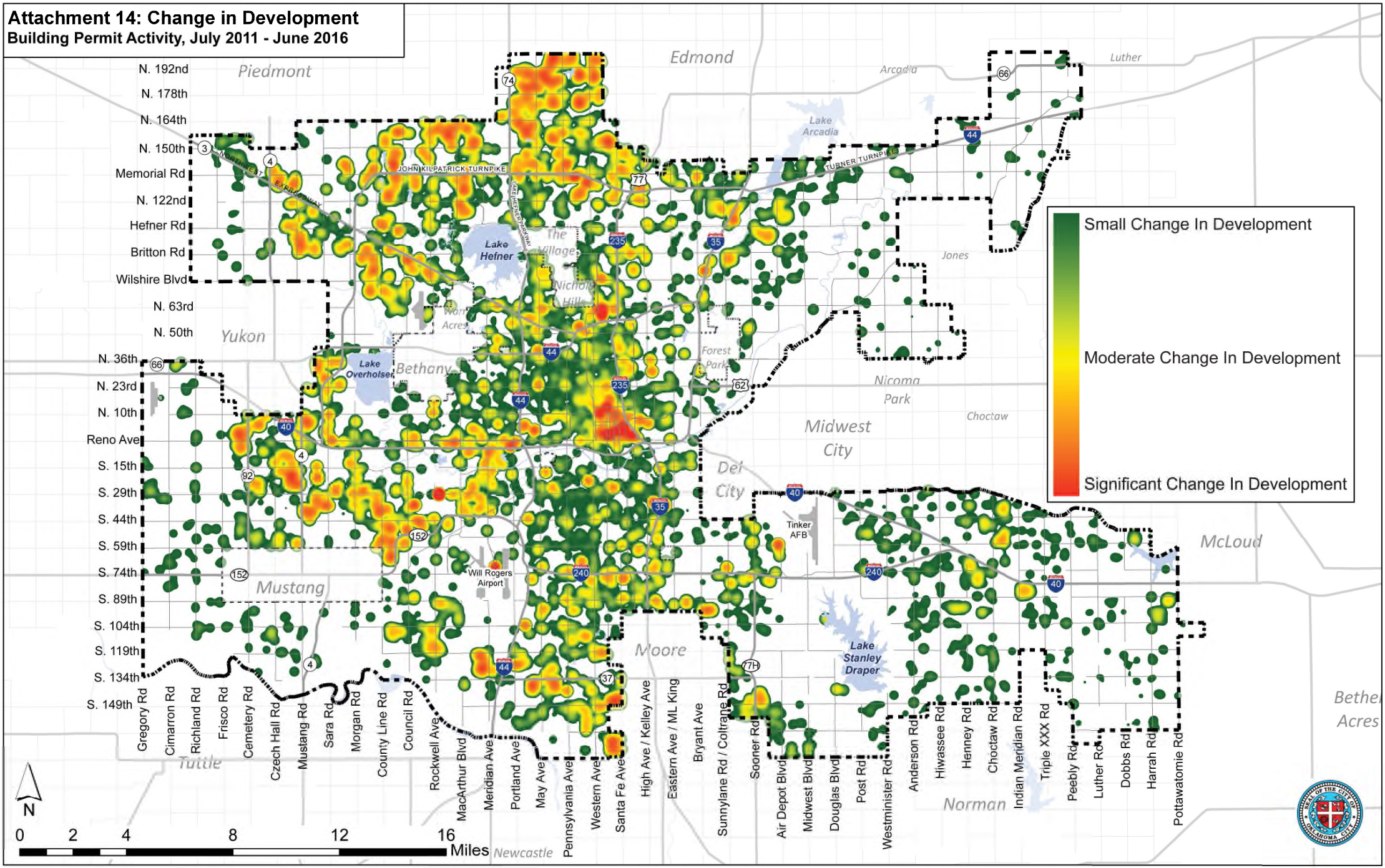


Attachment 13: Population, Employment, and Visitation Density, 2015 (ppl/sq. mi.)

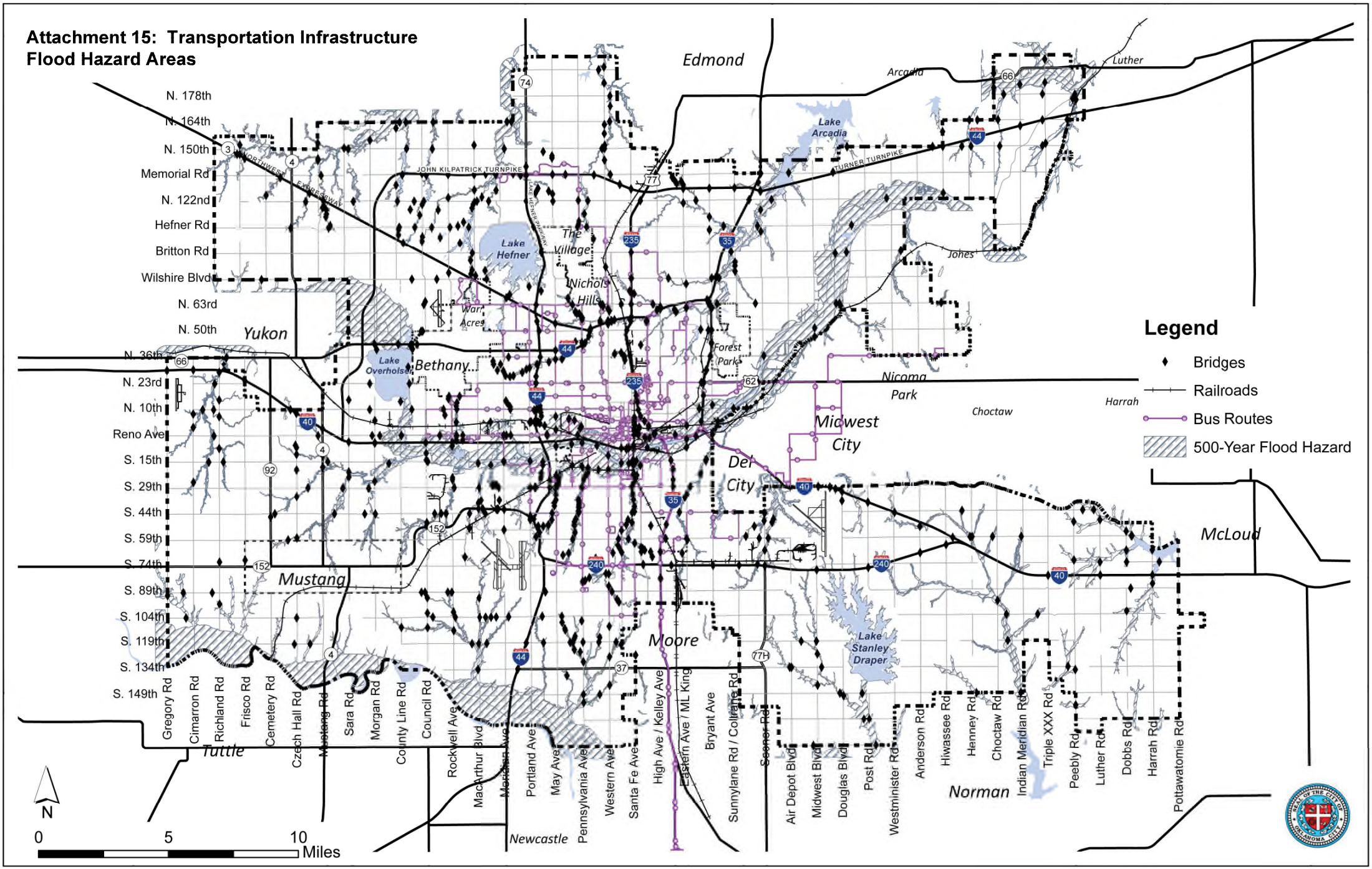


Attachment 14: Change in Development

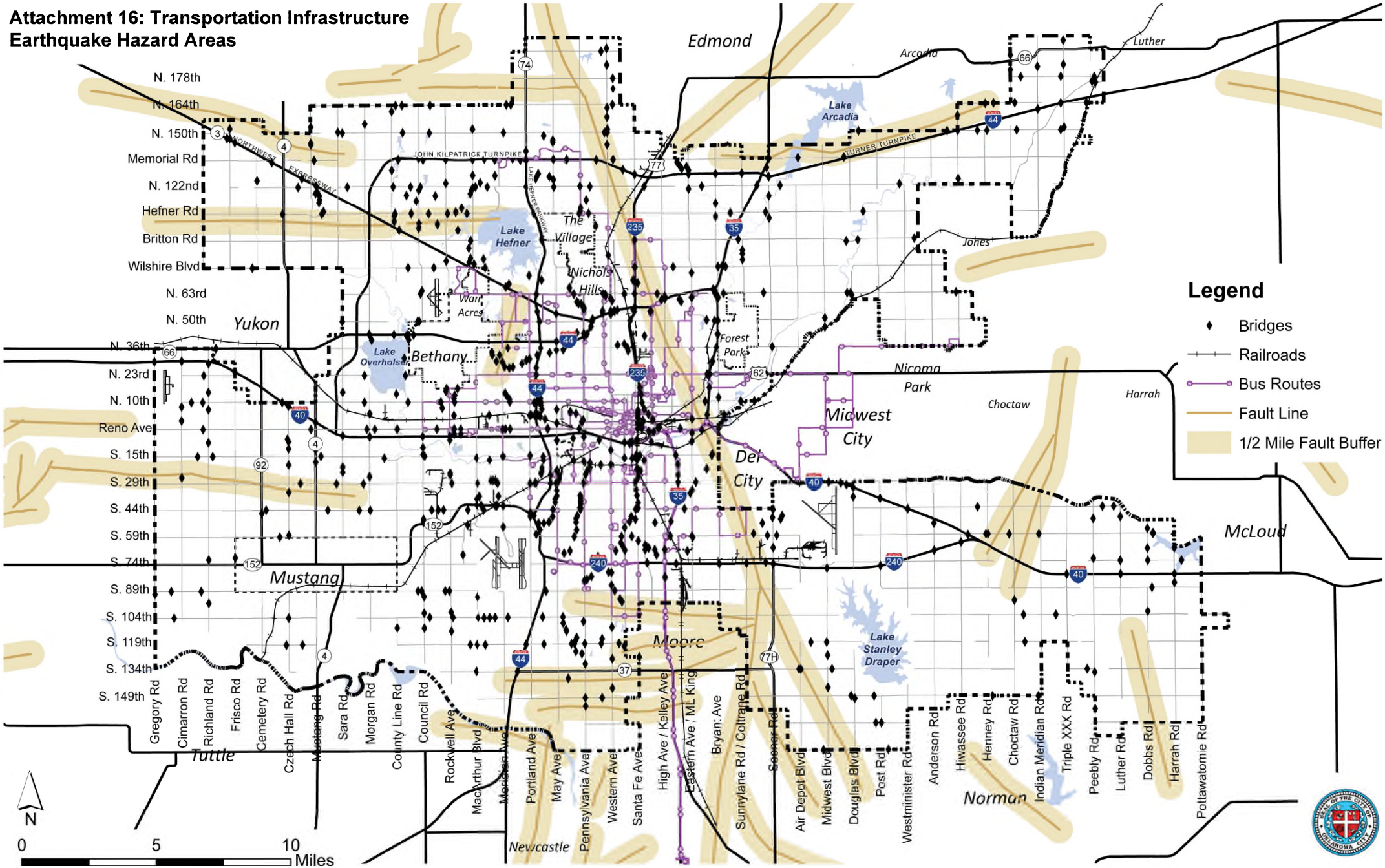
Building Permit Activity, July 2011 - June 2016



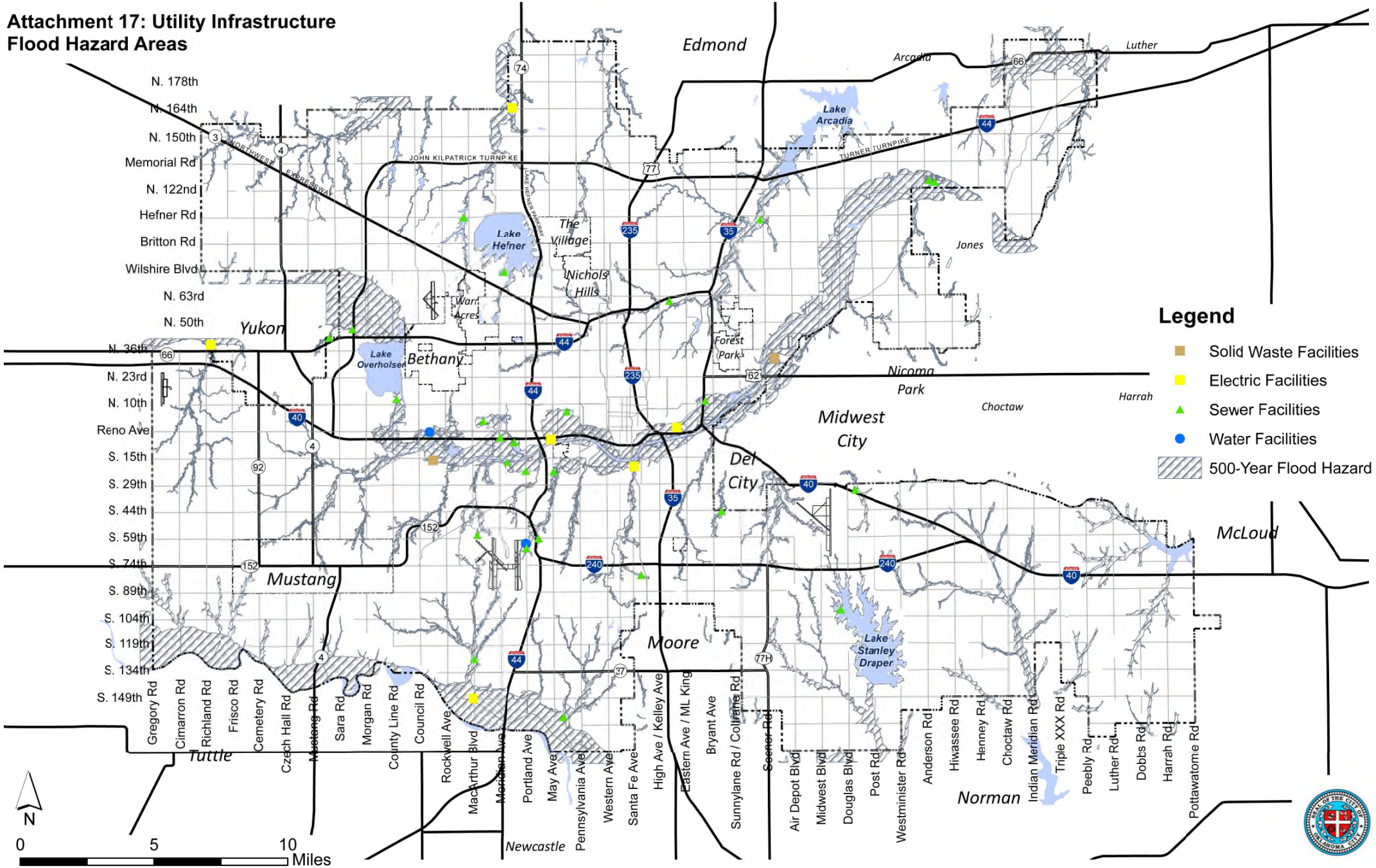
Attachment 15: Transportation Infrastructure Flood Hazard Areas



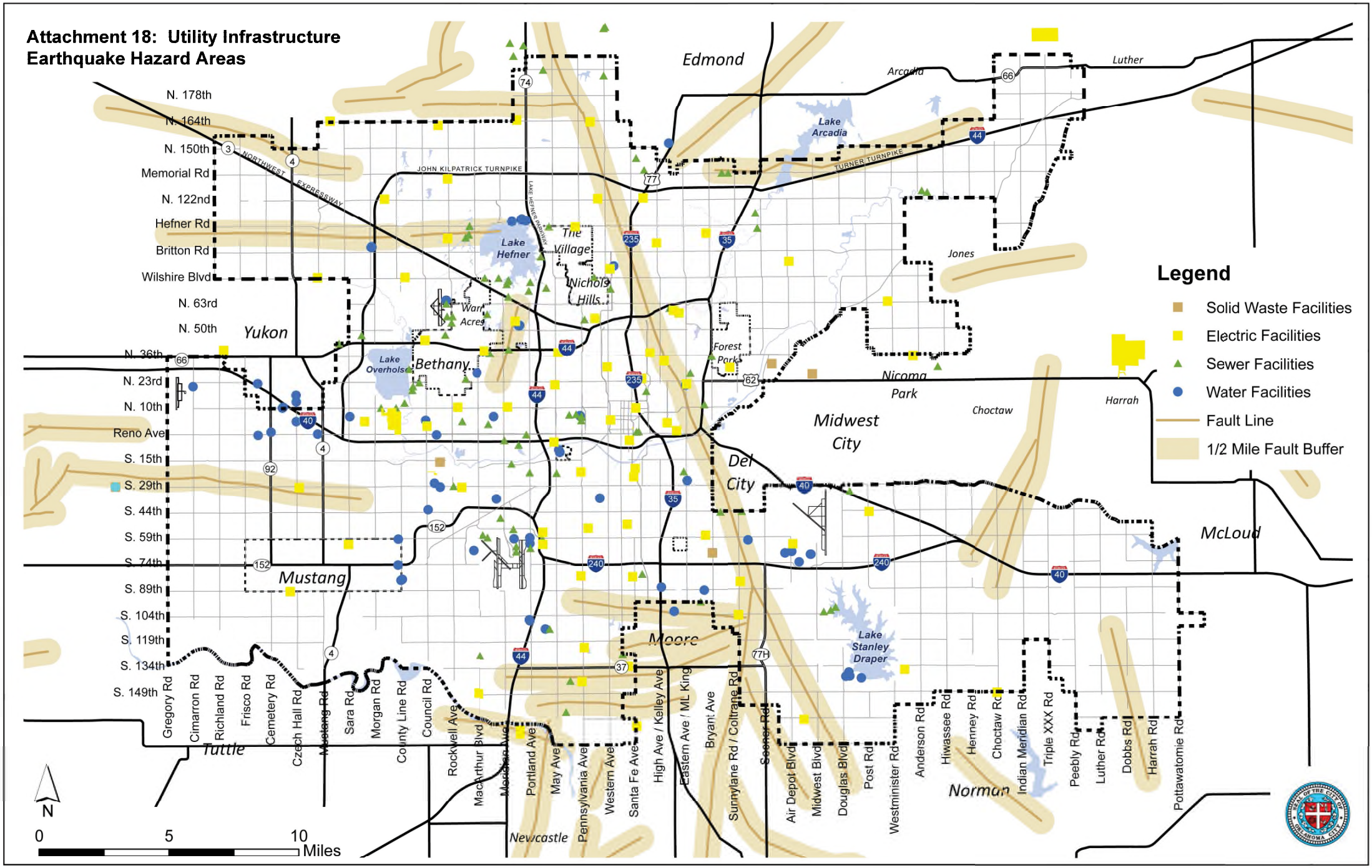
Attachment 16: Transportation Infrastructure Earthquake Hazard Areas



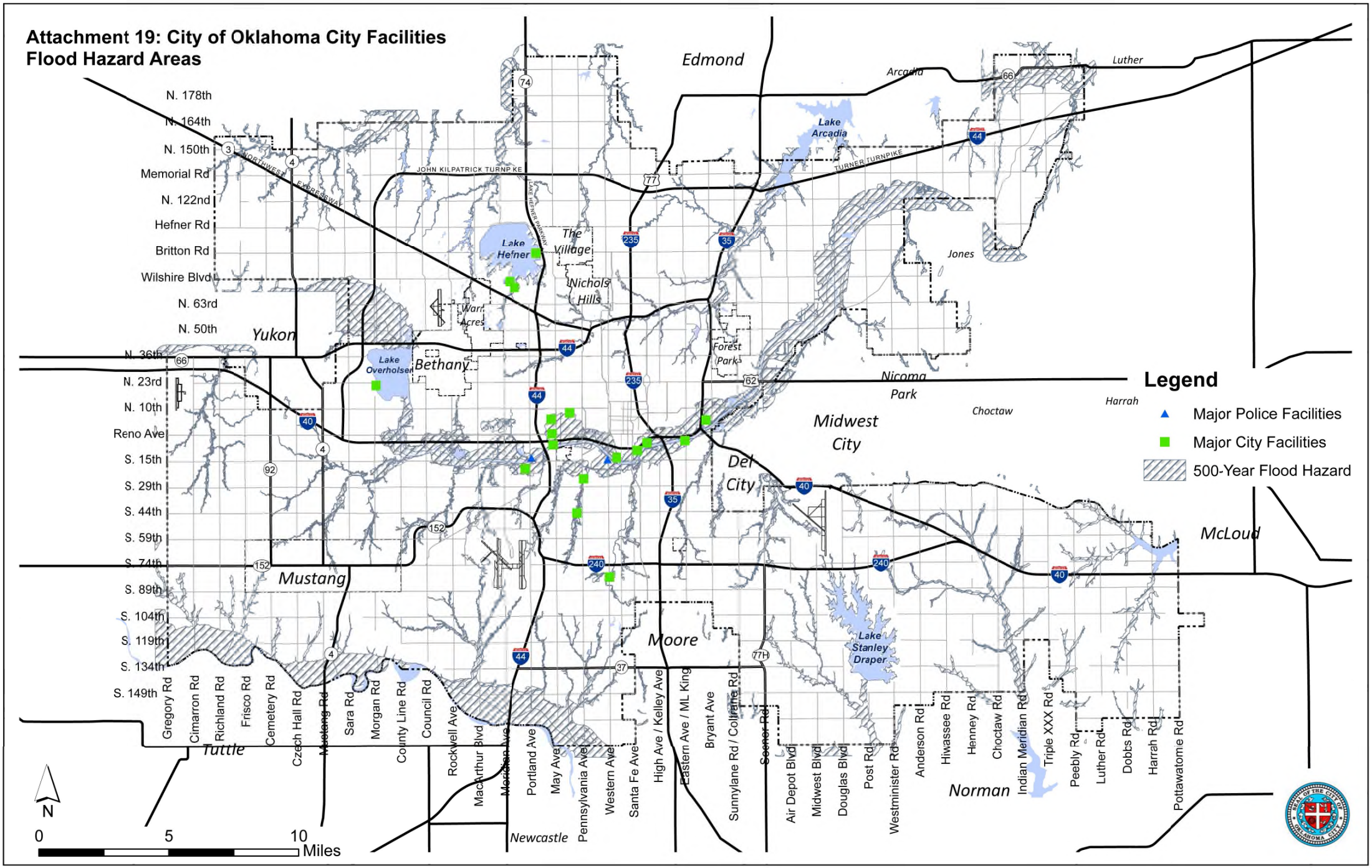
Attachment 17: Utility Infrastructure Flood Hazard Areas



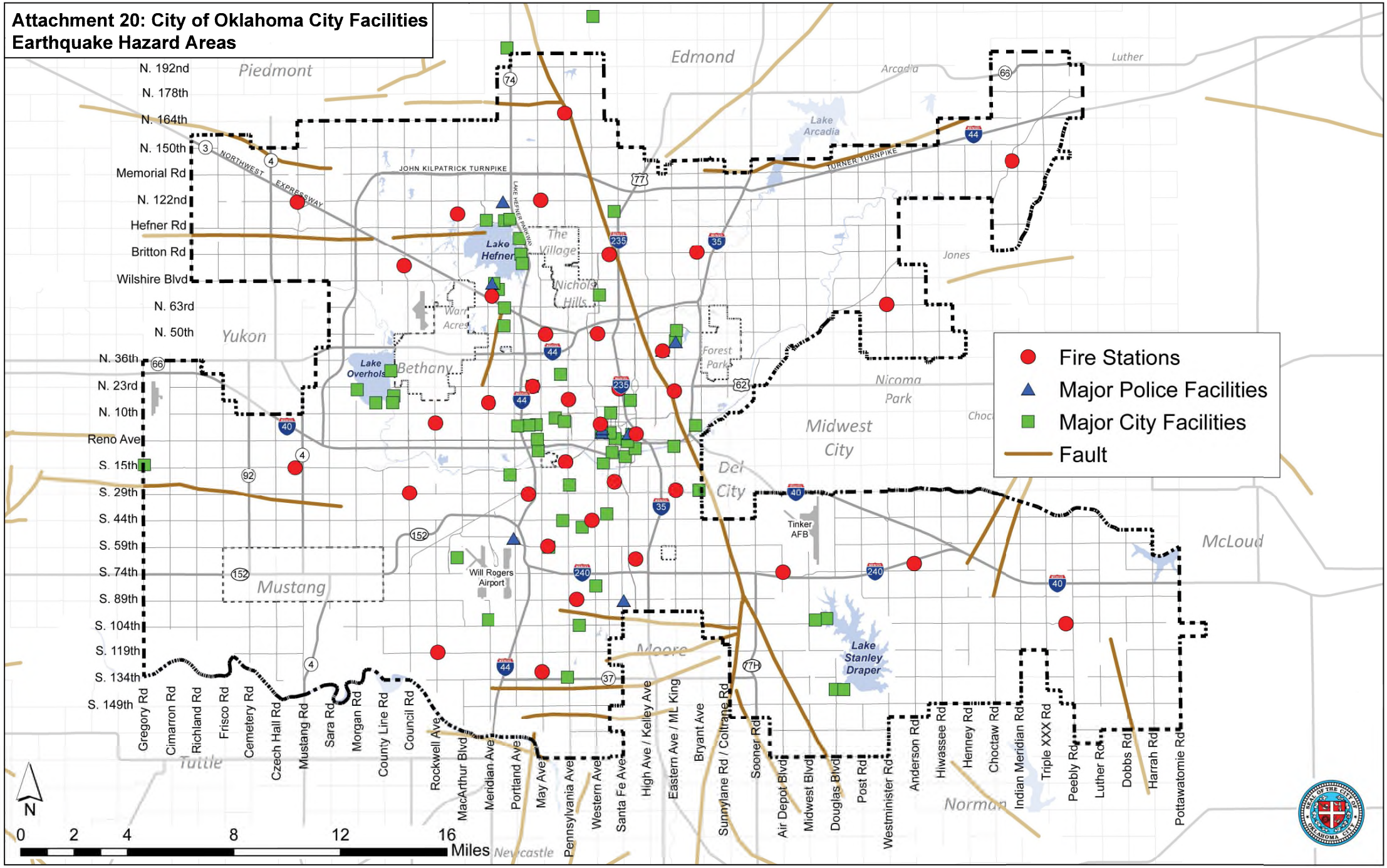
Attachment 18: Utility Infrastructure
Earthquake Hazard Areas



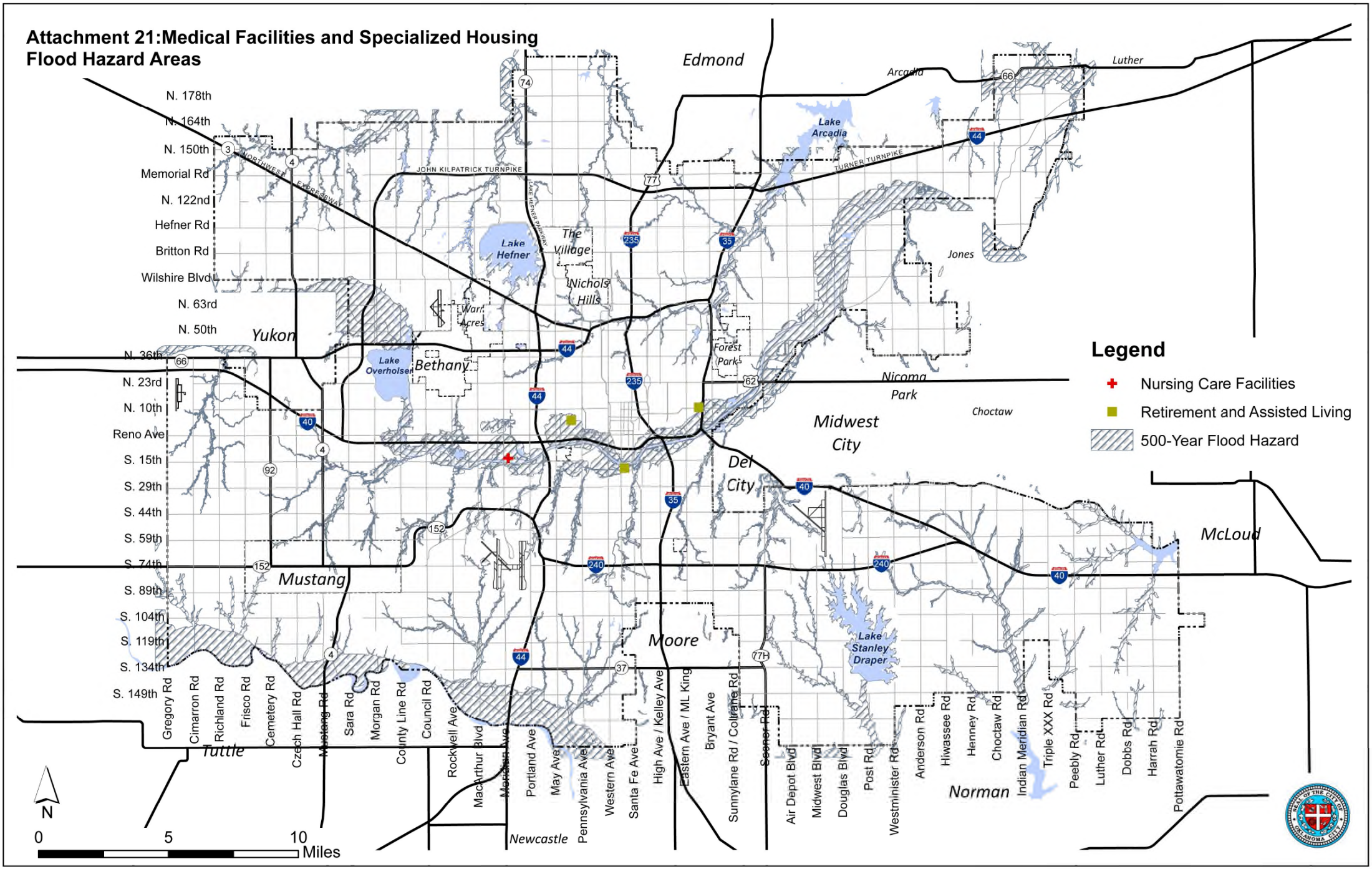
Attachment 19: City of Oklahoma City Facilities Flood Hazard Areas



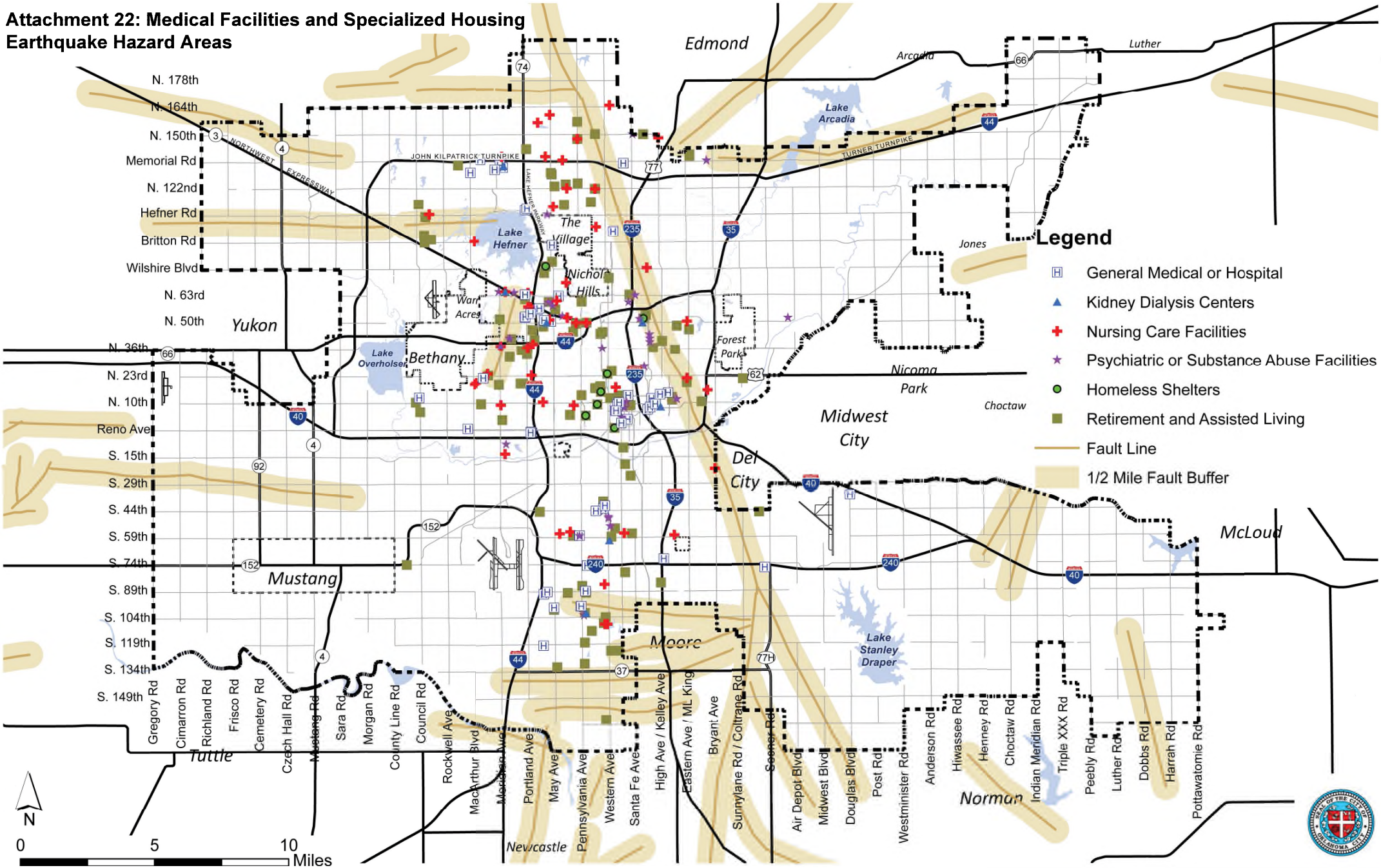
Attachment 20: City of Oklahoma City Facilities Earthquake Hazard Areas



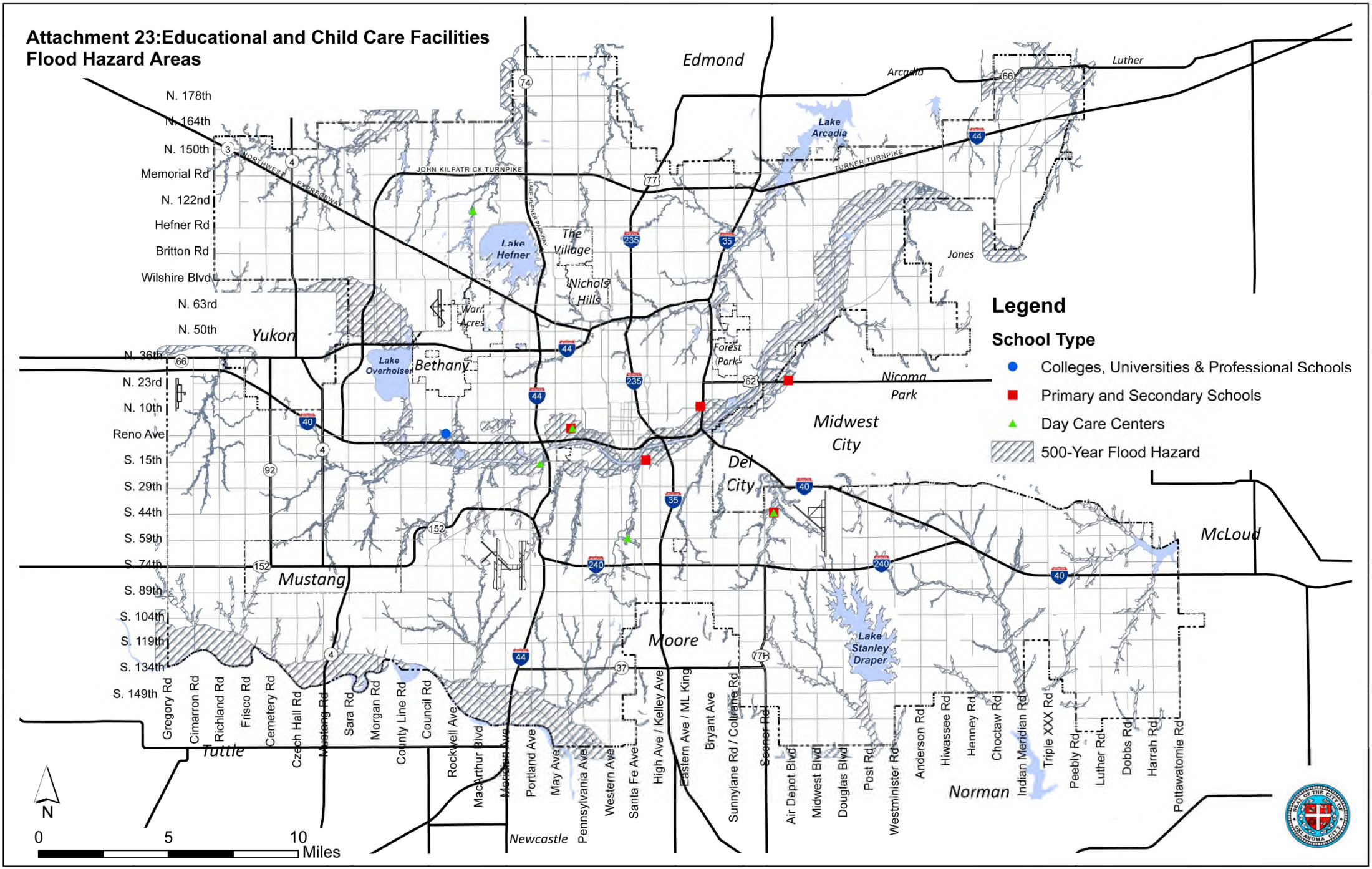
Attachment 21:Medical Facilities and Specialized Housing Flood Hazard Areas



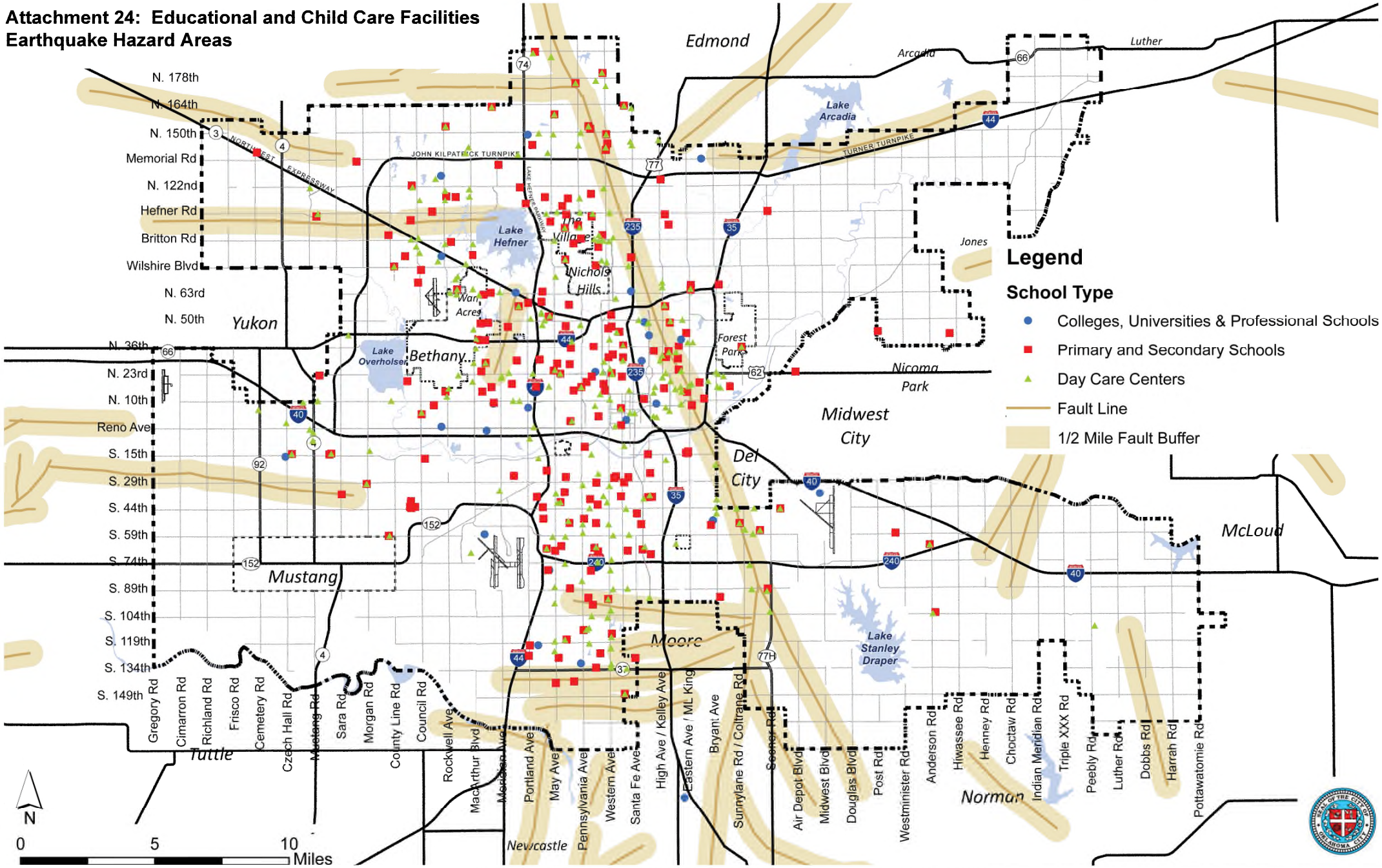
Attachment 22: Medical Facilities and Specialized Housing Earthquake Hazard Areas



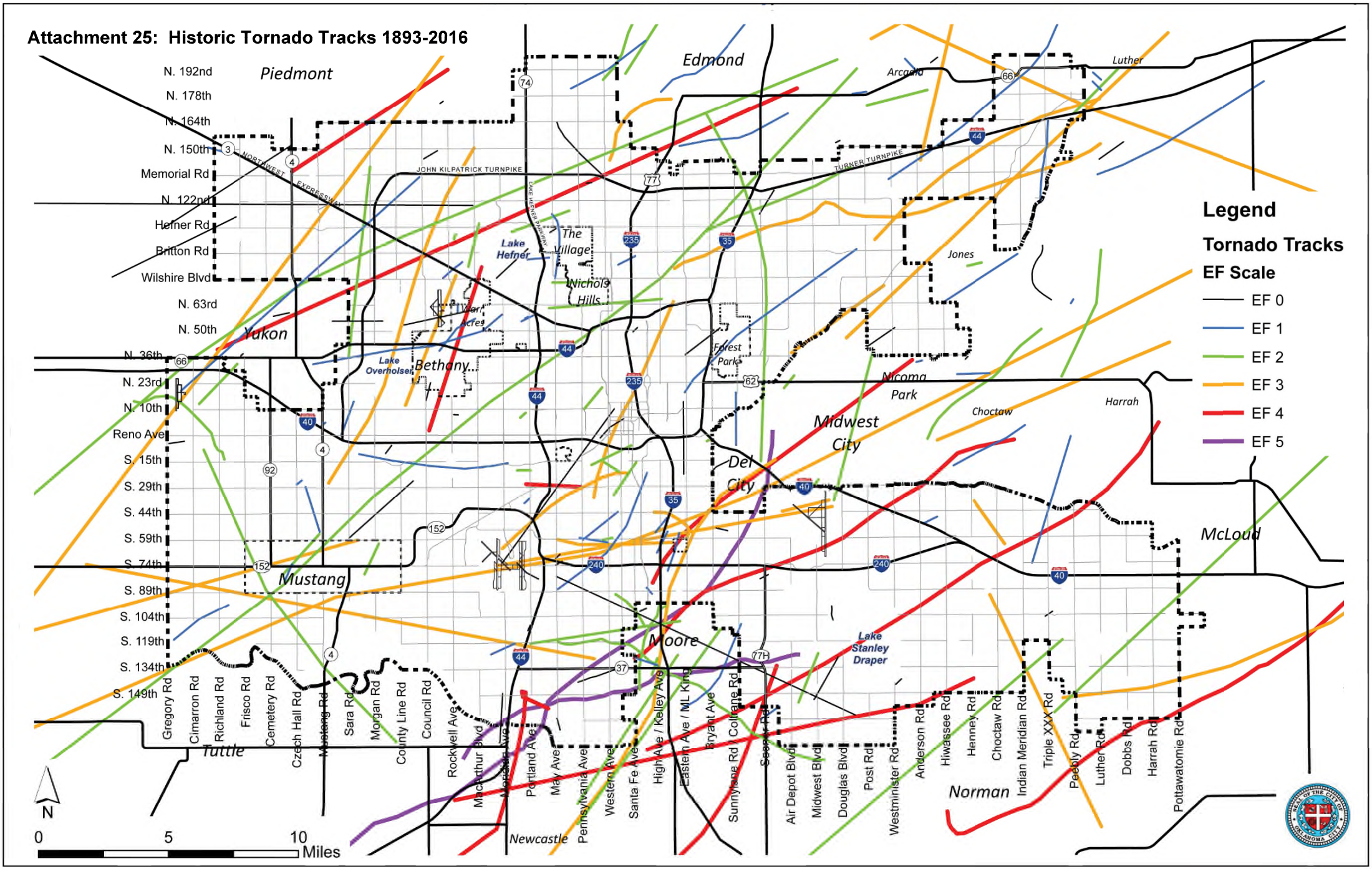
Attachment 23:Educational and Child Care Facilities Flood Hazard Areas



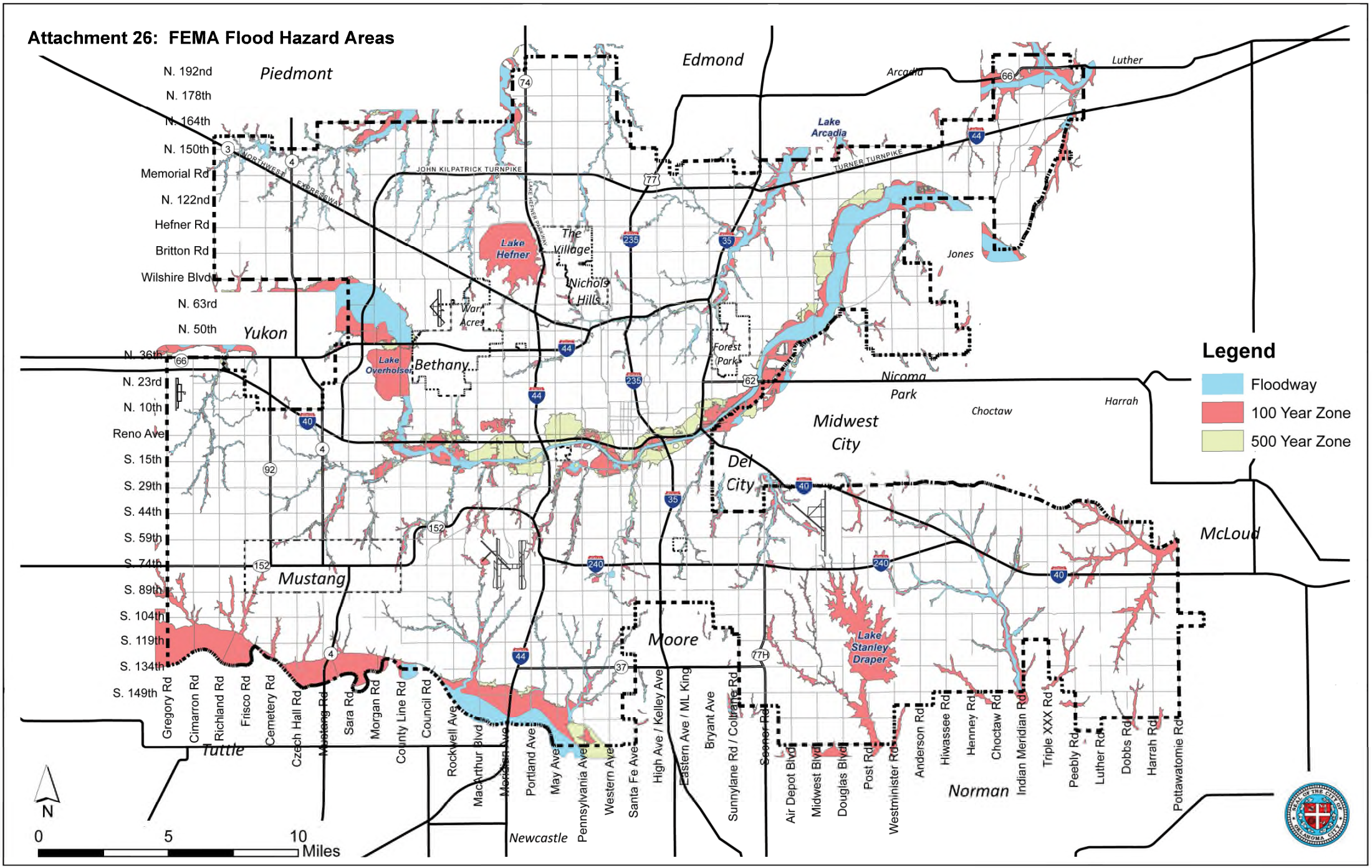
Attachment 24: Educational and Child Care Facilities
Earthquake Hazard Areas



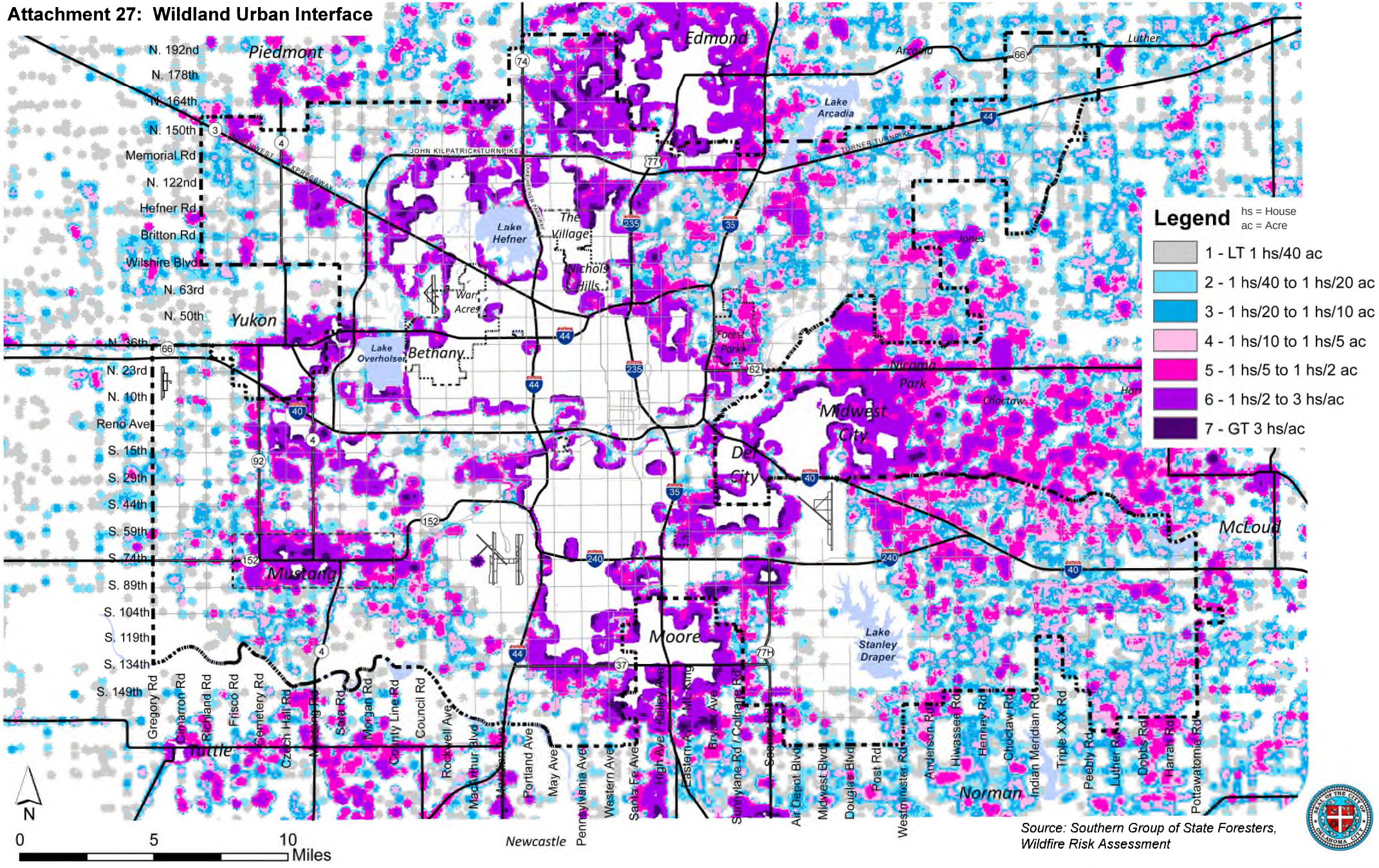
Attachment 25: Historic Tornado Tracks 1893-2016



Attachment 26: FEMA Flood Hazard Areas

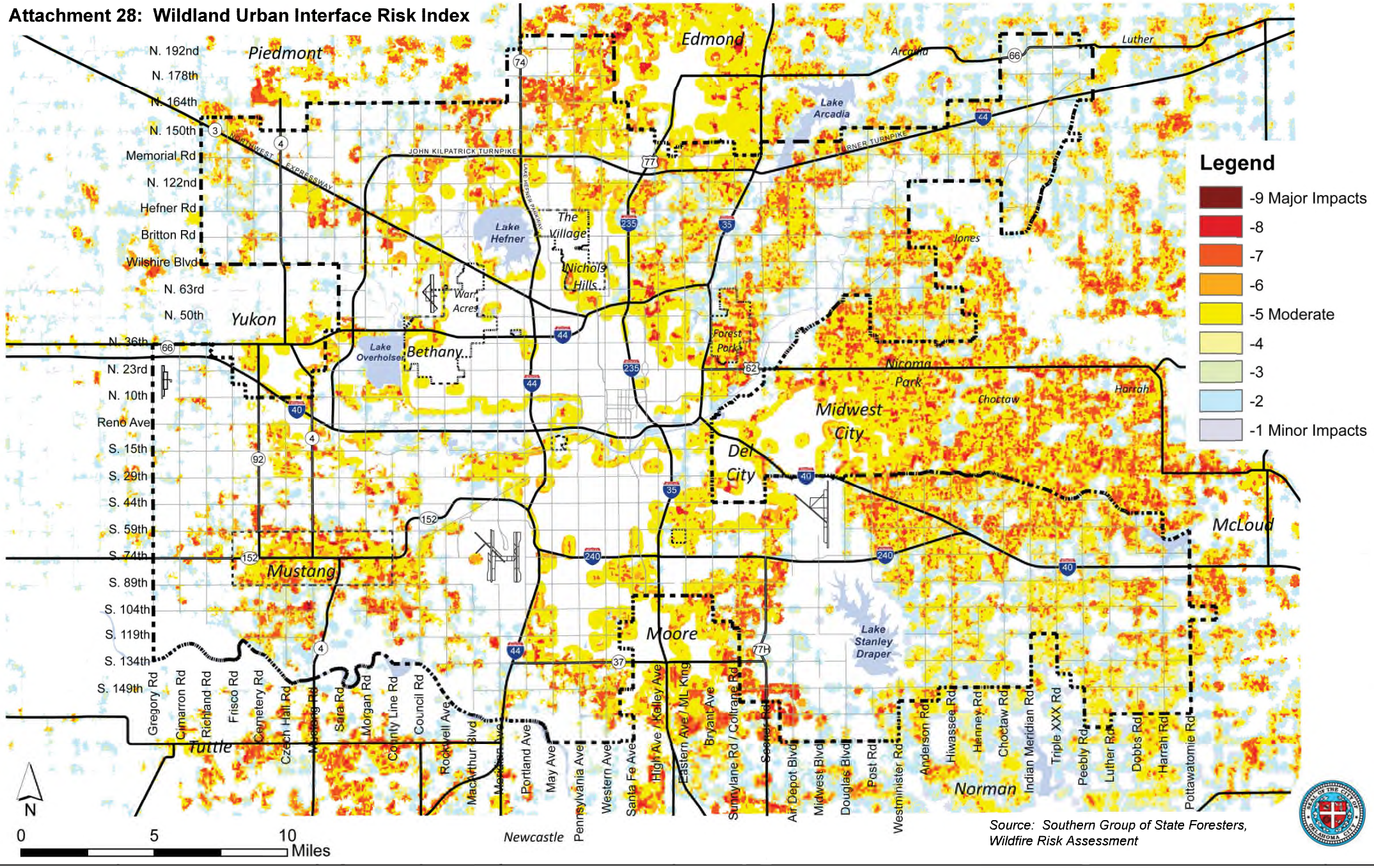


Attachment 27: Wildland Urban Interface



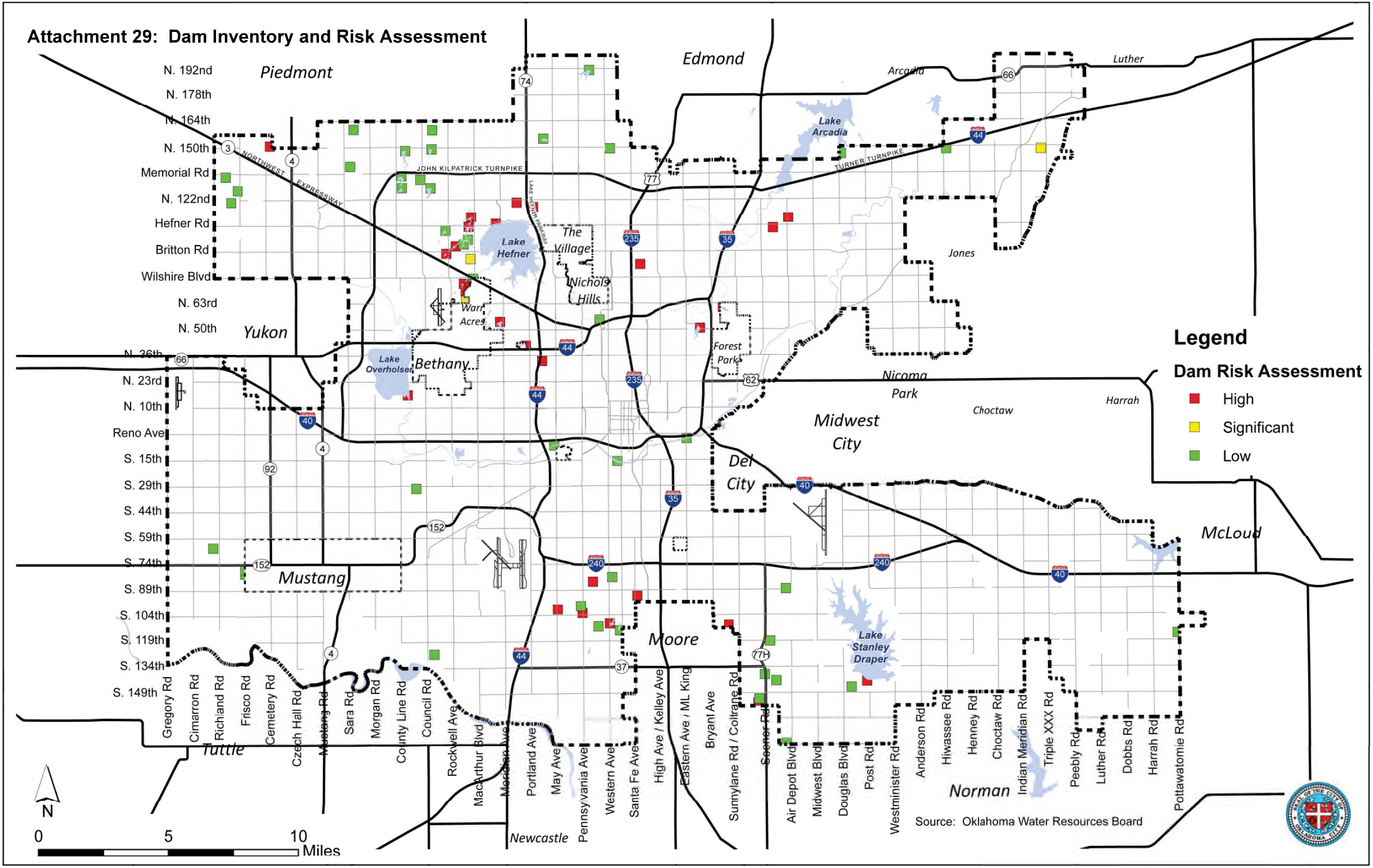
Source: Southern Group of State Foresters, Wildfire Risk Assessment

Attachment 28: Wildland Urban Interface Risk Index

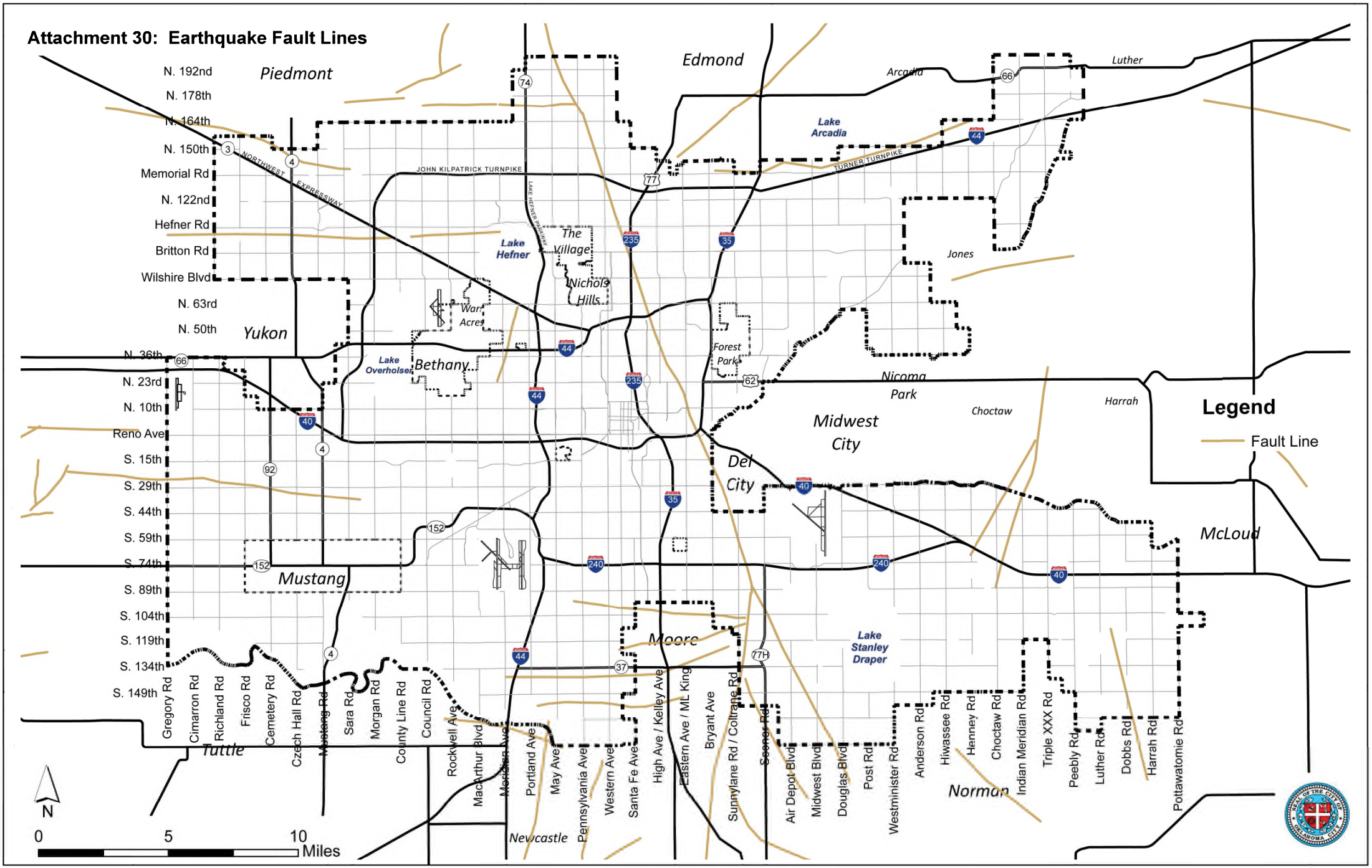


Source: Southern Group of State Foresters, Wildfire Risk Assessment

Attachment 29: Dam Inventory and Risk Assessment



Attachment 30: Earthquake Fault Lines



Attachment 31:
SUMMARY DEMOGRAPHIC PROFILE
American Community Survey 2010-2014 Estimates

	OKLAHOMA CITY			OKLAHOMA CITY MSA			STATE OF OKLAHOMA		
SUBJECT	**ACS 2010-2014**	**Census 2010**	**Pct Change**	**ACS 2010-2014**	**Census 2010**	**Pct Change**	**ACS 2010-2014**	**Census 2010**	**Pct Change**
GENERAL POPULATION AND HOUSING CHARACTERISTICS									
Total Population	600,729	579,999	3.6%	1,297,998	1,252,987	3.6%	3,818,851	3,751,351	1.8%
Total Housing Units	259,863	256,930	1.1%	547,093	539,077	1.5%	1,680,457	1,664,378	1.0%
Occupied housing units	230,517	230,233		490,013	489,654		1,450,117	1,460,450	
Vacant housing units	29,346	26,697		57,080	49,423		230,340	203,928	
GENDER									
Male	296,120	285,556	3.7%	639,781	617,347	3.6%	1,891,526	1,856,977	1.9%
Female	304,609	294,443	3.5%	658,217	635,640	3.6%	1,927,325	1,894,374	1.7%
RACE									
One race	560,158	550,022	1.8%	1,216,534	1,188,342	2.4%	3,522,741	3,530,030	-0.2%
Two or more races	40,571	29,977	35.3%	81,464	64,645	26.0%	296,110	221,321	33.8%
One race									
White	404,171	363,646	11.1%	962,807	900,730	6.9%	2,799,122	2,706,845	3.4%
Black or African American	87,452	87,354	0.1%	131,681	130,597	0.8%	277,007	277,644	-0.2%
American Indian and Alaska Native	18,283	20,533	-11.0%	46,868	51,303	-8.6%	274,099	321,687	-14.8%
Asian	25,309	23,310	8.6%	38,991	35,218	10.7%	71,396	65,076	9.7%
Native Hawaiian and Other Pacific Islander	304	586	-48.1%	1,013	1,115	-9.1%	4,390	4,369	0.5%
Some other race	24,639	54,593	-54.9%	35,174	69,379	-49.3%	96,727	154,409	-37.4%
HISPANIC OR LATINO AND RACE									
Hispanic or Latino (of any race)	108,145	100,038	8.1%	154,696	142,042	8.9%	357,916	332,007	7.8%
Not Hispanic or Latino	492,584	479,961	2.6%	1,143,302	1,110,945	2.9%	3,460,935	3,419,344	1.2%

SUMMARY DEMOGRAPHIC PROFILE
American Community Survey
2010-2014 Estimates

SUBJECT	OKLAHOMA CITY NUM	OKLAHOMA CITY PCT	OKLAHOMA CITY MSA NUM	OKLAHOMA CITY MSA PCT	STATE OF OKLAHOMA NUM	STATE OF OKLAHOMA PCT
GENERAL POPULATION CHARACTERISTICS						
SEX AND AGE						
Total Population	600,729		1,297,998		3,818,851	
Male	296,120	49.3%	639,781	49.3%	1,891,526	49.5%
Female	304,609	50.7%	658,217	50.7%	1,927,325	50.5%
Under 5 years	47,236	7.9%	93,683	7.2%	264,867	6.9%
5 to 9 years	44,069	7.3%	92,593	7.1%	264,936	6.9%
10 to 14 years	39,867	6.6%	87,099	6.7%	259,640	6.8%
15 to 19 years	35,291	5.9%	86,123	6.6%	259,043	6.8%
20 to 24 years	44,692	7.4%	101,742	7.8%	281,342	7.4%
25 to 34 years	98,909	16.5%	193,862	14.9%	520,394	13.6%
35 to 44 years	77,345	12.9%	163,511	12.6%	466,958	12.2%
45 to 54 years	76,438	12.7%	170,423	13.1%	506,554	13.3%
55 to 59 years	37,328	6.2%	81,483	6.3%	247,977	6.5%
60 to 64 years	31,194	5.2%	69,149	5.3%	213,072	5.6%
65 to 74 years	38,359	6.4%	90,137	6.9%	301,305	7.9%
75 to 84 years	21,015	3.5%	48,783	3.8%	168,209	4.4%
85 years and over	8,986	1.5%	19,410	1.5%	64,554	1.7%
Median age (years)	33.8		34.6		36.2	

SUBJECT	OKLAHOMA CITY NUM	OKLAHOMA CITY PCT	OKLAHOMA CITY MSA NUM	OKLAHOMA CITY MSA PCT	STATE OF OKLAHOMA NUM	STATE OF OKLAHOMA PCT
RACE						
One race	560,158	93.2%	1,216,534	93.7%	3,522,741	92.2%
Two or more races	40,571	6.8%	81,464	6.3%	296,110	7.8%
White	404,171	72.2%	962,807	79.1%	2,799,122	79.5%
Black or African American	87,452	15.6%	131,681	10.8%	277,007	7.9%
American Indian and Alaska Native	18,283	3.3%	46,868	3.9%	274,099	7.8%
Asian	25,309	4.5%	38,991	3.2%	71,396	2.0%
Native Hawaiian and Other Pacific Islander	304	0.1%	1,013	0.1%	4,390	0.1%
Some other race	24,639	4.4%	35,174	2.9%	96,727	2.7%
Two or more races	40,571	6.8%	81,464	6.3%	296,110	7.8%
HISPANIC OR LATINO AND RACE						
Hispanic or Latino (of any race)	108,145	18.0%	154,696	11.9%	357,916	9.4%
Not Hispanic or Latino	492,584	82.0%	1,143,302	88.1%	3,460,935	90.6%

SUBJECT	OKLAHOMA CITY NUM	OKLAHOMA CITY PCT	OKLAHOMA CITY MSA NUM	OKLAHOMA CITY MSA PCT	STATE OF OKLAHOMA NUM	STATE OF OKLAHOMA PCT
GENERAL ECONOMIC CHARACTERISTICS						
EMPLOYMENT STATUS						
Population 16 years and over	462,537		1,007,827		2,977,835	
In labor force	309,931	67.0%	657,958	65.3%	1,843,140	61.9%
Civilian labor force	306,861		652,471		1,824,414	
Employed	286,646	92.5%	612,668	93.1%	1,699,610	92.2%
Unemployed	20,215	6.5%	39,803	6.0%	124,804	6.8%
Armed Forces	3,070	1.0%	5,487	0.8%	18,726	1.0%
Not in labor force	152,606	33.0%	349,869	34.7%	1,134,695	38.1%
OCCUPATION						
Civilian employed population 16 years and over	286,646		612,668		1,699,610	
Management, business, science, and arts occupations	100,305	35.0%	219,477	35.8%	562,025	33.1%
Service occupations	51,390	17.9%	105,582	17.2%	300,128	17.7%
Sales and office occupations	73,249	25.6%	157,491	25.7%	414,893	24.4%
Natural resources, construction, and maintenance occupations	31,409	11.0%	66,142	10.8%	199,754	11.8%
Production, transportation, and material moving occupations	30,293	10.6%	63,976	10.4%	222,810	13.1%
INDUSTRY						
Agriculture, forestry, fishing and hunting, and mining	9,170	3.2%	23,278	3.8%	85,657	5.0%
Construction	23,791	8.3%	45,345	7.4%	120,100	7.1%
Manufacturing	20,914	7.3%	43,046	7.0%	167,846	9.9%
Wholesale trade	8,562	3.0%	17,258	2.8%	45,851	2.7%
Retail trade	34,887	12.2%	73,884	12.1%	196,516	11.6%
Transportation and warehousing, and utilities	12,718	4.4%	28,155	4.6%	86,486	5.1%
Information	5,966	2.1%	11,244	1.8%	30,750	1.8%
Finance and insurance, and real estate and rental and leasing	19,219	6.7%	40,688	6.6%	97,432	5.7%
Professional, scientific, and management, and administrative and waste management services	29,070	10.1%	57,257	9.3%	136,922	8.1%
Educational services, and health care and social assistance	59,615	20.8%	137,534	22.4%	385,055	22.7%
Arts, entertainment, and recreation, and accommodation and food services	27,063	9.4%	55,303	9.0%	152,558	9.0%
Other services, except public administration	16,001	5.6%	32,429	5.3%	88,134	5.2%
Public administration	19,670	6.9%	47,247	7.7%	106,303	6.3%

SUBJECT	OKLAHOMA CITY NUM	OKLAHOMA CITY PCT	OKLAHOMA CITY MSA NUM	OKLAHOMA CITY MSA PCT	STATE OF OKLAHOMA NUM	STATE OF OKLAHOMA PCT
INCOME AND BENEFITS (IN 2014 INFLATION-ADJUSTED DOLLARS)						
Total households	230,517		490,013		1,450,117	
Less than $10,000	19,249	8.4%	35,923	7.3%	115,957	8.0%
$10,000 to $14,999	12,348	5.4%	25,122	5.1%	90,529	6.2%
$15,000 to $24,999	26,667	11.6%	53,167	10.9%	177,996	12.3%
$25,000 to $34,999	28,149	12.2%	55,515	11.3%	171,338	11.8%
$35,000 to $49,999	34,362	14.9%	70,669	14.4%	216,597	14.9%
$50,000 to $74,999	41,512	18.0%	92,817	18.9%	271,794	18.7%
$75,000 to $99,999	25,787	11.2%	59,194	12.1%	165,158	11.4%
$100,000 to $149,999	25,988	11.3%	59,856	12.2%	152,419	10.5%
$150,000 to $199,999	8,260	3.6%	19,371	4.0%	46,078	3.2%
$200,000 or more	8,195	3.6%	18,379	3.8%	42,251	2.9%
Median household income (dollars)	$47,004		$50,967		$46,235	
Mean household income (dollars)	$66,050		$69,147		$62,871	
With earnings	185,899		392,774		1,115,190	
Mean earnings (dollars)	$65,709		$68,613		$63,729	
With Social Security	58,093		130,931		443,697	
Mean Social Security income (dollars)	$17,233		$17,250		$17,021	
With retirement income	36,935		87,928		249,043	
Mean retirement income (dollars)	$22,119		$22,699		$20,421	
With Supplemental Security Income	12,629		23,598		80,237	
Mean Supplemental Security Income (dollars)	$8,842		$9,231		$9,199	
With cash public assistance income	8,341		15,310		47,849	
Mean cash public assistance income (dollars)	$2,153		$2,172		$2,117	
With Food Stamp/SNAP benefits in the past 12 months	35,304		64,852		202,916	
Per capita income (dollars)	$26,275		$26,994		$24,695	
HEALTH INSURANCE COVERAGE						
Civilian noninstitutionalized population	590,955		1,277,263		3,737,426	
With health insurance coverage	475,220	80.4%	1,066,246	83.5%	3,075,817	82.3%
With private health insurance	355,552	60.2%	837,024	65.5%	2,315,865	62.0%
With public coverage	177,633	30.1%	368,653	28.9%	1,204,848	32.2%
No health insurance coverage	115,735	19.6%	211,017	16.5%	661,609	17.7%

SUBJECT	OKLAHOMA CITY NUM	OKLAHOMA CITY PCT	OKLAHOMA CITY MSA NUM	OKLAHOMA CITY MSA PCT	STATE OF OKLAHOMA NUM	STATE OF OKLAHOMA PCT
GENERAL SOCIAL CHARACTERISTICS						
HOUSEHOLDS BY TYPE						
Total households	230,517		490,013		1,450,117	
Family households (families)	144,564	62.7%	321,754	65.7%	964,329	66.5%
With own children under 18 years	68,843		147,936		423,844	
Married-couple family	101,542	70.2%	236,385	73.5%	713,388	74.0%
With own children under 18 years	43,857		99,151		279,994	
Male householder, no wife present, family	12,139	8.4%	23,923	7.4%	70,347	7.3%
With own children under 18 years	6,079		12,062		36,620	
Female householder, no husband present, family	30,883	21.4%	61,446	19.1%	180,594	18.7%
With own children under 18 years	18,907		36,723		107,230	
Nonfamily households	85,953	37.3%	168,259	34.3%	485,788	33.5%
Householder living alone	70,699		137,981		407,376	
65 years and over	20,317		44,189		149,817	
Households with one or more people under 18 years	76,898	33.4%	164,784	33.6%	478,327	33.0%
Households with one or more people 65 years and over	48,827	21.2%	111,336	22.7%	374,711	25.8%
Persons in Group Quarters	11,959		31,761		110,114	
Average household size	2.55		2.58		2.56	
Average family size	3.23		3.18		3.13	
EDUCATIONAL ATTAINMENT						
Population 25 years and over	389,574		836,758		2,489,023	
Less than 9th grade	25,476	6.5%	38,230	4.6%	111,451	4.5%
9th to 12th grade, no diploma	32,920	8.5%	63,938	7.6%	219,751	8.8%
High school graduate (includes equivalency)	98,815	25.4%	228,870	27.4%	789,276	31.7%
Some college, no degree	95,426	24.5%	209,990	25.1%	597,883	24.0%
Associate's degree	25,810	6.6%	57,330	6.9%	177,796	7.1%
Bachelor's degree	74,461	19.1%	156,570	18.7%	396,647	15.9%
Graduate or professional degree	36,666	9.4%	81,830	9.8%	196,219	7.9%

SUBJECT	OKLAHOMA CITY NUM	OKLAHOMA CITY PCT	OKLAHOMA CITY MSA NUM	OKLAHOMA CITY MSA PCT	STATE OF OKLAHOMA NUM	STATE OF OKLAHOMA PCT
DISABILITY STATUS OF THE CIVILIAN NONINSTITUTIONALIZED POPULATION						
Total Civilian Noninstitutionalized Population	590,955		1,277,263		3,737,426	
With a disability	78,964	13.4%	171,094	13.4%	583,194	15.6%
LANGUAGE SPOKEN AT HOME						
Population 5 years and over	553,493		1,204,315		3,553,984	
English only	445,164	80.4%	1,050,962	87.3%	3,212,248	90.4%
Language other than English	108,329	19.6%	153,353	12.7%	341,736	9.6%
Speak English less than "very well"	53,013	48.9%	68,571	44.7%	141,231	41.3%
Spanish	79,015	14.3%	104,659	8.7%	230,639	6.5%
Speak English less than "very well"	41,202	52.1%	50,623	48.4%	104,866	45.5%
Other Indo-European languages	7,264	1.3%	13,732	1.1%	33,899	1.0%
Speak English less than "very well"	1,737	23.9%	2,869	20.9%	7,111	21.0%
Asian and Pacific Islander languages	18,108	3.3%	27,823	2.3%	51,468	1.4%
Speak English less than "very well"	9,204	50.8%	13,360	48.0%	24,234	47.1%
Other languages	3,942	0.7%	7,139	0.6%	25,730	0.7%
Speak English less than "very well"	870	22.1%	1,719	24.1%	5,020	19.5%
GENERAL HOUSING CHARACTERISTICS						
TOTAL HOUSING UNITS	259,863		547,093		1,680,457	
HOUSING OCCUPANCY						
Occupied housing units	230,517	88.7%	490,013	89.6%	1,450,117	86.3%
Vacant housing units	29,346	11.3%	57,080	10.4%	230,340	13.7%
Homeowner vacancy rate	1.9%		2.0%		2.3%	
Rental vacancy rate	7.2%		7.3%		8.1%	
UNITS IN STRUCTURE						
1-unit, detached	174,633	67.2%	392,834	71.8%	1,225,540	72.9%
1-unit, attached	8,642	3.3%	14,505	2.7%	34,224	2.0%
2 units	6,735	2.6%	11,695	2.1%	34,729	2.1%
3 or 4 units	9,435	3.6%	15,950	2.9%	42,298	2.5%
5 to 9 units	17,061	6.6%	28,198	5.2%	61,023	3.6%
10 to 19 units	16,550	6.4%	25,405	4.6%	58,134	3.5%
20 or more units	18,239	7.0%	26,713	4.9%	61,686	3.7%
Mobile home	8,506	3.3%	31,431	5.7%	160,465	9.5%
Boat, RV, van, etc.	62	0.0%	362	0.1%	2,358	0.1%

SUBJECT	OKLAHOMA CITY NUM	OKLAHOMA CITY PCT	OKLAHOMA CITY MSA NUM	OKLAHOMA CITY MSA PCT	STATE OF OKLAHOMA NUM	STATE OF OKLAHOMA PCT
YEAR STRUCTURE BUILT						
Built 2010 or later	5,584	2.1%	11,256	2.1%	26,280	1.6%
Built 2000 to 2009	37,511	14.4%	88,694	16.2%	238,049	14.2%
Built 1990 to 1999	26,554	10.2%	61,648	11.3%	195,825	11.7%
Built 1980 to 1989	40,459	15.6%	86,931	15.9%	256,542	15.3%
Built 1970 to 1979	43,968	16.9%	100,100	18.3%	331,777	19.7%
Built 1960 to 1969	35,909	13.8%	72,510	13.3%	205,795	12.2%
Built 1950 to 1959	29,551	11.4%	57,615	10.5%	184,594	11.0%
Built 1940 to 1949	16,315	6.3%	29,941	5.5%	99,344	5.9%
Built 1939 or earlier	24,012	9.2%	38,398	7.0%	142,251	8.5%
BEDROOMS						
No bedroom	4,912	1.9%	8,289	1.5%	25,797	1.5%
1 bedroom	34,298	13.2%	53,379	9.8%	149,471	8.9%
2 bedrooms	69,831	26.9%	131,676	24.1%	426,492	25.4%
3 bedrooms	113,938	43.8%	265,631	48.6%	823,671	49.0%
4 bedrooms	32,930	12.7%	78,526	14.4%	222,351	13.2%
5 or more bedrooms	3,954	1.5%	9,592	1.8%	32,675	1.9%
HOUSING TENURE						
Occupied housing units	230,517		490,013		1,450,117	
Owner-occupied	135,641	58.8%	316,467	64.6%	964,573	66.5%
Renter-occupied	94,876	41.2%	173,546	35.4%	485,544	33.5%
Average household size of owner-occupied unit	2.66		2.65		2.60	
Average household size of renter-occupied unit	2.40		2.45		2.48	
VEHICLES AVAILABLE						
Occupied housing units						
No vehicles available	16,125	7.0%	27,178	5.5%	83,133	5.7%
1 vehicle available	83,578	36.3%	163,896	33.4%	482,331	33.3%
2 vehicles available	90,263	39.2%	199,432	40.7%	571,497	39.4%
3 or more vehicles available	40,551	17.6%	99,507	20.3%	313,156	21.6%
SELECTED CHARACTERISTICS						
Occupied housing units						
Lacking complete plumbing facilities	806	0.3%	1,665	0.3%	6,829	0.5%
Lacking complete kitchen facilities	2,260	1.0%	4,254	0.9%	12,958	0.9%
No telephone service available	4,970	2.2%	10,218	2.1%	36,377	2.5%

SUBJECT	OKLAHOMA CITY NUM	OKLAHOMA CITY PCT	OKLAHOMA CITY MSA NUM	OKLAHOMA CITY MSA PCT	STATE OF OKLAHOMA NUM	STATE OF OKLAHOMA PCT
VALUE						
Owner-occupied units	135,641		316,467		964,573	
Less than $50,000	13,495	9.9%	31,166	9.8%	153,635	15.9%
$50,000 to $99,999	30,379	22.4%	72,521	22.9%	257,804	26.7%
$100,000 to $149,999	34,348	25.3%	79,761	25.2%	215,191	22.3%
$150,000 to $199,999	25,970	19.1%	57,523	18.2%	146,795	15.2%
$200,000 to $299,999	18,932	14.0%	44,855	14.2%	114,831	11.9%
$300,000 to $499,999	8,904	6.6%	21,546	6.8%	53,539	5.6%
$500,000 to $999,999	2,908	2.1%	7,109	2.2%	17,500	1.8%
$1,000,000 or more	705	0.5%	1,986	0.6%	5,278	0.5%
Median (dollars)	$135,200		$133,700		$115,000	